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Digitisation as a Contingent Factor in India's Financial Sector Development-growth Nexus: An Empirical Study

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Financial sector development (FSD) has been recognised as a supportive factor, acting as a shift variable in the growth function, besides the fundamental variables of capital stock and labour. Since the beginning of the new millennium, rapid strides in the spread of information and communication technology (ICT) have enabled the hitherto reluctant, urban-based banking institutions to reach the rural masses for mobilising savings. Digitisation through various innovations has made it possible that 'brick and mortar less' bank branches now increasingly provide financial services to rural India. This study examines the role of digitisation as a contingent factor in India's FSD and growth nexus during the last 13 years (2003–2015). The findings of the empirical study through employment of ARDL methodology and application of bounds testing procedure by utilising 52 quarterly observations of the data series of relevant variables reveal that digitisation has indeed emerged a significant factor in the FSD and growth nexus, by playing a complementary role to FSD. There are two policy implications: (a) as ICT has emerged a major tool, it has to be supported at all levels, and (b) the financial inclusion process should be carried forward as it has all the potential to speed up economic growth and development.

Keywords: *India, Financial Sector Development, ICT, Economic Growth*
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1. Introduction

Empirical studies over the last two decades have established that financial sector development (FSD) is an important factor for economic growth besides the existing capital stock and labour. The degree of FSD is represented by financial deepening that is often reflected in the financialisation of savings through the spread of financial institutions led by commercial banks, savings and loan institutions, and others. All of them act as intermediaries between savers and investors for mobilising savings and investing them.

Mobilisation of savings has never been easy in developing economies, because financial institutions, which ware mostly urban based, are seen reluctant to go into rural areas on the grounds of diseconomies. However, recent advances in information and communication technology (ICT) along with the spread of mobile phones and internet services have altered the global scenario. The introduction of ICT in developing economies including India, since the late 1990s helped the spread of access to mobile voice and data networks across villages and towns, resulting in innovations across many spheres ranging from labour productivity and improvements in entrepreneurship skills to innovations in business practices and service delivery. One of the most visible areas of improvements is the enhanced access to financial services such as mobile money, micro insurance and micro venture capital. All these unlocked the entrepreneurial potential of the unbanked sections of the population through a reduction in transaction costs.

Although India has been lagging behind in the formalisation of its economy compared to other similarly placed countries in the lower-middle income group[1] (World Bank, 2017a, 2017b), Kumar and Radcliffe (2015) note that the impact of initiatives in recent years has been considerable. One striking example is the period of cash crunch the economy went through consequent to demonetisation decision in November 2016; the adverse effects of cash crisis were minimal[2] in some states of India, which had recorded major progress in digitalisation since the mid-2000s since most payments were settled in mobile money.

In regard to FSD, India among the South Asian economies has made considerable progress since its economic reforms in the 1990s. This study seeks to assess the impact of FSD supported by ICT, as a contingent factor on

[1] The *2014 Intermedia Financial Inclusion Insight Survey (IFIIS)* of 45,000 Indian adults, which was conducted by the Consultative Group to Assist the Poor (CGAP), found that 0.3 per cent of adults use mobile money, compared to 76 per cent in Kenya, 48 per cent in Tanzania, 43 per cent in Uganda and 22 per cent in Bangladesh.

[2] Success stories were reported in the Indian newspapers and in social media. These include: Ghosh (2017) and *Hindustan Times* (2016).

economic growth in India. Specifically, the focus is on investigation whether FSD and ICT are complements to each other or substitutes. The article is organised along the following lines: the next section undertakes a brief literature review of the current financial inclusion efforts though the spread of ICT. The third section reviews the trends in FSD and ICT development. The fourth section deals with the modeling and methodology. The fifth section presents the empirical results of the econometric analysis; and the sixth and final section is a summary, drawing some conclusion and policy implications.

2. Review of Literature

An extensive body of literature on FSD and growth nexus is now available, covering the pioneering theoretical studies by Gurley and Shaw (1955), Patrick (1966) and McKinnon (1973) and as well as empirical studies over 35 years from 1960 to 1995 (Jayaraman, 1996). In addition, developments at the beginning of the new millennium and results from empirical studies are also available in Beck, Levine, and Loayza (2000) and Demirgüç-Kunt and Levine (2009). To recapitulate, financial sector institutions led by commercial banks act as intermediaries between savers and investors, mobilising savings and lending to prospective investors and channelising resources into economic activities through: (a) technical and financial appraisal of projects in regard to their viability, (b) supply of information ex ante on possible alternate investments and capital allocation, (c) regular periodical supervision of projects once loans are sanctioned, by checking that loan proceeds are used for the purpose they are meant and (d) enabling the diversification and management of risk (Beck, Levine, & Loayza, 2000; Demirgüç-Kunt & Levine, 2009).

Furthermore, recent developments on financial inclusion and the spread of ICT to strengthen FSD, have come to occupy a central place in the economic growth literature.[3] Various empirical studies on ICT and its effects on FSD in several economies have been undertaken over the years. Wilson (1993), Radecki, Wenninger, and Orlow (1997) and Freund, König, and Roth (1997) have stressed the beneficial impact of ICT on banks and financial markets. The industry-level research studies of the 1990s by Wilson (1993) and Jordan and Katz (1999) indicate the positive correlations between ICT investment and bank

[3] Unlike the government, which can raise financial resources through taxes, along with borrowing powers from the central bank amounting to printing money to fund productive activities, the private sector can only save for investment or borrow from institutions that act as intermediaries between savers and investors (Killick, 1993).

efficiency. On the other hand, studies by Strassman (1990) and Dos Santos, Peffers, & Mauer (1993) reveal that additional investment in ICT does not necessarily contribute positively to bank efficiency and productivity, arguing that the calculated marginal benefits are less than the marginal cost.

Recent studies have pointed out that ICT has become an important feature in the development of financial sector in developing countries, notably a study by IMF staff (Andrianaivo & Kpodar, 2011) on African economies that focused on a sample of 44 countries for period of 20 years (1988–2007). By employing rigorous econometric methodology, they examined the impact of mobile phone use on financial inclusion as one of the channels through which ICT influences economic growth. They utilised a wide range of ICT indicators, including the mobile and fixed telephone penetration rates and the cost of local calls. Financial inclusion was captured by variables measuring access to financial services, such as the number of deposits or loans per head. The results confirm that ICT development impacts economic growth in African countries, partly through financial inclusion; at the same time, the use of mobile phones consolidates the impact of financial inclusion on economic growth, especially in countries where ICT services take hold.

3. Review of Trends in FSD, ICT and Financial Inclusion in India

The growth of India's commercial banks is well reflected in the rapid growth of deposits and credit disbursed (Table 1). Their deposits increased from 41.3 per cent of GDP in 1999–2000 to 69.5 per cent in 2015–2016; whereas advances have grown from 20.5 per cent of GDP to 54.4 per cent in the corresponding period.

The effects of ICT on the banking sector in India began to be felt only from the 2000s, although the spread of mobile technology globally began in the 1990s. Progress was not quick as it could be (Table 2) and picked up only by the mid-2000s. The number of cell phones rose rapidly and the teledensity (mobile subscribers per 100) reached 79 per 100 of the population by 2015–2016. However, the number of internet users for every 100 persons was only around 26 in 2015–2016.

In tandem, government-sponsored schemes to promote financial inclusion,[4] supported by the spread of mobile technology, has given a big push to the spread of banking habits. Table 3 provides an annual series of variables used in the

[4] The official definition of financial inclusion is a 'process of ensuring access to financial services, and timely and adequate credit where needed, by vulnerable groups, such as weaker sections and low-income groups, at an affordable cost' (Government of India, 2008).

Table 1 India's Financial Markets and Institutions, 2001–2017

Institutions	*Fiscal Years*							
Commercial banks	*2001–2006 (Average)*	*2006–2011 (Average)*	*2011–2012*	*2012–2013*	*2013–2014*	*2014–2015*	*2015–2016*	*2016–2017*
Public sector banks	27	28	28	28	26	27	27	27
Private sector banks	29	21	20	20	20	20	20	21
Foreign banks	0	31	34	41	43	43	44	45
Non-bank finance companies (NBFCs)								
NBFCs	735	341	297	271	254	240	220	202
Residuary non-banking finance companies (RNBFCs)	4	2	2	2	2	2	2	1
Insurance companies								
Life	11	21	23	24	24	24	24	24
Non-life	12	22	25	27	27	28	28	29
Re-insurers	1	1	1	1	1	1	1	1
Pension fund	1	1	1	1	1	1	1	1

Source: Reserve Bank of India (RBI) Database on the Indian Economy (2017) and Mohan and Ray (2017).

Notes: (a) NBFCs include deposit-taking NBFCs (NBFCs-D), mutual benefit financial companies and mutual benefit companies, (b) RNBFCs is a group of NBFCs, whose principal business is of receiving deposits.

Table 2 Financial Inclusion Indicators: World, South Asia and India (Percentages)

Categories	*World*	*South Asia*	*India*
Bank Accounts (2015)			
All	61.5	46.4	53.1
Women	58.1	37.4	43.1
Financial institution account			
Adults			
2015	60.7	45.5	52.8
2011	50.6	32.3	35.2
Mobile account			
2015	2.0	2.6	2.4
Access to a financial account			
Has debit card			
2015	40.1	18.6	22.1
2011	30.5	7.2	8.4
ATM as the main mode of withdrawal with account (%)			
2015	NA	31.1	33.1
2011	48.1	16.9	18.4
Use of accounts in the past year 2015			
To receive wages	17.7	3.5	4.0
To receive government transfers	8.2	3.1	3.6
To pay utility bills	16.7	2.7	3.4
Other digital payments: 2015			
Use of debit card	23.2	8.5	10.7
Use of credit card	15.1	2.6	3.4
Use of internet	16.6	1.2	1.2
Received remittances: 2015			
Via financial institutions	NA	15.8	15.8
Via mobile phones	NA	4.7	4.7
Via money operators	NA	9.8	9.8

Source: World Bank (2017b).
Note: The data relates to people over the age of 15 years.

empirical analysis of India's FSD, digitisation and growth nexus. As observed the broad money (comprising demand deposits and quasi money including saving deposits of varying periods of maturity) as a percentage of GDP also rose to a new high at above 79 per cent.

Table 3 Summary of Data Series Used in the Analysis

Year	*Y*	*K*	*BM*	*MS*
2003–2004	886	7,873	62.1	3.1
2004–2005	941	8,376	63.5	4.7
2005–2006	1,012	8,992	64.5	8.0
2006–2007	1,089	9,700	67.4	14.5
2007–2008	1,165	10,524	71.0	20.2
2008–2009	1,193	11,330	75.8	29.5
2009–2010	1,276	12,193	77.7	44.1
2010–2011	1388	13,160	76.2	62.4
2011–2012	1,460	14,255	78.8	73.2
2012–2013	1,523	15,215	76.9	69.9
2013–2014	1,604	16,261	77.9	70.8
2014–2015	1,699	17,130	77.8	74.5
2015–2016	1,806	18,640	79.2	78.8

Source: The authors.

Note: Y is per capita GDP in constant US$; K is per capita capital stock in constant US$; BM is broad money as a percentage of GDP; and MS is cellular subscription per 100 inhabitants.

4. Modeling, Data and Methodology

This section outlines the data series utilised, model employed and the estimation methodology applied to examine the impact of: (a) FSD on per capita real gross domestic product (RGDP) and (b) spread of ICT on per capita RGDP. The econometric analysis was undertaken using autoregressive distributed-lag (ARDL) estimation methodology and applying the bounds testing procedure.

Data: Consistent data on the spread of ICT in terms of the rise in the use of mobile phones and the internet was available only from 2003 to 2004 onwards. Although we have data for earlier than 2003–2004 on per capita real GDP and FSD, the data series on capital stock is available only up to 2014–2015. Hence, we are constrained to limit our study to the 13 years, from 2003–2004 to 2014–2015.

While we utilise the data series of India' capital stock in constant prices from the US Federal Reserve St Louis data resources, the other data series are sourced from *World Development Indicators* (World Bank, 2017). As the number of annual observations is not sufficient, they are split into quarterly observations through the cubic spline procedure, to yield a total of 52 quarterly observations.[5]

[5] The cubic spline interpolation procedure, recognised as a robust method of disaggregating annual data to quarterly series (Ajao, Ibrahim, & Ayoola, 2012), is amongst various procedures that have been

4.1 Model

Our choice of model is a Cobb-Douglas production function (which was employed by Luintel, Khan, Arestis, & Konstantinos [2008] and Rao, Tamazian, Singh, & Vadlamannati [2008]) with constant returns and Hicks—neutral technical progress.

$$y_t = A_t k_t^{\alpha} 0 < \alpha < 1 \quad (1)$$

Where:
y = per capita output;
A = stock of technology;
k = capital stock per capita;
α = share of capital.
The evolution of technology is given by:

$$A_t = A_o e^{gT} \quad (2)$$

where A_o is the initial stock of technology and T is time.

Since our objective is to study the role of FSD and ICT in promoting per capita output (y) growth, we considered various proxies for FSD: broad money as a percentage of GDP (BM), quasi-money (savings and time deposits) as a percentage of GDP (QM) and bank credit to the private sector as a percentage of GDP (PSC). Similarly, for ICT we use the number of cellular mobile subscriptions (MS) per 100 people, internet usage (IU) and number of cellular mobile phones (CN).

We chose broad money (BM) as a percentage of GDP to represent FSD. Furthermore, in order to capture the interaction between FSD and ICT, we used an interaction term, which is the product of broad money and mobile cellular subscription ($BM \times MS$).

We assume that the stock of technology can be decomposed as:

$$A_t = f(BM_t, MS_t, BM * MS_t) \quad (3)$$

Where:
BM = broad money as a percentage of GDP
MS = mobile cellular subscriptions per 100
$BM \times MS$ = the interaction term

We enter *BM*, *MS and BM×MS* as shift variables into the production function,

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widely applied in empirical studies. The procedure was found by various researchers to be free of any bias (Baharumshah, Lau, & Khalid, 2006; Smith, 1998; Tang, 2008).

noting that capital stock per capita is the fundamental and conditioning variable, explaining output per capita.

The Cobb-Douglas production model is further modified as:

$$A_t = A_0 e^{g^T} BM_t^{\beta}, MS_t^{\lambda}, BM_t * MS_t^{\gamma} \tag{4}$$

and

$$y_t = \left(A_0 e^{g^T} BM_t^{\beta}, MS_t^{\lambda}, BM_t * MS_t^{\gamma}\right) k_t^{\alpha} \tag{5}$$

For the purpose of econometric estimation, the above model is transformed into logs and written as:

$$\ln y_t = \alpha_0 + \alpha_1 \ln k_t + \alpha_2 \ln BM_t + \alpha_3 \ln MS_t + \alpha_4 \ln BM * \ln MS_t + e_t \tag{6}$$

Where:

ln$y$ = natural logarithm of per capita GDP (in US$ constant 2010 prices)

ln$k$ = natural logarithm of real capital stock per capita (in US dollars in 2005 prices)

lnBM = natural logarithm of broad money as a percentage of GDP

lnMS = natural logarithm of mobile cellular subscriptions

lnBM×lnMS = natural logarithm of the interaction of broad money and mobile subscriptions

e_t = random error term

There are three hypotheses to be tested: (a) ln$k$ is directly associated with ln$y$, (b) lnBM positively influences ln$y$ and (c) lnMS *is* positively connected with ln$y$. There is no a priori conclusion about the interaction term of lnBM×lnMS, since we are not sure how the interaction term would behave. If lnBM and lnMS are complements and mutually support growth, the sign of the interaction term would be positive and significant; on the other hand, if the sign is negative and significant, the interpretation would be that lnBM and lnMS are substitutes in promoting growth; and if the coefficient of lnBM×lnMS is not found to be significant, two are independent in their contribution to output growth.

4.2 Methodology

To examine the existence of a long-run relationship between the logs of y, k, BM and MS and the log of the interactive term (BM×MS), we resort to the bounds testing procedure proposed by Pesaran, Shin, and Smith (2001). The bound testing procedure with an ARDL framework has some advantages: (a) it allows testing for the existence of a cointegrating relationship between variables whether the underlying regressors are I(0) or I(1) (Pesaran & Shin, 1999; Pesaran et al., 2001), (b) it is considered more appropriate than the Johansen-Juselius multivariate approach for testing the long-run relationship amongst variables when the sample size is small (Mah, 2000; Tang & Nair, 2002), (c) estimators of the short-run parameters are consistent and the estimators of long-run parameters are super-consistent in small sample sizes (Pesaran & Shin, 1999). Therefore, the ARDL model has become increasingly popular in recent years. Accordingly, we begin the empirical analysis with this procedure.

Given that we do not have prior evidence on the course of long-run cointegration among per capita GDP (*y*), FSD and ICT, we formulate the following unrestricted error correction model equations in the ARDL framework:

$$\begin{aligned}\Delta \ln y_t = {} & c_0 + \beta_1 (\ln y)_{t-1} + \beta_2 (\ln k)_{t-1} + \beta_3 (\ln BM)_{t-1} \\ & + \beta_4 (\ln MS)_{t-1} + \beta_5 (\ln BM * MS)_{t-1} \\ & \sum_{i=1}^{n} \beta_6 \Delta (\ln y)_{t-1} + \sum_{i=1}^{n} \beta_7 \Delta (\ln k)_{t-1} + \sum_{i=1}^{n} \beta_8 \Delta (\ln BM)_{t-1} \\ & + \sum_{i=1}^{n} \beta_9 \Delta (\ln MS)_{t-1} + \sum_{i=1}^{n} \beta_{10} \Delta (\ln BM * MS)_{t-1} + \varepsilon_t\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta \ln k_t = {} & c_0 + \alpha_1 (\ln y)_{t-1} + \beta_2 (\ln k)_{t-1} + \alpha_3 (\ln BM)_{t-1} \\ & + \alpha_4 (\ln MS)_{t-1} + \alpha_5 (\ln BM * MS)_{t-1} \\ & \sum_{i=1}^{n} \alpha_6 \Delta (\ln y)_{t-1} + \sum_{i=1}^{n} \alpha_7 \Delta (\ln k)_{t-1} + \sum_{i=1}^{n} \alpha_8 \Delta (\ln BM)_{t-1} \\ & + \sum_{i=1}^{n} \alpha_9 \Delta (\ln MS)_{t-1} + \sum_{i=1}^{n} \alpha_{10} \Delta (\ln BM * MS)_{t-1} + \varepsilon_t\end{aligned} \tag{8}$$

$$\begin{aligned}\Delta \ln BM_t = {} & c_0 + \lambda_1 (\ln y)_{t-1} + \lambda_2 (\ln k)_{t-1} + \lambda_3 (\ln BM)_{t-1} \\ & + \lambda_4 (\ln MS)_{t-1} + \lambda_5 (\ln BM * MS)_{t-1} \\ & \sum_{i=1}^{n} \lambda_6 \Delta (\ln y)_{t-1} + \sum_{i=1}^{n} \lambda_7 \Delta (\ln k)_{t-1} + \sum_{i=1}^{n} \lambda_8 \Delta (\ln BM)_{t-1} \\ & + \sum_{i=1}^{n} \lambda_9 \Delta (\ln MS)_{t-1} + \sum_{i=1}^{n} \lambda_{10} \Delta (\ln BM * MS)_{t-1} + \varepsilon_t\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta \ln MS_t = {} & c_0 + \alpha_1 (\ln y)_{t-1} + \alpha_2 (\ln k)_{t-1} + \alpha_3 (\ln BM)_{t-1} \\ & + \alpha_4 (\ln MS)_{t-1} + \alpha_5 (\ln BM * MS)_{t-1} \\ & \sum_{i=1}^{n} \alpha_6 \Delta (\ln y)_{t-1} + \sum_{i=1}^{n} \alpha_7 \Delta (\ln k)_{t-1} + \sum_{i=1}^{n} \alpha_8 \Delta (\ln BM)_{t-1} \\ & + \sum_{i=1}^{n} \alpha_9 \Delta (\ln MS)_{t-1} + \sum_{i=1}^{n} \alpha_{10} \Delta (\ln BM * MS)_{t-1} + \varepsilon_t \end{aligned} \quad (10)$$

There are two steps involved in the procedure for examining the long-run relationship between the logs of y, k, BM, MS and $BM \times MS$. First, we estimate Equations (7)–(10) by ordinary least squares techniques. Second, the existence of a long-run relationship can be traced by imposing a restriction on all the estimated coefficients of the lagged level variables equating to 0. Hence, the bounds test is based on the F-statistics (or Wald statistics) with the null hypothesis of no cointegration ($H_0 : \beta_{i1} = \beta_{i2} = \beta_{i3} = \beta_{i4} = \beta_{i5} = 0$) against its alternative hypothesis of a long-run cointegration relationship ($H_1 : \beta_{i1} \neq \beta_{i2} \neq \beta_{i3} \neq \beta_{i4} \neq \beta_{i5} \neq 0$).

Since the F-statistics used for this test have a non-standard asymptotic distribution, Pesaran et al. (2001) have generated two different sets of critical values for given significance levels. The first set assumes that all variable are integrated of order zero, I(0) and the second set assumes all variables are integrated of order one, I(1). If the computed F-statistic is greater than the upper critical bounds value, then the null hypothesis is rejected. In contrast, if the computed F-statistic is smaller than lower critical bounds value, it indicates that there is no long-run relationship between variables. If the computed F-statistic lies between lower and upper bounds values, then the test becomes inconclusive. Next, we examine the ARDL model with several diagnostic tests and obtain the long-run estimates of independent variables.

However, before we undertake an empirical analysis, potential non-stationary concerns of the variables are investigated. We use the Augment Dickey Fuller (ADF) test to examine the time series properties of individual series and calculate the unit root statistics. We also resort to a final test to ensure there is no Granger causality at least in one direction in the long run, in case the bound test reveals a cointegrating relationship between the variables. The Granger causality test results are expected to examine the short-run and the long-run Granger causality within the error correction mechanism (ECM).

5. Results and Discussion

In the ARDL approach, the series can be either I(1), I(0) or a mixture of both. However, to avoid spurious regression results, we conducted a unit root test to ensure that variables are stationary and their integration order is not more than one, in order to apply the ARDL procedure (Makun, 2018). The likely non-stationary concern was addressed using the ADF test. The ADF unit-root test was applied on two sets, that is, constant and constant with a time trend. The findings (Table 4) indicate that all the variables were stationary in their first difference form.

The calculated F-statistics (F-statistics = 11.01) for Equation (7), with per capita output as the dependent variable, is found to be higher than the upper band critical value of 5.06 at the 1 per cent significance level (Table 5). This confirms that there is a long-run equilibrium relationship between the dependent and independent variables. On the other hand, the *F*-test statistics for the other equations with different dependent variables are either far below the lower bound value or in-between the lower and upper bound critical values. Thus, we have only one cointegration equation when per capita output is the dependent variable.

Next, we examine the long-run effect of FSD, ICT and their interactive term on per capita real GDP. The long-run estimates of these independent variables are provided in Table 6.

Table 4 Unit Root Test Results

Augmented Dickey Fuller Test					
	In Level		*In First Difference*		
Variables	*Constant*	*Constant with Trend*	*Constant*	*Constant with Trend*	*Conclusion*
$\ln y_t$	2.224	–1.086	–4.332*	–3.916**	I(1)
$\ln k_t$	2.933	1.250	–3.534**	–5.479*	I(1)
$\ln BM_t$	–1.389	–3.149	–6.848*	–7.967*	I(1)
$\ln MS_t$	–0.246	–2.407	–5.152*	–5.410*	I(1)
$\ln BM*MS_t$	0.110	–2.503	–4.501*	–4.948*	I(1)
ε_t	–5.247*	–5.254*	–12.049*	–11.946*	I(1)

Source: The authors.

Note: * and ** represent significance at the 1% and 5% levels, respectively. The critical value of the constant is –3.65 at 1%. A critical value for the constant with trend is –4.26 at the 1% level. The lag length based on the Schwarz information criterion is 2. ε_t is the residual from the unrestricted regression.

Table 5 Results of the Bounds *F*-Tests

Dependent Variable	Calculated *f*-statistic	
ln*y*	11.01*	
ln*k*	2.57	
ln*BM*	1.72	
ln*MS*	2.31	
ln*BM*×ln*MS*)	3.80	
Pesaran et al. (2001)[a]		
	Critical Values	
Significance Level (%)	*Lower Band*	*Upper Band*
1	3.74	5.06
5	2.88	4.01
10	2.45	3.52

Source: The authors.
Notes: [a] Critical values are obtained from Pesaran et al. (2001), Table CI (iii) Case III: Unrestricted intercept and no trend, p. 300. * represents significance level at 1 %.

Table 6 Long-run Coefficients

Dependent Variable is lny			
Variable	*Coefficient*	*T-Ratio*	*p-value*
$\ln k_t$	0.346	2.589	0.014**
$\ln BM_t$	0.291	9.097	0.000*
$\ln MS_t$	0.025	2.915	0.006*
$\ln BM{*}\ln MS)_t$	0.072	4.598	0.000*
Constant	4.605	4.020	0.000*
Time trend	0.006	2.744	0.009

Source: The authors.
Note: * and ** represent significance at the 1% and 5% respectively.

In the long run, the effect of capital (k) is found to be positive ($k = 0.346$) and statistically significant at the 5 per cent level. This implies that the share of capital stock in total output is 35 per cent, with the labour share being 65 per cent in the long run, which is the finding in similar empirical studies on developing economies (Rao, 2010; Rao et al., 2008). The effect of broad money is found to be positive. This is also in accordance with theoretical expectations. The increase in financial deepening leads to higher economic output. The findings are similar to King and Levine (1993) and Levine et al. (2000).

Furthermore, the long-run effect of log MS is positive and significant statistically at the 5 per cent level and increases per capita output by about 0.025 per cent in the long run. Although the contribution of ICT appeared to be relatively small, given India's progress in ICT, it is likely to play a predominant role in the economy as indicated by the positive time trend.

We also examine the effect of FSD and ICT as an interactive term. The results show that the interactive term is positive and statistically significant at the 1 per cent level, indicating that FSD and ICT mutually enhances economic output.

5.1 Granger Causality

The existence of a cointegrating relationship among the logs of per capita real GDP, FSD, ICT and the interactive FSD and ICT term suggests that there must be Granger causality at least in one direction, although it does not indicate the direction of temporal causality among the variables. Table 7 examines the Granger causality within the ECM. The estimated coefficient of the error correction term is negative and statistically significant at the 1 per cent level for Equation (7), with per capita real GDP as the dependent variable. The significant error correction term is an indication of long-run causality (Granger et al., 2000), in this case running from FSD, ICT and the interactive term of FSD and ICT to per capita real GDP.

In the remaining Equations (8)–(10), none of their error correction terms is found to be statistically significant, indicating the absence of evidence of any long-run causality running from the relevant variables to FSD and ICT.

Table 7 Granger Causality Tests

Dependent	*F-statistics*					*ECT*
Variable	*Δlny*	*Δlnk*	*ΔlnBM*	*ΔlnMS*	*ΔLnBM*lnMS*	*(t-statistics)*
Δln*y*	–	0.325*	0.276*	0.034*	0.022**	–0.216 (–8.253)
Δln*k*	3.346**	–	7.833*	6.677*	6.014*	–0.154 (–1.448)
Δln*BM*	5.848**	1.508	–	1.260	0.726	–0.169 (–1.595)
Δln*MS*	3.036	2.932	6.050*	–	4.933**	–0.024 (–2.743)
Δln*BM**MS*	2.261	1.733	3.217**	4.987*	–	–0.0705 (–2.094)

Source: The authors.

Note: * and ** represent significance at the 1% and 5% respectively.

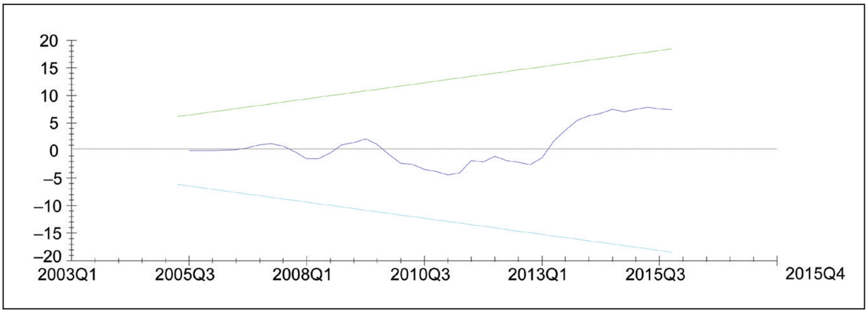
Thus, we have only one long-run causality link connecting FSD and ICT to real economic output, which also confirms the result of only one cointegration equation, obtained from the bounds *F*-test procedure.

On the basis of significant *F*-values, there is a short-run causal relationship as well, running from all the aforesaid variables to per capita real GDP. We find evidence of causality running from per capita real GDP, FSD, ICT and the interactive of FSD and ICT to capital stock per capita, indicating a bi-directional relationship between per capita out and capital stock per capita. We also note a bi-directional causality between per capita real GDP and broad money. Moreover, we note a unidirectional causation from broad money to ICT at the one per cent significance level.

We also examined several diagnostic tests from estimates of the ARDL regressions results. The stability test designed by H. M. Pesaran and B. Pesaran (1997) for parameter instability suggests using the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMQ) test proposed by Brown et al. (1975) to evaluate coefficient constancy. Accordingly, models were estimated and residuals were subjected to the CUSUM and CUSUMQ test. Figures 1 and 2 show the plots of CUSUM and CUSUMQ statistics, when per capita GDP is the dependent variable. The results indicate the absence of instability in the coefficient as the CUSUM and CUSUMQ statistics are within the 5 per cent critical bounds of parameter stability.

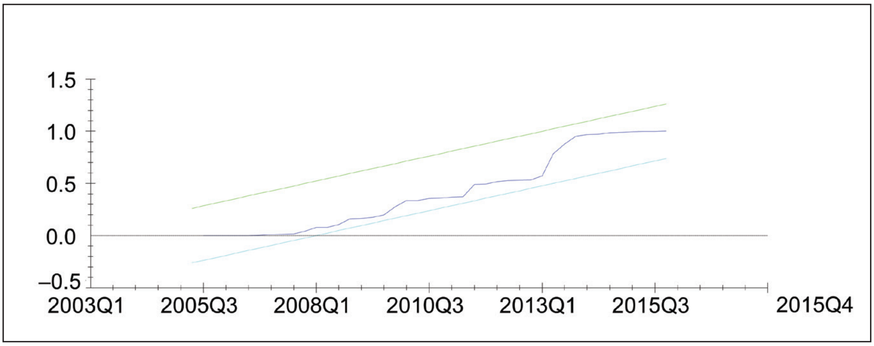
Table 8 presents the results of other diagnostics checks conducted to assess the overall reliability of the estimated model. The outcome of these diagnostic checks indicated that the model did not suffer from severe econometric problems. The LM test indicated that the null hypothesis of no serial correlation cannot be rejected. The Ramsey and Jarque-Bera check for model specification and normality showed that the specification was correct and the errors were normally

Figure 1 Plot of the CUSUM Test



Source: The authors.

Figure 2 Plot of the CUSUMQ Test



Source: The authors.

Table 8 Diagnostic Test Results

Diagnostic Test	*Null Hypothesis*	*Statistics*	*Decision*
Breusch-Godfrey serial correlation LM test	No Serial correlation	F(1) = 17.815 (0.053)	Do not reject H_0
Ramsey RESET test	Model is correctly specified	F(1) = 0.088 (0.766)	Do not reject H_0
Jarque-Bera test	Normality of error term	X^2 = 0.386 (0.824)	Do not reject H_0
ARCH test	Homoskedasticity	F(1) = 0.177 (0.674)	Do not reject H_0

Source: The authors.
Note: Figures in parentheses are *p*-values. *R*-square is 0.96 and the DW statistics is 1.82.

distributed. Furthermore, the autoregressive conditional heteroskedasticity (ARCH) test indicated that the regressors were independent and errors were homoskedastic. Thus, the ARDL model was found to be reliable.

5.2 Threshold Level of ICT

From the following long-run equation

$$\begin{aligned} &\ln y_t = 4.605 + 0.345 \ln k_t + 0.291 \ln BM_t + 0.025 \ln MS_t \\ &t = \quad (4.020)\ (2.589) \qquad (9.097) \qquad\qquad (2.915) \\ &+0.072 \ln MB_t * \ln MS_t + 0.006T \\ &(4.598) \qquad\qquad (2.744) \end{aligned},$$

we proceed to derive the threshold level of the ICT variable, namely, mobile cellular subscribers per 100 (MS). As the model is in logs, we use the differential of ln*y* with respect to ln*BM* and interactive term of ln*BM and* ln*MS* and equate its first order derivative to zero to determine the required threshold levels of *BM and MS* that contribute to economic growth. We calculate the threshold level for *MS* as:

$$\Delta \ln y / \ln BM = 0.291 + 0.072 \ln MS$$

From the above, we obtain the natural logarithm of the exponential value: 0.291/0.072 = 4.041667. The exponential value of the natural logarithm will give us the actual percentage that would be the pre-required level of *MS* to enhance economic growth. The threshold level of MS is 56.92 per cent of the population owning and using mobile phones.

The result shows that *FSD* stimulates economic growth in India through ICT development. Therefore, we conclude that FSD (*BM*) and ICT (*MS*) act as complements to each other. Once the threshold level of ICT, represented by mobile cellular subscriptions, is reached, the complementary relationship between the two begins to work and pushes up economic growth. We also observe that the actual, observed percentage is much higher than the calculated threshold in the recent years of the study (increasing from 62.4 per 100 in 2010–2011 rising to 78.8 per 100 in 2015–2016).

6. Conclusion and Policy Implications

In this article, we set out to explore the role of digitisation as a contingent factor in the connection between FSD and growth in India over the fiscal period of 2003/2004–2014/2015. We applied the Cobb-Douglas production model within an extended Solow framework, adopted the ARDL bounds testing approach, and applied Granger causality tests to explore the short-run and long-run effects of FSD and ICT.

The findings showed that FSD, represented by the variable broad money as a percentage of gross domestic output, has a positive and significant effect on per capita output both in the long run and short run. Further, ICT represented by mobile phone subscriptions per 100 is also directly associated with growth and was found to be significant. The interactive term of FSD and ICT emerged to be positive and significant, indicating that they are complements to each other. The impact of per capita capital stock on output per capita was positive and close to the stylised value of one-third obtained in several empirical studies in various developing countries. From the results, we conclude that FSD, when supported by the spread of ICT, emerges as a key driver of economic output.

These results also confirm that FSD with the ICT as a contingent factor has been a major shift variable in the production function.

The full potential of FSD and ICT as a contingent factor in supporting financial inclusion can be realised to a fuller extent only when an enabling environment is provided and nurtured. The challenges facing India at this stage of development lie in certain critical areas: the provision of rural infrastructure, which include roads and bridges linking farms and marketing centres. The latter would lead to a growth in employment opportunities and rising incomes of landholders and wages of the landless agriculture labourers and create a demand for services such as local food processing, eateries and other commercial activities to cater to the local needs as well as the agricultural machinery repair and automobile workshops. These activities will further enhance the growth through forward and backward linkages (Hirschman, 1958). As the activities are cash-intensive and cannot be accommodated by savings from farming incomes, they become credit-intensive, which results in the stepping up of credit flow to all rural enterprises, small and medium.

Besides financial requirements, they need additional support in terms of provision of uninterrupted supply of electricity, which is critical for promoting the use of ICT for bringing the banking facilities closer to entrepreneurs and rural households through reliable internet services and use of mobile phones. On the human resource side, farm-based enterprises would give rise to a demand for local skilled labour, requiring vocational training and technical education, which would reduce the gap in technical skills in rural areas.

Finally, most important is raising the credit-absorptive capacity of rural households. The provision of public services in essential areas of health and education would greatly enhance the credit-absorptive capacity as most of the current rural incomes are spent on these needs. While borrowing for productive activity would be made easier through rural credit programmes, the servicing capacity of rural households lags. If medical and education and other critical services are made available to rural households at reasonable costs, the ongoing financial inclusion efforts would further strengthen the financial sector and growth nexus.

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