Working Paper Series

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February 2022

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[1] An earlier draft of the paper was presented at an open seminar at the Centre for Development Studies. The authors are grateful for the comments and suggestions received during that seminar. Further, they are much thankful to the referee to the paper, whose suggestions vastly improved the arguments and inferences. Thanks are due also to Ganesh Kumar and R Nagaraj for comments on an earlier draft. S M Mohanakumar helped us in compiling the data from disparate sources. We are very much indebted to him for his excellent research assistance. The usual disclaimer holds good.

ABSTRACT

India, through its central bank, has put in place an elaborate set of institutions and technologies for diffusing digital payments in the country since 2010. In fact, the Reserve Bank of India has designated the 2010-2020 period as the digital payments decade. The union government through the union budgets too have been incentivising digital transactions. Further, two temporary shocks, namely the demonetisation episode of 2016-17 and the pandemic since March 2020 are also expected to have spurred digital payments. But has digital payments really diffused in the economy during this period and could one explain the move towards digital payments using the sectoral system of innovation framework. The ensuing analysis shows that the rate of growth of digital payments have actually declined during the decade despite the fact two of the three building blocks of the sectoral system have been strengthened. But public policies from both the monetary and fiscal authorities do not appear to have had any effect on the third building block, namely the demand for digital transactions.

Keywords: digital payments, demonetisation, currency in circulation, sectoral system of innovation, Reserve Bank of India, India

JEL Codes: E42, E51,033,053

Introduction: India has gone through a controversial policy of demonetising two of its specified bank notes, which accounted for over 86 per cent of the currency in circulation in the country. Although the initial objective of the policy was stated to be dealing with fake Indian currency notes and reducing unaccounted income, half way through the implementation of this much-discussed policy, government's objective shifted to moving the economy to a digital one supposedly for preventing tax evasion and corruption both of which are the main conduit for the emergence and sustenance of unaccounted incomes. However, the process of creating and diffusing a digital payment system in the country started much earlier in 2007 when the Reserve Bank of India (RBI) enunciated the *Digital Payments and Settlement Act* to provide a legal framework for digital payments to occur. This was followed in quick succession with the creation of institutions and technologies, both software and hardware, to facilitate digital payments. The union government, in its successive budgets have also provided a number of fiscal incentives for digital payments to flourish. The RBI has even designated the 2010-2020 decade as the *digital payments decade.* In the context, the purpose of the paper is to analyse the trends in diffusion of digital payments and to explain the measured trends in diffusion. In order to accomplish the latter, we employ the sectoral system of innovation framework (Malerba, 2004).

The paper is structured into seven sections. In the first section we discuss the motivation for this study. The second section engages with the existing scholarly literature on this issue essentially to make out a case for our study. The third section details the main research questions and the research problem that the paper seeks to answer and the analytical framework that is employed to answer those questions. The fourth section maps out the trends in diffusion of digital payments in India both at the aggregate and disaggregated levels. The fifth section attempts to provide an explanation for the observed trends in diffusion in terms of the three building blocks of the Sectoral System of Innovation of digital payments. The sixth section attempts at an empirical estimation of the factors that explain adoption of digital payments and the seventh section concludes the paper.

1. Motivation

The 2000s have been characterised by a number of epoch making economic reforms in India. Among these the move towards digital transactions from cash-based one is an important one which has far reaching ways in making the economy more efficient especially in terms of formalising it somewhat. Given the fact that the digital payments in sizeable numbers commenced from 2010 onwards, it is necessary to analyse its performance over the years and the factors that would have contributed to that performance. This is what is being analysed in our present study. So the specific reasons that have motivated us are as follows:

- The RBI has designated the 2010-2020 period as the *Digital Payments Decade.* During this decade there have been tremendous improvement in institutions and the technologies that support digital payments. Recently in the union budget for 2021-22, the government had allocated Rs 1500 crores incentivising digital transaction and especially small sized retail payments. The union budget for 2022-23 has continues these incentives.

- There were two shocks, albeit of temporary nature that would have spurred digital payments. The two shocks that would have increased the diffusion of digital payments are: (i) the demonetisation episode of 2016-17 which had removed specified bank notes which accounted for 86 per cent of the cash transactions at that time forcing people to resort to digital payments; and (ii) the pandemic period since March 2020 with its requirement for social distancing also created conditions for more contact less forms of payments to be used.

- The only available study of household level adoption of digital payments by the NPCI-PRICE (2020) had found that nearly one-third of the households surveyed across three income groups, bottom 40 per cent, the middle 40 per cent and the top 20 per cent had adopted some form of digital payments.

- The world over the concept of Central Bank Digital Currency (CBDC) is gaining currency (Prasad, (2021). According to Atlantic Council[2] which tracks introduction of CBDC 9 countries have already fully launched CBDCs in 2021 and another 87 countries (representing over 90 percent of global GDP) are exploring a CBDC. In May 2020, only 35 countries were considering a CBDC. The union budget for 2022-23 has stated that the RBI will introduce a digital currency in 2022-23. CBDC will take the country to the highest form of digital transactions.

- India is also in the process of establishing exclusive digital banks- Scheduled commercial banks to set 75 digital banking units in 75 districts (Sitaraman, 2022).

Given the growing importance of digital forms of payments, it will be interesting to analyse the progress which the country has made thus far in digital payments.

2. Engagement with the past literature

From the perspective of our paper, for a meaningful engagement with literature, we classify the literature into three strands: Demonetisation; Technology adoption; and Effect of demonetisation on digital payments. This classification allows us to find a lacuna in literature which orients the aim of our paper.

2.1 Demonetisation

Sudden withdrawal of 86 per cent of the bank notes is huge shock to any economy, more so to the second most populous country in the world i.e. India. No wonder, this shock move by the Indian government in 2016, has generated a plethora of studies that analyse the impact of demonetisation on the Indian economy. Ghosh et al (2017) note that given the dependence of the Indian economy on cash, demonetisation was a severe measure. They state that when demonetisation was announced, 95 per cent of all transactions in the country were in cash. Cash transactions were the norm in informal sector which employed bulk of the workers. Given the linkages of the formal

[2] See Atlantic Council, https://www.atlanticcouncil.org/cbdctracker/ (accessed on February 5 2022)

and informal sector, demonetisation struck a heavy blow on all economic activities. The flip flops made by the government after the move made it apparent that the policy goals of demonetisation were unclear. Reddy (2017) constructs a narrative of the impact demonetisation had on people and their lives. Given that black money may not necessarily be in cash, sudden withdrawal of cash resulted in loss of income and employment especially in those sectors that were dependent on cash. If the aim was to target black money of some, then there were other effective means than demonetisation – which imposes a cost on many.

2.2 Technology adoption

Can the sudden unavailability of cash effect a permanent change in payment behaviour? Summary of available literature on technology adoption is that shocks can have temporary effect on adoption. However, there other factors that are necessary for a change in behaviour. For example, the first and foremost requirement is the availability of an alternate mode of payment. Digital payment as we all understand is a rubric for a range of technologies through which payment can be done or received, without the need for an actual cash transaction. The sectoral system of innovation (SSI) for digital payments, which we discuss later, has been active in India for more than decade and half. For this section it may be enough to state that alternate mode of payment i.e., digital payment was available at the time of demonetisation. However, as is well known, technology adoption is not automatic, hence, recalling some literature on technology adoption may be relevant. Digital payments have characteristics of network industries, i.e., adoption by a new user benefits everybody using that technology. Gowrisankaran and Stavins (2004) argued that low use of electronic payment products could be because of lesser preference at existing prices or existence of network externalities. For electronic payments in the United States they show that network externalities are moderately large and call for policy intervention to reduce the network externalities.

2.3 Effect of demonetisation on digital payments

Using the Indian demonetisation experience, Chodorow-Reich et al (2020) find that before demonetisation at the aggregate level, ATM withdrawals, E-Wallet, and Point of Sale (PoS) transactions, show no growth; while post demonetisation, i.e., between October and December 2016, one observes a 50% decline in ATM withdrawals, a doubling of e-wallet transactions, and a sextupling of POS transactions. The most probable cause for these changes as per them is the demonetisation shock. They set up a demonetisation model which among others predicts that districts facing severe cash crunch will adopt alternative payment technologies faster. The model is empirically verified using a cross sectional approach. Empirical results confirm that districts that faced drastic reduction in cash, experienced faster use of e-wallet and POS. The faster growth in digital payments for these districts was accompanied with a reduction in their overall economic activity and ATM usage. Crouzet et al (2020) acknowledge that coordination failures can be an important obstacle for technology adoption. They build a model and use the Indian demonetisation data to point out that though large-scale temporary interventions can overcome coordination problems, geographies with high initial adoption rates (prior to the intervention) experience lasting long-run adoption effects, but, not for the other geographies. In other words, there is inequality

in adoption, areas with higher initial adoption rates – due to better infrastructure, proximity, access etc. – experience lasting adoption effects over other areas. In the Indian context they conclude that demonetisation reduced coordination problems, and, hence was followed by an adoption wave.

To measure the effect of demonetisation on digital payments, Lahiri (2020) looks at the time paths of digital transactions in the economy. The paper notes that volume of digital payments had already caught up with that of traditional payments just before demonetisation. It points out that since 2017, digital transactions have consistently exceeded traditional transactions both in level and growth rates since 2017. It has also been noticed that for the past decade the value of digital transactions has been larger and has also been growing faster than traditional transactions. Hence, Lahiri (2020) concludes that demonetisation does not appear to have affected the trends or levels of either digital or traditional transactions.

Studies that have dealt with digital payments have done so in the context of demonetisation. Thus, our engagement with literature in the Indian context points out to a lacuna of studies that focus on diffusion of digital payments at the aggregate level over the digital payments decade, which is the aim of this paper.

3. Research questions, problem and the analytical framework

3.1 Research questions

The paper deals with two inter-related questions:

- Given the tremendous improvements in institutions, policies and the two shocks, albeit temporary, what has been happening to the rate of diffusion of digital payments in India?

- What are the factors that explain the rate of diffusion?

3.2 Research problem

The diffusion of digital payments in the economy is a function of its sectoral system of innovation. The sectoral innovation system consists of three building blocks, namely key actors and institutions, the technology or knowledge domain in that sector and finally, the demand for that innovation. Temporary shocks applied to enhance more significant usage of digital payments can have only a short term effect in diffusing digital payments.

3.3 Analytical framework

The sectoral system of innovation (SSI) framework is due to Malerba (2004). The framework is conducive in explaining the catch-up process of developing countries as most developing countries focus on a specific sector of their economy to innovate and grow. For instance, the emphasis placed on innovations in the electronics sector in the catch-up economies of Korea, Taiwan, and China has really helped those countries become world leaders in specific subsectors. The argument is that innovations in a particular sector contribute to an economy's overall level of innovations. Innovations in a specific sector are supported through the interactions of three building blocks: key actors and institutions and their networks, the technology domain, and the

demand for innovations from consumers. Key actors and institutions can be both tangible and intangible. Tangible institutions are all those organisations such as regulatory agencies, financial institutions etc. and research institutes that generate new technologies in that sector. Intangible institutions are those which govern the legal framework and intellectual property right regime in that sector. The technology domain of the specific sector is also an important component as some sectors are characterised by very fast technological changes while in others the technologies change very slowly. The opportunities for improved technological developments that are extremely beneficial to both producers and consumers are possible in the former where technological improvement opportunities are phenomenal while in the latter category such opportunities are very scarce. The complexity of the technology domain and the availability of sufficient human resource with the requisite skills is another contributory factor. Finally, even if there are a number of institutions and a conducive technological domain is present, the generation and diffusion of innovations may happen only when there is sufficient demand for such an innovation especially from the domestic sources. If the economic growth in the country is on a continuous decline and if the economy is in recession, one need not expect the innovations to diffuse even if they are generated somehow.

The first objective of measuring the rate of diffusion is basically accomplished through a variety of indicators such as the rate of growth of digital payments in both volume and value terms and by developing an index of digital payments and tracking its movements over the decade. The second objective is accomplished by invoking the SSI framework explained earlier. We have also attempted to empirically estimate the impact of the building blocks of the SSI by employing a regression analysis.

3.4 Empirical estimation

To estimate the impact of the SSI on the digital ecosystem, we try to look for empirical evidence for the government's push towards digital payments especially after demonetisation. As already mentioned, although the initial objective of the demonetisation policy was stated to be dealing with fake Indian currency notes and reducing unaccounted income, half way through its implementation, government's objective shifted to moving the economy to a digital one Further, the government supported all ongoing efforts to create an elaborate digital payment system. Thus, post-demonetisation the SSI for digital payments was strengthened. In the analytical framework for the empirical estimation, we exploit the fact that compared to a weaker SSI, a stronger SSI will make access and hence cost of using digital payments lower. We set up the framework for empirical estimation as follows.

For an individual user, adoption and use of digital payments are critically dependent on the cost it imposes on the user vis-a-vis the cost of cash. Lower the relative costs, higher the adoption and usage. This implies that the rate of growth of digital payments for the user is a function of the difference between these two costs. Let y_d denote the growth rate of digital payments, C_c the cost of cash, C_{du} the cost of using, and C_{da} the cost of adoption of digital payment for the user. Thus,

$$y_d = f(\Delta C)$$
$$\Delta C = C_c - (C_{du} + C_{da})$$

It is obvious that ΔC will not be the same for adopters and non-adopters. Higher the difference implies faster growth rate and relatively lower costs for digital payments; and slower growth implies relatively higher costs for digital payments. The diversity of microeconomic agents across the country will make aggregation of this framework very challenging. Hence, to keep the framework simple, for the macroeconomy, we postulate that,

$$y_{DM} = f(C_C, C_{DU}, X) \ldots\ldots\ldots 1$$

Where y_{DM} is the growth rate of digital payments, C_C is the cost of cash, C_{DU} is the cost of using digital payments, X is a matrix of other factors that will include the cost of adoption of digital payments. The SSI for digital payments will try to reduce the cost of digital payments (both adoption and using) by providing easy access to the digital payment ecosystem, and strengthen other factors responsible for the growth of digital payments, such as demand. Given a cost of cash, a stronger SSI for digital payments would have created a digital payment ecosystem that will provide cheaper and faster access to digital payments, which will lead to faster growth; while given a digital ecosystem created by the existing SSI, higher the cost of cash will lead to faster growth of digital payments. Demonetisation, in our opinion, increased the cost of cash for a very short period of time, as a result of which, given the digital ecosystem created by the existing SSI at that point of time, the growth rate of digital payments accelerated. A recent report (NPCI-PRICE, 2020) states that only a third of Indian households use digital payments in one form or the other. This resonates well with the National Food Security Act (NFSA) of India statement that '*around 80 crore persons have been covered under NFSA at present for receiving highly subsidised foodgrains.*' Taken together, these statements imply that currently the number of individual users capable of digital payment transactions may not exceed more than 30 crores. The ability or strength of the existing SSI to facilitate digital payments access to these 30 crore users will influence the growth rate of digital payments. Empirical estimation can be seen in section 6.

4. Rate of diffusion of digital payments

As noted before, India is a cash based economy. Demonetisation supposedly removed 86 per cent of the cash in circulation then and the data on remonetisation states that almost 99 per cent of the demonetised currencies were returned to the RBI by February 2017. Although the original stated motive of the government for demonetisation was to unearth black money kept in the form of liquid cash, the fact that a lion's share of the demonetised currency was surrendered at the commercial banks also contributed to the government changing the motive for demonetisation to usher in a cashless economy through the digital payments mode.

There are numerous digital modes of payment currently used in the country (Table 1). As a part of the policy to encourage digital payments transaction costs to consumer have been kept to a minimum. The most frequently used is the debit or credit card at a Point of Sale (PoS) terminal, online transfer from one bank account to a beneficiary's account, either through the National Electronic Fund Transfer (NEFT) or the Real Time Gross Settlement (RTGS) facility.

Table 1: Types of digital payments in India

Type	Transaction cost	Other conditions	Service availability
Banking cards (Debit/Credit/Cash/Travel)	Yes 0.5% to 2.205% Although paid by the merchant		751 banks
Unstructured Supplementary Service Data (USSD)	Rs. 0.50 Charged to customer	Fund Transfer limit of Rs.5000/- per day Rs. 50000/- per annum	51 banks
Aadhar Enabled Payment System (AEPS)	Nil to customer	Banks define limit	138 banks
Unified Payment Interface (UPI)	* Nil to customer By most banks * Customer pay for data charges	Rs. One lakh per transaction	282 banks
Mobile Wallets	0.5% - 2.5%	For users: * No KYC = Rs. 20,000 per month * Fully KYC = Rs. 1,00,000 per month	40 companies
Internet & Mobile Banking	NEFT – Maximum of Rs 30/- RTGS – Maximum of Rs 60/-		All banks

Source: Cashless India, http://cashlessindia.gov.in/digital_payment_methods.html (accessed on October 28, 2021)

As expected by literature, as cash was scarce, demonetisation seems to have increased the probability of using digital modes of payment. However, paradoxically after the initial spurt in digital modes of payment, and that too immediately after demonetisation, people have turned back to cash for payments. We demonstrate this using both aggregate and disaggregated data. To track the diffusion of digital payments, we consider three separate but related indicators: (i) digital payments both in volume and value and also trends in a newly introduced digital payments index; (ii) payment modes and channels; and (iii) payment infrastructure.

4.1 The volume and value of digital payments

We have computed the year-on-year growth rates in the volume and value of all kinds of digital payments published by the RBI. RBI has introduced a change in the definition of payments that constitute digital payments in 2017-18. So there is a truncation in the data series between 2011-12 to 2016-17 and from 2017-18 through 2020-21. Annexure 1 documents these definitional changes according to the old and new formats. We have taken the five years 2011-12 through 2015-16 as the pre-demonetisation period and the three years 2018-19 through 2020-21 as the post-demonetisation period. 2017-18 cannot be computed given this definitional change. See Figure 1.

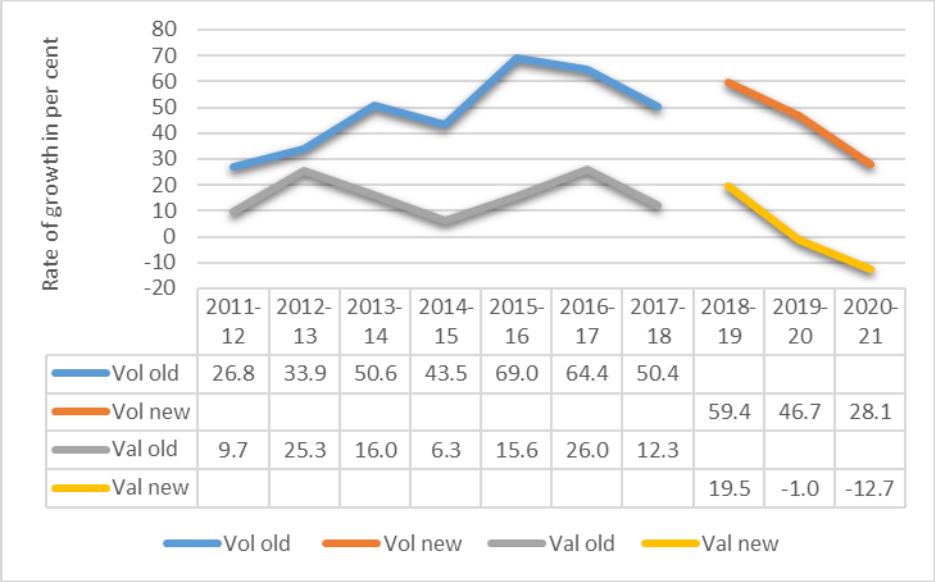


Figure 1: Rate of growth of digital payments in India, 2011-12 through 2020-21
Source: Computed from Database of Indian Economy, Reserve Bank of India
Note: See Annexure 1 for definitions of the old and new formats.

Volume growth rate peaked in 2015-16 while value growth rate peaked in 2016-17. After peaking, both of them display a declining trend. This decline is more pronounced in value terms than in volume. Surprisingly, this is also the case in 2020-21, when one would have expected more people to have used digital means of payment because of the ongoing pandemic. This is more evident when we divide the entire period into three sub-periods: pre-demonetisation (2011-12 through 2015-16), demonetisation (2016-17) and post-demonetisation (2018-19 through 2020-21). See Table 2

Table 2: Rate of growth of digital payments (annual percentage changes)

	Period	Volume	Value
1. Pre- demonetisation	2011-12 to 2015-16	44.8*	14.60*
2. Demonetisation**	2016-17	64.4	26.0
3. Post-demonetisation***	2018-19 to 2020-21	44.7*	1.94*

* Average during the period
**Growth rate for 2017-18 cannot be computed because of the change in definition
*** Growth rate is based on the new definition as per RBI
Source: Computed from Database of Indian Economy, RBI

4.2 The RBI- Digital Payment Index (RBI-DPI)

The RBI has developed a composite index called the RBI-DPI to measure the diffusion and deepening of digital payment systems across the country. It comprises five broad parameters that measure the deepening and penetration of digital payments in the country over different periods. Each of these parameters has sub-parameters

which, in turn, consist of various measurable indicators. See Table 3 for the five indicators, their respective weights, and each of the five sub-indicators. Fifty per cent of the weight is assigned to those factors which enable digital payments to materialise, and only 45 per cent of the weights are assigned to actual digital payments per se. The RBI also does not make the detailed computations for arriving at this index public. March 2018 has been taken as the base year for the indicator, and it has been calculated for every September and March (Figure 2). There are two major difficulties with this index. First, it assigns more weight to those infrastructure variables such as the number of broadband and mobile users, the number of subscribers with internet bank facility, number of Aadhar holders etc., - all of which has been showing exponential growth recently (Annexure 2). Second, it is very likely that all indicators included in the parameter the indicator 'consumer centricity' suffer from measurement errors as these are not regularly collected by any of the official statistical agencies in the country. So, it is not surprising that, as indicated in Figure 2, the index shows a continuous upward trend.

Table 3: RBI- Digital Payments Indicator

Parameters	Weight (Per cent)	Indicators
1	2	3
1. Payment Enablers	25	Internet users, mobile users, Aadhaar numbers, bank accounts, digital payment facilitators, and payment system members.
2. Payment Infrastructure - Demand-side Factors	10	Payment and other instruments issued, customer registrations for mobile and internet banking, and FASTags.
3. Payment Infrastructure - Supply-side Factors	15	Physical and digital payment acceptance points and payment intermediaries.
4. Payment Performance	45	Volume and value of various payment systems, unique users in such systems, cheque transactions, cash withdrawals using cards, and cash estimates.
5. Consumer Centricity	5	Consumer awareness and education initiatives, declines, complaints, frauds, and system downtime.

Source: (i) https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50901 (accessed on February 2, 2022)
(ii) https://rbidocs.rbi.org.in/rdocs/content/pdfs/PR87401012021.pdf (accessed on February 2, 2022)

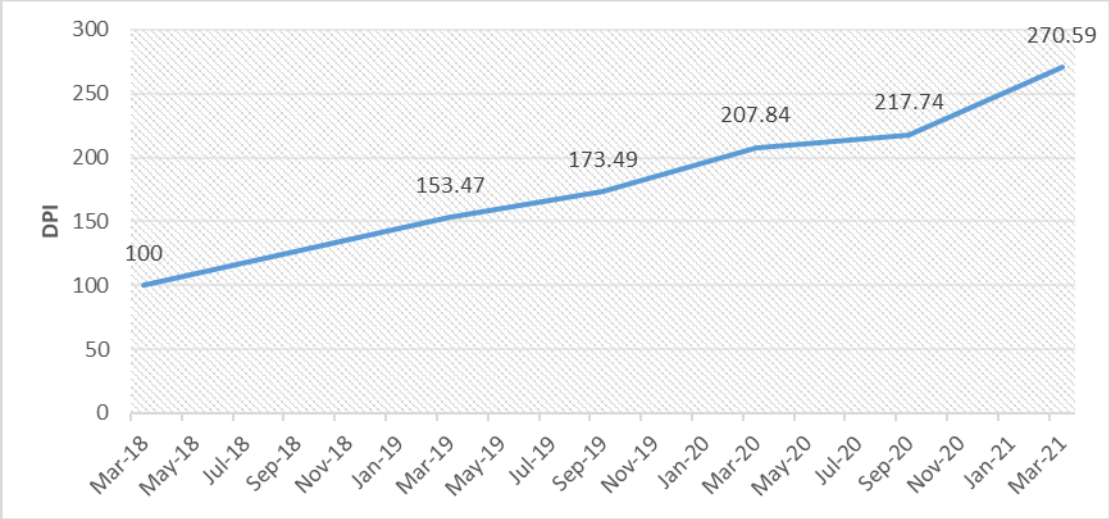


Figure 2: Trends in the RBI- Digital Payment Index
Source: Reserve Bank of India, https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51962 (accessed on November 8, 2021)

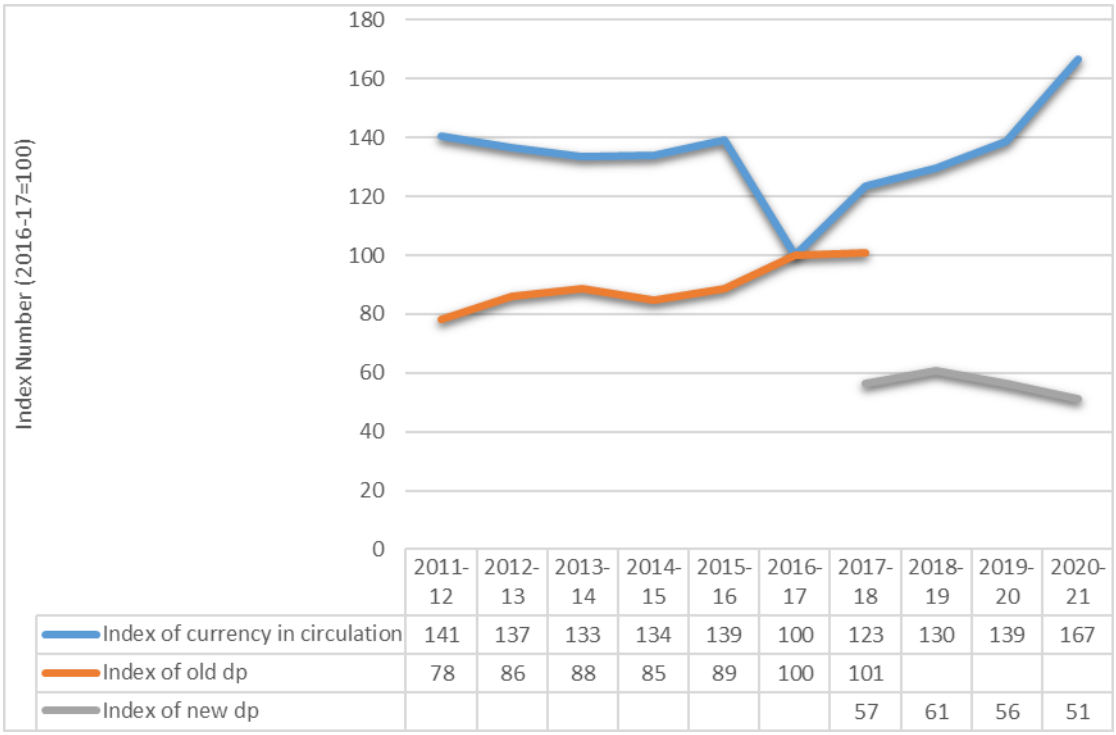
Contrary to the growth rate of both volume and value of digital payments, which does not register any increase in the post-digital payments period, the RBI-DPI shows a steady increase. An explanation for this may be found in how the index is devised, with the infrastructure indicators accounting for about one-half the weightage.

We argue that figure 1 and Table 2 are better indicators of the performance of digital payments in the country as it is based on the volume and value of digital payments, and it shows an apparent decline in their growth rate. It has even become negative during the pandemic year of 2020-21.

4.3 Our Index of digital payments

The finding that digital payments' growth rate has declined since the demonetisation exercise is intuitive. To support our argument, we have compared the value of digital payments to currency in circulation from 2011-12 till 2020-21[3]. For making this comparison meaningful, we have first converted the two variables, currency in circulation and digital payments, to an intensity figure by taking them as ratios of GDP. Further, we convert these intensity indicators as an index number by taking 2016-17 – the demonetisation year – as the base year[4]. The direction of movement of these two indices is charted in Figure 3.

[3] Over the long-term the share of currency in broad money (M3) has fallen, see Chart 10, Mohan and Ray (2018).
[4] We realize the difference in definition of digital payments between 2016-17 (old) and 2017-18 onwards (new). Though this may affect the level of the index, the trend, we believe will be unaffected and is our variable of interest.



	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Index of currency in circulation	141	137	133	134	139	100	123	130	139	167
Index of old dp	78	86	88	85	89	100	101			
Index of new dp							57	61	56	51

Figure 3: Trends in currency in circulation and digital payments, 2011-12 to 2020-21
Source: Computed from RBI, online Database of Indian Economy

The results further corroborate our earlier finding that the growth of digital payments has been declining while currency in circulation is back to pre-demonetisation levels. What is more surprising is that digital payments declined even in 2020-21 when due to the pandemic, restricted movement, and increased online purchases, one would have expected consumers to use digital forms of payments, especially when most of these are contactless. This decline could be due to macroeconomic factors such as the overall growth performance of the economy, the extent of financial inclusion etc. and specific factors that impact digital payments like the availability of physical infrastructure to effect digital payments and financial literacy. The fact that the economy has been on a downward trend since 2017-18 and in the negative territory in 2020-21 is now well established. COVID-19 induced lockdown leading to subdued economic activity certainly played a role in reducing the growth of digital transactions in 2020-21 (RBI, 2021)

4.4 Decomposition of the overall growth rate in digital payments

As noted earlier, digital payments consist of a motley assortment of payment methods such as bank transfer, card payments, UPI etc. A disaggregated picture of digital payments will give us a better sense of the growth performance of digital payments. This is attempted below in Table 4.

Digital payments are still dominated by large value credit transfers in RTGS wherein each transaction is more than Rs 2 lakhs. Compared to 2016-17, its share has decreased by over 12 percentage points in 2020-21 (Table 4). RTGS is a transfer between individual customers and interbank transactions, the former accounting for

about 99 per cent and the latter about 1 per cent. It is seen that other forms of digital payments like cards, Bharat Interface for Money (BHIM), Aadhar enabled amounts, UPI etc., account for an insignificant value share of digital payments. Also, as shown by Table 5, all common forms of digital payments have shown a decline in their growth rate during the 2017-18 to 2020-21 period. Thus, based on the evidence presented both at the aggregate and the disaggregated levels, the diffusion of digital payments, as explained by its growth and absolute numbers, has been much below its expected levels. This is in sync with the finding of a recent report (NPCI-PRICE, 2020) that only a third of Indian households use digital payments in one form or the other.

Table 4: Distribution of digital payments (in per cent)

	2016-17			**2020-21**	
Type of digital payment	**Volume**	**Value**	**Type of digital payment**	**Volume**	**Value**
1. RTGS	1.10	87.54	*1. Large Value Credit Transfers – RTGS*	0.36	74.64
2. Total Retail Electronic Clearing	43.18	11.80	*2. Credit Transfers*	72.72	23.69
2.1 ECS DR	0.09	0.00	2.1 AePS (Fund Transfers)	0.00	0.00
2.2 ECS CR	0.10	0.01	2.2 APBS	3.29	0.08
2.3 NEFT	16.58	10.70	2.3 ECS Cr	0.00	0.00
2.4 IMPS	5.18	0.37	2.4 IMPS	7.50	2.08
2.5 UPI	0.18	0.01	2.5 NACH Cr	3.76	0.87
3. National Automated Clearing House (NACH)	21.03	0.71	2.6 NEFT	7.08	17.76
4. Total Card Payments	55.72	0.66	2.7 UPI	51.09	2.90
4.1 Credit Cards	11.11	0.29	*3. Debit Transfers and Direct Debits*	2.39	0.62
4.2 Debit Cards	24.53	0.29	3.1BHIM Aadhaar Pay	0.04	0.00
5. Prepaid Payment Instruments (PPIs)	20.08	0.07	3.2 ECS Dr	0.00	0.00
Total Digital Payments (1+2+3+4+5)	**100.00**	**100.00**	3.3NACH Dr	2.20	0.61
			3.4 NETC (Linked to Bank Account)	0.15	0.00
			4. Card Payments	13.23	0.91
			4.1Credit Cards	4.04	0.45
			4.2 Debit Cards	9.20	0.47
			5 *Prepaid Payment Instruments*	11.30	0.14
			Total Digital Payments (1+2+3+4+5)	**100.00**	**100.00**

Source: RBI

Table 5: Rate of growth of selected digital payments
(Average annual growth rate)

	RTGS		NEFT		Card payment	
	Volume	**Value**	**Volume**	**Value**	**Volume**	**Value**
2011-12 to 2015-16	14.97	11.45	57.67	55.89	40.38	31.47
2016-17	9.66	19.08	29.47	44.15	101.31	65.54
2017-18 to 2020-21	10.29	3.07	17.54	21.5	5.74	16.46

Source: Computed from Reserve Bank of India

This discussion clarifies that the effect of demonetisation on the diffusion of digital payments was temporary. We argue that the diffusion of digital payments is primarily due to its SSI, which we turn to in our next section.

5. Sectoral system of innovation for digital payments

The transition to digital payments has been facilitated by its SSI, the origin of which can be traced back to the early 1990s when a committee on 'Technology Upgradation in the Payment Systems' was constituted in 1994 by the RBI. The SSI for digital payments consists of actors & institutions, knowledge domain, and demand. We will focus on each of these factors in turn.

5.1 Actors and Institutions

We identify three important actors and networks in the system – The RBI, Bank Network, and Payment System Operators.

RBI – Prime Mover

The RBI, the statutory regulator of the payment and settlement systems in the country, is the prime mover in the digital payments sectoral system of innovation. It has designed and built the institutions and networks required for the digital payment ecosystem in the country. One of the first steps that RBI took in technology absorption in the banking and financial sector was to set up the Institute for Development and Research in Banking Technology (IDRBT) in 1996. IDRBT primarily focused on developing and managing information technology (IT) infrastructure for the banking and financial sectors. It developed many technological systems that are the backbone around which payment settlement systems in India rally today. IDRBT is also the certifying authority for digital certificates. Research and academic activities at IDRBT engendered the technical know-how to create these services and helped in training and updating skills in the banking sector.

The Clearing Corporation of India (CCIL), a finance market infrastructure that operates various payment systems and functions as a Trade Repository (TR), was set up by the RBI in April 2001 to provide guaranteed clearing and settlement for transactions in money, government securities, forex and derivative markets. CCIL also provides non-guaranteed settlements for rupee interest rate derivatives and cross-currency forex transactions.

The Payment and Settlement System Act of 2007 designated the RBI as the statutory regulator of the payment and settlement systems in the country. As per the Payment and Settlement Act, 2007, digital payment has been defined as any transfer of funds which is initiated by a person by way of instruction, authorisation or order to a bank to debit or credit an account maintained with that bank through electronic means and includes point of sale transfers; automated teller machine transactions, direct deposits or withdrawal of funds, transfers initiated by telephone, internet and, card payment.

In 2009, as a part of the re-defining role for IDRBT, RBI created a wholly-owned subsidiary Indian Financial Technology and Allied Services (IFTAS), that took over the IT services that IDRBT was providing until then. IFTAS was created to provide critical infrastructure services to RBI, banks, cooperative societies and other financial institutions. These two organisations were vital in providing the country's IT backbone for digital payments. RBI established the National Payments Corporation of India (NPCI) in 2008 as an umbrella organisation for all the retail payment systems in the country to optimally use the resources through consolidation of existing infrastructure and building new infrastructure to enable national reach seamlessly. NPCI was expected to have a robust technology platform and provide high-quality services to customers at an affordable price structure. The incorporation of these organisations by RBI clearly shows that to support the growth of the fledgling digital payments sectoral innovation system, RBI introduced actors with the right expertise at an appropriate moment.

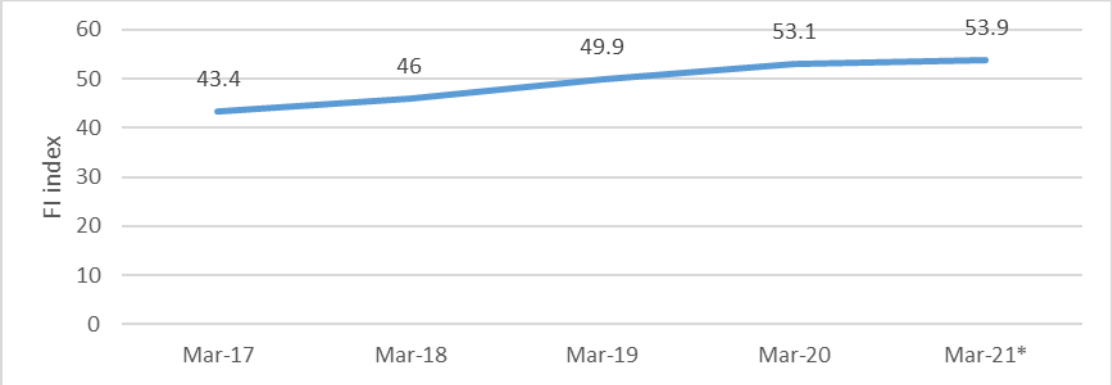
In its regulatory approach, RBI has remained technology-neutral, enabling India's digital ecosystem to develop and adopt various technologies. Though initially, the system was bank led, RBI has included non-banks to widen the scope, access, and outreach of the ecosystem over a period of time. Thus, the RBI ensured that the length and breadth of actors were considerably enhanced.

Bank Network

The RBI has facilitated the establishment of an extensive bank network across the country. As per the RBI, in March 2021, the number of commercial bank branches was 158,386, up from 72,274 in March 2006. This has helped the aim of financial inclusion across the country. One of the primary requirements for digital payments is to have a bank account. One out of every two Indians still does not have a bank account. There are four official sources of data on financial inclusion. First is the decennial census data, the latest of which refers to 2011. Second is the All India debt and investment survey (the NSSO 59th Round). Between these two sources, one can glean a fair idea of the extent of financial inclusion in the country. According to the former source, 58.7 per cent of the households are availing of banking services in the country. In contrast, according to the later source, almost 51.4 per cent of the farmer households are financially excluded from both formal and informal sources.

The third is a very recent index of financial inclusion developed by the RBI (Sharma and Sengupta, 2021). It is a multidimensional composite index based on 97 indicators that quantify the extent of financial inclusion and is responsive to availability, ease of access, usage, unequal distribution and deficiency in services, financial literacy, and

consumer protection. This index is available from March 2017 through March 2021 and shows a steady increase. See Figure 4.



* Provisional estimates.

Figure 4: Trends in the Financial Inclusion Index

Source: Sharma and Sengupta, 2021

Fourth is the Pradhan Mantri Jan Dhan Yojana (PMJDY) accounts. The number of such accounts has increased from 12.55 crores in 2015 to 43.50 crores by the end of September 2021 (Department of Financial Services, 2021). But most of the accounts in the scheme are small counts; hence they cannot be expected to be digitally active on their own. However, whenever they occur, government transfers to these accounts are now being carried out digitally, implying that the RTGS, NEFT, and IMPS transactions we discussed earlier have directly benefitted from the bank accounts created by the bank network expansion.

Payment System Operators

For smooth functioning of various payment systems, the RBI has authorised numerous payment system operators (PSO) to set up and operate in India under the Payment and Settlement Systems Act, 2007. CCIL and NPCI are two such crucial public sector stakeholders. Presently the cards payment network has five players, while the pre-paid instruments system has 38 players,[5] many of whom have entered the market in 2017. These pre-paid instruments have incentivised utility, grocery, or other online purchases. As a result, the number of mobile and internet banking transactions per 1,000 adults that was 183 in 2015 has shot up to 13,615 in 2020 (Ecowrap, 2021). In addition, other systems have multiple players. The primary aim of most of the PSO's is to popularise the use of their payments systems, which, at least as per the evidence above, seems to be gaining traction.

5.2 Technology/Knowledge domain

This domain can be classified into software and hardware domain.

[5] m.rbi.org.in/scripts/publicationsview.aspx?id=12043 (accessed on November 2, 2021).

Software

The software domain is primarily engaged in developing competing and complementary technologies to facilitate and improve the user experience for all the parties involved in a transaction. Some of the technologies that are currently used in the country are electronic payments through bank networks, mobile phone-based systems to send or receive money instantly, interoperable online transactions at micro-ATM using biometric authentication, card payments, and electronically stored pre-paid value which facilitates the purchase of goods and services against the value stored in such instruments. IDRBT, in collaboration with a switch vendor, launched the National Financial Switch (NFS) by 2004, which provided ATM connectivity in the country and offered an e-commerce gateway. The variety of systems introduced and operated by NPCI has helped the retail payments space in India to develop and mature. For example, in November 2010, NPCI had developed the IMPS, a platform accessible overall online channels, including mobile phones. In January 2011, AePS introduced by NPCI allowed payment recipients to perform banking activities with Aadhar numbers and biometric authentication. In March 2012, NPCI introduced India's domestic debit card, 'RuPay'. It came up with the UPI in April 2016, which standardised and secured digital financial messages that allowed for an unbundling of accounts from customer experience and the rapid adoption of payment apps. The national electronic toll collection (NETC), which automates road toll collection, is another NPCI product introduced in December 2016 (Cook and Raman, 2019). Of all the technologies introduced, UPI has been the biggest disruptor. It is remarkable for its simplicity of construction. It allows for person to person, person to merchant transactions without full bank account details on a real-time basis. Transactions can be carried out using a mobile, 24x7 and 365 days a year. No wonder India is now exporting UPI technology to other countries. In Table 4, we have already mentioned some popular modes in the digital retail payments ecosystem.

The software domain has benefitted from the technology neutrality stance of the RBI, enabling the digital payments ecosystem in India to develop and adopt a variety of technologies. Starting with a bank-led system, the RBI has gradually included non-banks with different technologies to increase competition and widen the scope, access and outreach of the digital payments ecosystem.

Hardware

The hardware domain involves the actual setting up – electronic instruments, infrastructure etc. – of the technologies for use by all the parties involved in a transaction. This involves the physical infrastructure required and supply of the electronic instruments necessary for the payment network.

Physical infrastructure for digital payments

Demand for digital payments is critically linked to the physical infrastructure for digital payments. The physical infrastructure for digital payments is not in place in an optimal manner, which has led to inequality in adoption, as discussed earlier. The first aspect of this is access to broadband Internet, the fundamental requirement. Most Indians who are Internet subscribers are narrowband subscribers (characterised by

very low speeds). As per estimates by the Telecom Regulatory Authority of India (TRAI), there were, as of the end of June 2021, about 770 million broadband subscribers in the country (TRAI, 2021). Over 94 per cent of them access it through a mobile device while only about 6 per cent do it through fixed Internet. Further, India has the lowest broadband speeds in the world. See Table 6.

Table 6: India's rank in Broadband internet speed vs China

(as of October 2021)

	Mobile broadband		**Fixed broadband**	
	India	**China**	**India**	**China**
Rank	117*	11*	70**	8**
Download speed (Mbps)	13.45	78.61	46.18	129.45
Upload speed (Mbps)	3.36	21.86	44.11	36.03
Latency (ms)	36	24	6	9

Source: Ookla (2021)

Notes: * Rank is out of 141 countries; and ** Rank is out of 181 countries

The second aspect is the availability of PoS machines. Although the total number of PoS machines and ATMs has increased, their growth rates have declined since March 2018 (Table 7). According to industry sources, the available 4.7 million PoS in 2021 is used by not more than a million merchants who accept card payments. This means that the country will have to import and install many PoS machines within a short period for increased usage so that the installation base of PoS machines is raised. Large-scale imports of PoS machines and those within a short period have another unintended consequence. It can add to the bourgeoning import bill for electronic products, including other requirements such as mobile phones for a digital payment ecosystem, thus denting the "Make in India" policy. One probable reason why PoS adoption is not widespread across smaller shops is its cost. Typically, a PoS machine costs Rs 8,000-12,000, which could cost further less after the waiver on excise duty and special additional duty on all components used in their manufacture. In addition to providing card machines to merchants, banks have to bear the operational costs, including merchant discount rate (MDR), which they cannot collect for now. MDR is a commission charged by acquiring banks to the merchant for every transaction on its card machine. A bank typically earns an MDR of 0.75% for transactions up to Rs. 2,000 and 1% for those above Rs. 2,000. Both these costs may need to come down for widespread adoption.

Table 7: Trends in the growth of ATMs and POS in India
(Numbers are in lakhs and growth rate is in per cent)

	ATM	Growth rate	POS	Growth rate
Mar-2012	0.96		6.61	
Mar-2013	1.14	19.15	8.54	29.26
Mar-2014	1.60	40.38	10.66	24.78
Mar-2015	1.89	18.26	11.27	5.70
Mar-2016	2.12	12.04	13.86	22.98
Mar-2017	2.22	4.91	25.29	82.52
Mar-2018	2.22	-0.10	30.83	21.90
Mar-2019	2.22	-0.24	37.22	20.73
Mar-2020	2.34	5.71	44.34	19.12
Mar-2021	2.39	1.81	47.20	6.45

Source: Reserve Bank of India

5.3 Demand

As per the *Report of the High-Level Committee on Deepening of Digital Payments* (2019), the number of digital payments per capita for India increased from 2.4 in March 2014 to 22.4 in March 2019. This implies that demand has been an important driver in this sectoral system. This demand has been primarily fueled by the growth of the economy and supply-side activities of the RBI, other public sector stakeholders, banks, and private players in the digital payment ecosystem.

Income growth

As the economy grows, per capita income rises, increases fuel consumption and access to the digital payment ecosystem. This implies that income growth is an essential factor for demand. For our purposes, we proxy income growth by the rate of real per capita GDP growth, which has been declining continuously since 2016-17. There is evidence that the unemployment rate – measured as a per cent of the labour force – was also increasing during this period (World Bank, 2021).

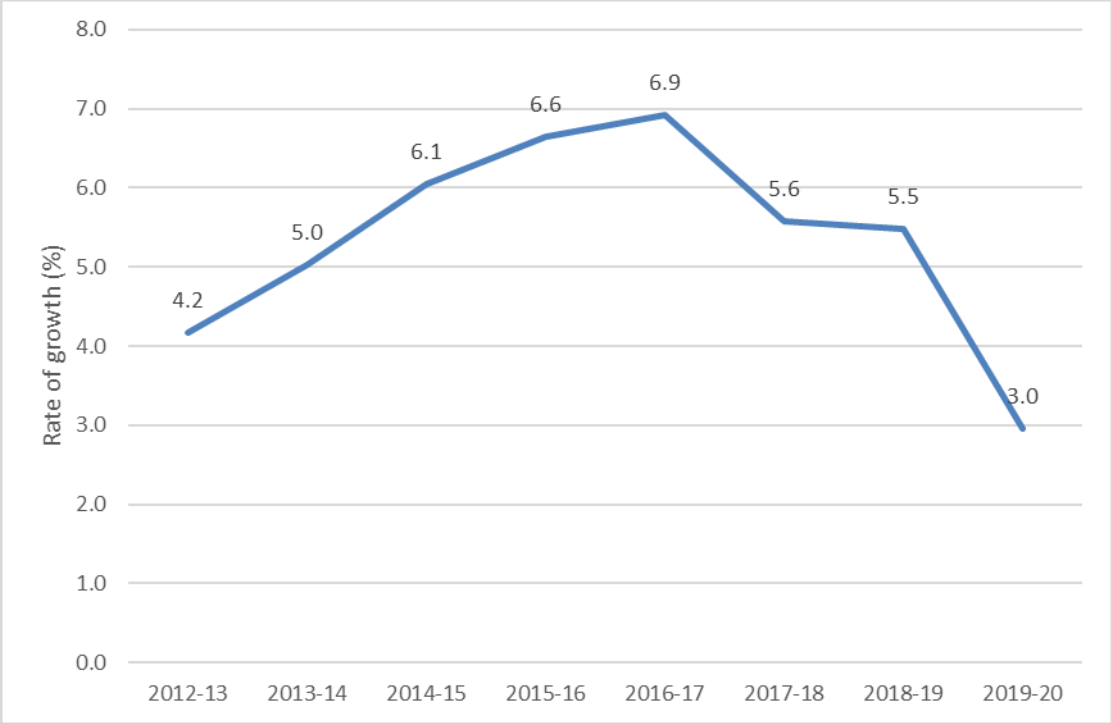


Figure 5: Rate of growth of real per capita GDP (Base: 2011-12)
Source: Central Statistical Organization (2021)

The parallel trend of the intensity of digital payments (Figure 3) and income growth (Figure 5) is apparent and striking.

Among the other supply-side activities, lowering the transfer cost has been an important factor in increasing demand and subsequent growth in RTGS, NEFT, and IMPS modes. Private PSOs offering pre-paid instruments have come up with innovative marketing schemes like cashback offers – both at the customer and merchant side – that helped them gain popularity among the younger generation and increase demand. The introduction of UPI in 2016, which offered interoperability across products, has acted as a multiplier for increasing the volume of digital payments.

6. Empirical estimation

To empirically estimate the impact of the building blocks of the SSI on the rate of growth of digital payments, we assume that equation 1 in section 3 can be expressed in the following simple linear form,

$$y_{DM,t} = \alpha + \beta(Cost\ of\ Cash)_t + \gamma(Cost\ of\ Digital\ Payments)_t + u_t \quad \ldots. 2$$

Our unit of time is a month, and we use data from April 2011 till October 2019[6]. We proxy the cost of cash by the currency in circulation (CC); the higher the currency in circulation in the economy, the lower the cost of cash. The cost of digital payments is proxied using three variables - teledensity per 100 population (TD), outstanding card

[6] See Annexure 1 for the definition of digital payment we use for the regression analysis.

volume (CV), and the number of PoS terminals (PS). Excellent reach of telecommunications is a vital necessity for a robust digital payment architecture; the higher the TD lower the cost of access to digital payments and the higher the growth. Government transfers to PMJDY accounts are digital; access to PMJDY accounts have been costless; thus, the number of bank accounts opened per month is also a good proxy for cost of digital payments. This data is not available. Since a debit card is issued to every new account, we try to proxy the access and the cost of digital payments through the number of outstanding cards every month. Higher CV lowers the cost and drives the growth. Finally, the number of PoS terminals across the economy will impact the cost of digital payments. Higher the PS reduces the cost and increases the growth of digital payments. For the dependent variable, we compute the growth rate of digital payments in volume terms and the growth rate of digital payments in value terms. In section 5, we had proxied income growth/demand by per capita real GDP; since this data is not available monthly, we cannot incorporate demand in our empirical analysis. Our econometric specification thus is,

$$y_{DM,t} = \alpha + \beta_1 CC_t + \beta_2 TD_t + \beta_3 CV_t + \beta_4 PS_t + u_t \quad \ldots. 3$$

We estimate equation 3 using the ordinary least squares method with robust standard errors. To understand the impact of demonetisation, which occurred in November 2016, we also carry the Chow test to look for a structural break in November 2016. The summary statistics for the variables can be seen in Table 8.

Table 8: Summary statistics

Variable	April 2011 – November 2016			December 2016 – October 2019		
	Obs	Mean	Std Dev	Obs	Mean	Std Dev
Digital payments Volume monthly growth rate	67	3.78	6.97	35	4.06	9.75
Digital payments Value monthly growth rate	67	2.7	19.37	35	2.27	16.27
CC	68	1304344	232019.7	35	1807022	342871.1
TD	68	77.62	3.66	35	91.4	1.48
CV	68	4564.1	1621.6	35	9007.94	759.13
PS	68	998599.2	279902.1	35	3272066	678150

Note: CC is currency in circulation, TD is teledensity per 100 population, CV is outstanding card volume, PS is the number of PoS terminals. The monthly growth rate is in %; CC is in crores, TD is per 100 of population, CV is in lakhs, PS is numbers.
Source: RBI, TRAI.

Means of all the variables – except digital payments value growth rate – in the post-demonetisation period are higher, probably indicating an improvement in the strength of the SSI in this period. We have already stated that post-demonetisation, the government supported all ongoing efforts to create an elaborate digital payment system, which may have strengthened the SSI. Mean digital payment value growth rate in the pre-demonetisation period is higher than that in the post-demonetisation period, probably indicating that though the SSI was strengthened, it could not become strong enough to propel a higher value growth rate. Regression results where the

dependent variable is the growth rate of digital payments in volume terms is presented in Table 9.

Table 9: Estimation results for growth rate - volume

Variable	April 2011 – November 2016		December 2016 – October 2019	
	Coeff	t value	Coeff	t value
CC	-0.00002***	-5.14	-0.00004	-1.63
TD	-0.07855	-0.15	-2.8333	-1.44
CV	.00291	0.91	0.00392*	1.91
PS	4.86e-07	0.04	0.00001*	1.81
Intercept	19.74	0.49	256.33	1.3
Obs	67		35	
Chow test H_0: No structural change, p-value = 0.0858				

Note: ***, **, * implies significant at 1%, 5%, and 10% respectively. Robust standard errors.

We note that the null is rejected at a 10 per cent level in the Chow test, implying a structural break in November 2016. In the pre-period, we find that only CC is negative and significant, which is as per our expectation, i.e. as the currency in circulation increases, the growth rate of digital payment decreases. The remaining variables capturing the cost of digital payments are insignificant. In the post-period, two of the variables capturing the cost of digital payments, CV and PS, are positive and significant. The t-value of CC implies that it is significant at 11.4 per cent, thus not significant at the conventional levels. However, it is plausible that CC may be harmful and significant in a more extended post-demonetisation data set. Coupled with Table 8, this implies that the performance of the SSI has improved in the post-demonetisation. This is understandable as, during the post-demonetisation period, the government supported the activities of the SSI by announcing several incentives to use digital payments. For example, the government made the oil marketing companies (OMCs) bear the MDR for transactions at petrol pumps. The government also asked the OMCs to give a 0.75 per cent discount on card payments for fuel purchases. As a result, the post-demonetisation monthly share of digital payments for fuel purchases at petrol pumps doubled to 40 per cent. Though the discount for credit card payments was stopped in October 2019, it continues for debit cards and other digital modes of payment. It is estimated that the OMCs outgo towards these announcements was Rs. 1,431 crore in 2017-18 and Rs. 2,000 crore in 2018-19[7].

Demonetisation did give a fillip to the volume of digital payments in the very short run; however, as the currency in circulation returned to normal levels, it was the strengthening of the SSI for digital payments that propelled the growth rate of the volume of digital payments and accounted for the observed structural break in November 2016.

Regression results where the dependent variable is the growth rate of digital payments in value terms can be seen from Table 10.

[7] https://economictimes.indiatimes.com/industry/energy/oil-gas/no-more-discounts-on-credit-card-payment-at-petrol-pumps/articleshow/71294152.cms?from=mdr (accessed on December 1, 2021).

Table 10: Estimation results for growth rate - value

Variable	April 2011 – November 2016		December 2016 – October 2019	
	Coeff	t value	Coeff	t value
CC	-0.00001	-1.12	0.0000054	0.17
TD	-1.0556	-0.67	1.75	0.82
CV	0.0082	0.82	0.0003	0.06
PS	-0.00003	-0.66	-0.000003	-0.29
Intercept	93.76	0.77	-157.76	-0.8
Obs	67		35	
Chow test H_0: No structural change, p-value = 0.9418				

Note: ***, **, * implies significant at 1%, 5%, and 10% respectively. Robust standard errors.

We can see that none of the independent variables significantly impact the value growth rate. As Table 4 showed, in 2016-17, RTGS and NEFT accounted for about 98 per cent of the value of digital payments, while in 2020-21, this share came down to around 92 per cent. RTGS transfers are high-value transfers; it is logical to expect that accessing cash will be very costly compared to transferring by digital means. From a definitional point of view, the definition of currency in circulation[8] clarifies that RTGS and NEFT and the value growth of digital payments will be unaffected by it. Similarly, the underlying platform or technology on which RTGS and NEFT operate has minimal overlap with TD, CV, and PS. Hence, the negligible impact of these independent variables on the value growth rate is understandable. This also sets us up for the expectation of no structural change in November 2016 for the value growth rate, which implies that the SSI has work to do to shift the trend of value growth rate. While discussing Table 4, we brought out that though the volume share of other platforms or technologies has increased exponentially, the rise in their value share has been gradual. Based on our above analysis, we would like to argue that the strengthening of the SSI after demonetisation resulted in a change only in the trend path of volume growth rate but could not influence the value growth rate. In other words, the sufficient supply-side push, or focus on two building blocks of SSI, i.e. Actors and institutions; and the Technology/Knowledge domain, changed only the trend path of volume growth. The gradual rise in value share of other platforms or technologies has been due to a lack of focus on the third important pillar of the SSI, i.e. demand. If demand had been given equal importance, then the increase in the value share of these other technologies could have been drastic. However, as we have seen previously, the growth of per capita real GDP has been declining from 2016-to 17, indicating that this critical pillar of the SSI requires attention. Thus, the policy should focus on strengthening demand, which will drive the diffusion of digital payments in the future.

[8] https://m.rbi.org.in/scripts/PublicationsView.aspx?id=9455 for the definition of currency in circulation (accessed on February 8, 2022).

7. Conclusions

The diffusion of any innovation is an ongoing phenomenon. The diffusion of innovations in digital payments is bound to increase in the future, given the strong policy thrust and the possibility of the economy growing faster. The temporary shocks of demonetisation and the pandemic have not helped hasten the diffusion process, thus supporting the results of the existing literature. While demonstrated success has been achieved in those building blocks which encourage the supply of digital payments, those affecting the demand has overtaken the supply side building blocks- resulting in only the volume of digital transactions and not the value of such transactions increasing. This is thus an instance where the impact of the level of economic activity dominates the technological substitution effect- one could see this in the diffusion of other digital technologies - a fertile area for further empirical research. Government policies must strengthen all three building blocks of a sectoral innovation system, especially the demand. Only then the innovation will diffuse widely.

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Annexure 1: Definitional changes in digital payments by RBI

This note provides the three definitions of digital payments used in this paper.

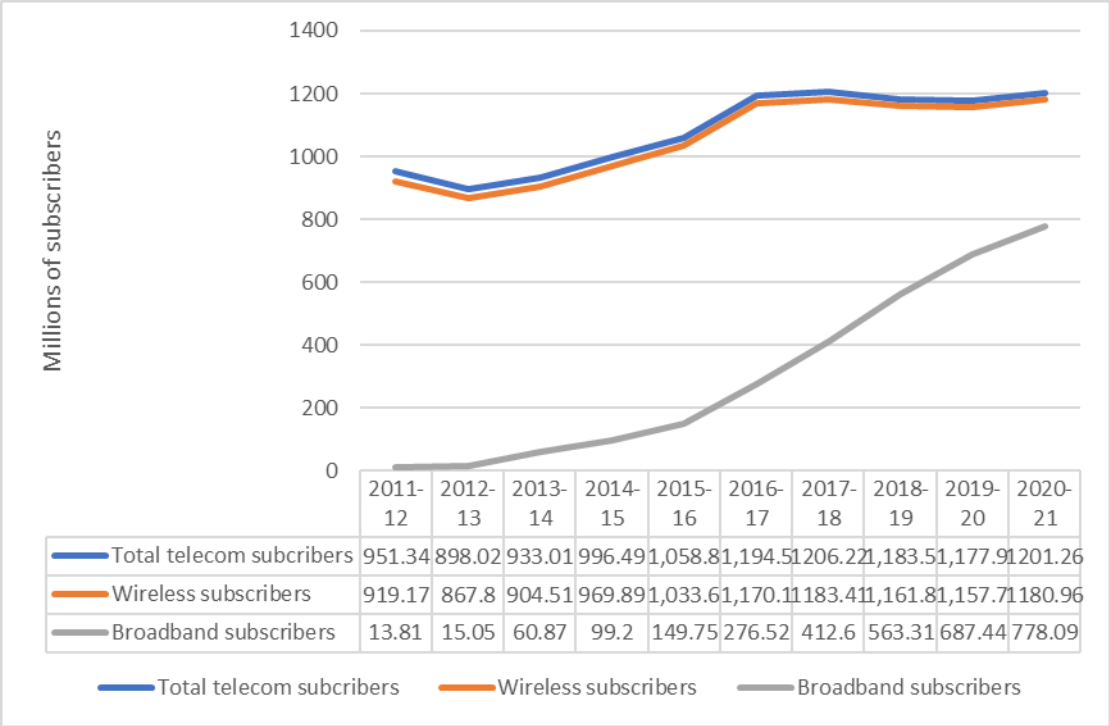
1) Old definition of digital payment: As per this definition digital payment is the sum of RTGS (Customer & Interbank transactions only), CCIL Operated Systems, Paper Clearing, Retail Electronic Clearing, Cards, and Pre paid instruments. RBI has provided data using this definition till 2016-17
2) New definition of digital payment: As per this definition digital payment is the sum of RTGS Credit transfers, Retail Credit transfers, Debit transfers & direct debits, Card Payments, and Pre paid instruments.

The above two definitions have been used in Figures 1 and 3

3) Definition of monthly digital payment used in regression analysis: Here we have defined digital payment as the sum of RTGS, Retail Electronic clearing, Card usage at PoS, Pre paid instruments, and Mobile Banking.

Old definition (2010-11 till 2016-17)	RTGS + CCIL Operated Systems + Paper Clearing + Retail Electronic Clearing + Cards + PPI
New definition (2017-18 till 2020-21)	RTGS+ Retail credit transfers (AePS+ ABPS+ECS+IMPS+NACH+NEFT+UP)+ Debit transfers (BHIM Aadhar Pay+ECS+NACH+NETC)+Card payments+ PPI
Regression Analysis (Apr 2011- Oct 2019)	RTGS + Retail Electronic clearing + Card usage at PoS + PPI + Mobile Banking

Annexure 2: Trends in the number of telecom, mobile phone and broadband subscribers (in millions)



Source: Telecom Regulatory Authority of India (various issues)

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