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Do Modern Technologies Work for The Rural?
ICT and Rural Credit Institutions in India

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Summary

This paper explores the impact of various forms and levels of ICT on the performance of rural cooperative banks using recent survey data from India. Findings from the research suggest that modern information technology serves to enhance both the efficiency and profitability of the rural credit institutions. Efficiency was significantly enhanced by the usage of moderate technology at the lower organisational level, e.g. stand-alone computers at the branch level, mobile phone usage at PACS (Primary Agricultural Credit Society) and field level. However, profitability appears to be associated with more advanced and sophisticated usage of information technology at branch or lower organisational level. Complementarities in human capital, training in IT skills of the bank staff, absorptive capacity of the customers and community, are of crucial importance for the efficiency of rural cooperative banks. Evidence from this study also suggests that using investment in ICT as a measure of the usage and advancement level of information technology may not reveal the full story of the impact of ICT on the efficiency of organizations.

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I. Introduction

The unprecedented speed of innovation and adaptation of Information and Communication Technologies (ICT) around the world has raised general expectations about their potential contribution to poverty alleviation. Can the ICT-related efficiency gains which have been achieved across different sectors in economically advanced countries be paralleled in developing economies and for the rural? There have been some interesting case studies suggesting that IT allows efficient and transparent storage, processing and communication of information and that entrepreneurial innovation in this field may affect economic and social change (TaraHaat, Kaushik and Singh, 2004). Growth in IT investment is also found to have a significant positive correlation with growth in both GDP and productivity in 12 Asia-Pacific countries for the period from 1984-1990 (Kraemer and Dedrick, 1994). However, despite increasing interest in Information and Communication Technologies (ICTs) for development and in best practice examples in the delivery of e-services[1], empirical evidences on the influence that ICTs have on the performance of development service providers in developing countries is rare. The impact of ICT on business performance in general is a well known topic in the field of business studies and management.[2] These studies have provided useful insights on the impact of ICT on the economic performance of firms. However, again, none of them deal directly with rural institutions for development, especially in service industries[3].

Taking a resource-centred perspective of the firm[4], this paper aims to asses the impact of ICT penetration on the performance of rural credit institutions using recent survey data from India. It contributes to the literature in several aspects as follows. First, it makes a pioneering contribution to the literature on ICT for development through microfinance. As far as we are aware there is no previous empirical research on IT investment and its impact on the performance of cooperative banks in India. This is in part due to the lack of specific data on their IT investments. Second, in contrast to the existing literature that focused on the effect of IT on the economic performance of financial institutions, this paper makes an attempt to take into account the social dimension of the rural cooperative banks and distinguishes different types of loans (for agricultural and non-agricultural purposes) using a non-parametric multi-output Data Envelopment Analysis (DEA) model. The aim is to find out how ICT affects both social and economic business performance of cooperative banks. Finally, and differently from most existing studies in this area which measure information technology using ICT

expenditure, this paper examines the actual usage of information technology in terms of function and different types of technology in addition to the traditional ICT expenditure approach. It distinguishes ICT usage in different aspects of the management and operations of the financial institution.

The main finding from this study on the effects of ICT on the performance of District Central Cooperative Banks (DCCBs) and the lower-tier branches of Primary Agricultural Credit Societies (PACS) in terms of financial profitability and output efficiency are threefold. First, IT expenditure is positively related to profitability in terms of return on equity (at decreasing marginal returns) but has no significant impact on output efficiency. Secondly, positive and significant effects on profitability have been found for the usage of computers at the level of head and branch offices (e.g. branches with network computers have a 36 per cent higher ROE than those without network computers), the usage of Local Area Networks (LAN) at the branch level, and the usage of IT applications in parts of DCCBs. Positive and significant relationships are found between output efficiency and the usage of stand-alone computers at the branch level, mobile phone usage at PACS and field level, ICT support from external organizations, the usage of IT applications and the number of trained staff per year.

The paper is organised as follows. Section 2 will briefly review the literature on the impact of IT on the performance of firms in general and on financial institutions in particular. Section 3 describes the current state and reforms of cooperative banks in rural India and the reasons for plans to introduce performance improvements through ICT. Section 4 discusses the data, methodology and model used in this study. Section 5 presents the empirical results, and section 6 concludes.

II. ICT and firm performance: received wisdom

This section provides a succinct overview of the literature on ICT and firm performance in general and the financial and rural financial sector in particular in order to place the present study into context and establish an appropriate framework for further analysis.

From the vast economic literature on the impact of ICT on business performance five points are particularly relevant for our study. First, measurements of firm performance in studies on the effects of ICT predominantly use traditional economic productivity indicators. In studies on both manufacturing and services, prominent measures include labor productivity and total factor productivity (TFP). Efficiency has received comparatively little attention in empirical studies.[5] In banking, the return on equity (ROE), which can be measured by the ratio of net income to equity capital, is considered to be a good performance criterion (Alpar and Kim 1990).[6]

Operating income of banks includes investment interest and dividends, interest from all types of loans, loan and deposit charges, trust fees, safe deposit fees, charges for data services for customers, and income from non-banking functions. Operating expenses consist of all interest and non-interest expenses. Equity capital includes common stock, surplus, undistributed profits, and contingent reserves, measured as averages for the year. Alpar and Kim (1990), for example, investigate how the demand for input factors has changed with the use of ICT in banks, using the ratio of IT expenses to total operating expenses as an input measure and the ROE as an output measure.

Secondly, studies on ICT have found mixed results on firm performance. Loveman (1988) and others found a "productivity paradox", i.e. results which indicated that the use of information technologies appeared to be linked to decreasing productivity and subnormal returns on investment. Licht and Moch (1999), using a large sample of German manufacturing and services establishments over the year 1996 measured no effects of IT on labor productivity. Assuming that there should be productivity gains from computers, several arguments have later been invoked to understand the paradox, including time lags, problems

of measurement, and underdeveloped management practices (Brynjolfsson 1993).[7] A large number of studies in recent years have found positive effects (e.g. Lehr and Lichtenberg 1999; Menon et al. 2000; Bresnahan et al. 2002; Beccetti et al. 2003; Stare et al. 2006). Harris and Katz (1991), for example, found that IT-enabled process integration and coordination enhanced the performance of the life insurance firms and suggest that IT is "an effective tool to combat and postpone the net diseconomies of size" (Harris and Katz 1991: 289). In the financial sector, the focus of our analysis, the same profitability paradox has been found, showing negative or non-significant impacts of ICT on banking profitability or efficiency. Using survey data of 31 Indonesian commercial banks, McKendrick (1992) argues that automation did not improve financial performance between 1980 and 1987. By most accounts, however, it did improve customer service. McKendrick suggests that automation should be integrated with a bank's existing procedures. Since these were still in formation at the time of automation in Indonesia, bank performance depended more on managerial know-how than on competence in specific technologies. Beccalli (2007) finds little relationship between the total size of IT investment and improved profitability or efficiency. Yet, an analysis of the scope of IT investments in terms of hardware, software and services reveals a more heterogeneous picture. While investment in IT services from external providers (e.g. consulting, implementation, training and education, support) has a positive influence on accounting profits and profit efficiency, acquiring hardware and software appears to reduce banking performance. Just as in other sectors, however, contrary evidence has been found which shows a positive impact. Holden and El-Bannany (2004), for example, find that the number of automatic teller machines (ATM) installed positively affected the profitability of banks in their sample of UK banks between 1976 and 1996. Moreover, Frischtak's (1992) study of the Brazilian experience of banking automation reveals a

consistently strong association between branch automation and productivity gains both industry-wide and at firm level.

Thirdly, there is significant evidence pointing to the complementary nature of information technology, organizational factors such as business strategies (Shin 2001), work organization (Black and Lynch 2001), human capital (Caroli and Van Reenen 2001), customer and supplier relationships, and new product design (Beccetti et al. 2003, Battisti and Stoneman 2005). Using firm-level data of 300 large firms across different industries in the United States, Bresnahan et al. (2002) point to complementarities among three related innovations– IT, complementary workplace reorganization, and new products and services – in factor demand and productivity regressions. Black and Lynch's study (2001), based on a survey of 600 US manufacturing firms between 1987 and 1993, find that ICT and workplace reorganization positively affect labor productivity and that it is not whether an employer adopts a particular work practice but rather how that work practice is actually implemented within the establishment that is associated with higher productivity. Complementarities are also found in studies on ICT in the financial sector. For example by Pereira (2004) finds a complementary (as opposed to substitution) effect between information systems and technology and labor in the Portuguese financial sector between 1994 and 1999. In the development context, Kaushik and Singh's (2004) research based on two ICT for development projects in North India find that the 'lack of knowledge of "best practices" in IT usage as well as IT-related skill deficiencies in the workforce are major constraints to maximising the returns on IT investments (2005: 697). They suggest that complementary investments into IT-related labour and organisational factors are necessary to provide a supportive work environment which enables IT to improve productivity.

Fourth, measuring information and communication technologies necessitates disaggregating capital into IT and traditional forms of capital (non-IT). ICT can be decomposed into components of information technology: hardware (computers, monitors, printers, etc.), software (applications such as word processing) and telecommunications technology (internet or intranet networking, e-mail, e-commerce, etc.). The measure of interest depends on the

intention of the study. Most commonly, IT is measured in terms of investment into hardware, usually defined as annual spending or as an annualized stock of computer investments including the depreciated value of previous investments that are still in use (see for example Brynjolfsson and Hitt 1995, 2003). The value of the volume measures is calculated using price and computing capacity information, and adjustments are useful if the data is to be applied in a production function framework (e.g. by deflating nominal values).

Last but not least, it is worth identifying some of the main inadequacies of common ICT measurements. As Melville et al. (2004) point out, when IT is operationalized using aggregate measures in terms of costs or counts of systems, our understanding of the differential effects of different types of IT as well as the role of usage may be limited. Devaraj and Kohli (2003), for example, in their longitudinal study of a healthcare system, find that the driver of IT impact on various financial and nonfinancial measures of hospital performance is not the investment in the technology, but the actual usage of the technology. Thus, they suggest that actual usage may be a key variable in explaining the impact of technology on performance, and that omission of this variable may be a missing link in IT payoff analyses. A related issue is the treatment of software. Often, software is either implicitly considered via "assumptive measures" or it is entirely omitted from the analysis. Yet, evidence suggests that software (specific IT applications) is associated with firm performance and should not be neglected. In their analysis of the impact of Enterprise Resource Planning (ERP) software systems, Hitt et al. (2002) show that investment in ERP tends to be rewarded by higher business performance across a wide variety of financial metrics. Feng et al. (2004) find a positive influence of the adoption of knowledge management systems (KMS) on firm performance in terms of reduced administrative costs and improved productivity with a time lag of one year after adaptation.

A serious limitation of our previous examination and its potential applicability to the topic of ICT for development in general and microfinance in particular is that most thorough academic research on the effects of ICT on firm performance uses data from OECD countries. There is a lack of studies on the same topic in developing countries where different challenges may arise from specific local contexts and institutions. The importance of such studies is highlighted by Chowdhury's (2006) study of East African small and medium sized enterprises in food processing, textiles and tourism. He finds a negative effect of ICT investment on labor productivity and no significant effect on the firm's return or exporter status. The negative effect on labor productivity is explained in terms of the low cost of labor relative to capital in East Africa (preventing substitutability from being profit maximizing). Chowdhury (2006) also points to the possibility of a technology-skill mismatch when technologies invented in industrialized countries do not ensure complementarities, i.e. low productivity of ICTs when operated by unskilled workers.

A few studies examine the performance of rural microfinance institutions (MFIs). For example, Cull et al. (2007) examine outreach and financial performance of MFIs in terms of profitability and loan repayment; and Gutiérrez-Nieto et al. (2007) evaluate the efficiency of MFIs against country and NGO status of the MFIs. However, empirical research on the impact of ICT on the performance of rural cooperative banks appears to be extremely limited. In a paper published by USAID, Mainhart (1999) suggests a flexible framework to analyze and evaluate the quality of information systems in microfinance institutions. It uses numerical ratings of categories such as functionality and expandability, usability, reporting, standards and compliance, administration and support, technical specifications and reliability and cost. So far, however, to our knowledge, this framework has not yet been empirically

tested or otherwise assessed. Theoretically, we may expect the introduction of ICT in DCCBs to enhance both their profitability and efficiency. However, the absorptive capacity of the local branches and rural communities as well as the complementarities between modern technology and local skills may pose a challenge for the reasons pointed out by Chowdhury (2006).

III. Rural credit institutions and the DCCBs in India

Since the structure and development of rural India's diverse financial landscape have been well described in the literature (e.g. Jones 1994; Ramachandran and Swaminathan 2005, Basu 2006), this section will focus on cooperative banks and provide a brief overview of their development, including the current reform process and the rationale behind its investments in computerization. In line with NABARD's (1999) definition of microfinance, this study treats cooperative banks as micro finance institutions.[8]

The growth of India's large network of rural credit cooperative banks is rooted in the country's post-independence development strategy in which institutional credit was perceived as "a powerful tool for enhancing production and productivity and for poverty alleviation" (Thorat 2006: 1). The consequent policies which have been implemented aimed to enable direct lending to disadvantaged borrowers and sectors at low interest rates and to gradually expand the institutional credit network through co-operatives, commercial banks and Regional Rural Banks (RRBs). Public sector (majority government owned) banks accounted for about 73 per cent of India's total banking sector assets in 2006 (Basu 2006: 34).

The three-tiered network of rural credit cooperative banks is an important source of formal credit in rural India. In 2006, it comprised 31 State Cooperative Banks (SCBs), 366 District Central Cooperative Banks (DCCBs) and 103,384 Primary Agricultural Cooperative Societies (PACS) (RBI 2006: 119). Our survey only included DCCBs and PACS. PACS usually operate at the village level and grant short and medium term loans for production and investment to individual borrowers. DCCBs provide a number of key services to PACS, including lending loans, sanctioning of loans from PACS, arranging insurance for cash in transit and personal accident insurance for PACS borrowers and conducting inspections of PACS. Apart from these services for PACS, DCCBs also lend to other cooperatives, individuals and incorporated bodies engaged in activities allied to agriculture or in the processing of agricultural output. They accept deposits and perform other banking functions similar to commercial banks.

The financial health and governance of rural credit banks have been constant sources of concern. In the year 2005-06, 76 per cent of all DCCBs reported a profit (Rs. 1,116 crore) and 24 percent reported a loss (Rs. 913 crore). Among the PACS, 42 percent reported a profit (Rs. 1,064 crore) and 50 percent reported a loss (Rs. 1,920 crore) (RBI 2006: 142). Most PACS cannot raise their own resources through deposit mobilization but depend instead on external funds from the government or higher levels of cooperative banks (Ministry of Finance 2007: 38). Thus, while actual ownership of the government varies between 13 percent in SCBs, 17 per cent in DCCBs and 11 percent in PACS (Sarma and Kumar 2008: 15), state governments control and intervene through various means, including control over refinancing and occasional loan waivers for political reasons (Government of India 2005: 26; see also Basu 2006: 34; Dev 2008).

Limited data validity and significant differences in terms of structure, functioning and regulations of the cooperative credit system makes it difficult to compare DCCBs and PACS across different states. A recent report by a government appointed reform committee pointed out that the data are not up-to-date and validated, no uniform formats exist for collecting and presenting data on comparable concepts and categories, and there are significant variations in the data obtained from different sources for the same period and parameters.[9] These deficiencies are particularly serious in the case of PACS (Government of India 2005: 19). Rules for accounting and disclosure of financial accounts of cooperatives also vary across different states, and the rules are not consistently applied (ibid.). A common problem faced by all cooperative banks is a "much higher risk profile as compared to [private] commercial banks" because they are restricted in their ability to diversify across regions and sectors (Patil 2008: 51). The biggest differences are apparent in the functions of PACS. Most PACS are not formally licensed as "banks" (World Bank 2007: 3). While in some regions there are a few pure thrift and credit societies that generate resources only from members and do not have financial transactions with non-members, in other regions, PACS collect deposits from members and non-members alike (ibid.: 22). In many regions they even perform certain distribution and marketing functions.

After the liberalization of India's financial sector in the 1990s and a dilution of the focus on social banking a number of committees have been appointed to suggest ways of reforming the cooperative sector and of expanding credit to agriculture.[10] In 2004, the Government of India appointed a task force, also known as the Vaidyanathan Committee, to analyze the problems faced by rural cooperative credit institutions and to suggest an action plan for their revival. Its main recommendations comprised institutional, legal and regulatory reforms (e.g. the removal of geographical restrictions), capacity building and technical assistance to

strengthen the managerial and technical capabilities of potentially viable CCBs (including computerization) and to enable financial revival (Government of India 2005). Following these recommendations, the government announced an assistance package in January 2006 aimed at transforming potentially viable cooperative credit banks into "democratically governed, efficiently managed, financially sustainable, self-reliant entities that can provide a wider range of financial services to the rural poor on more affordable terms" (World Bank 2007: 4). NABARD is in charge of implementing this revival package.[11] As of April 2008, implementation of the revival package had begun in 17 states[12] which signed a memorandum of understanding with the government of India and NABARD. Financial and technical assistance to support the package is also provided by the World Bank and other donor organizations.[13]

Computerization has been included in the revival package for various reasons. Commercial bank branches in rural India are typically not computerized and do not have ATMs, credit or debit card products (Basu 2006: 13, 34). Computerization is based on the setting up of a common accounting system and Management Information System (MIS) evolved for the institutions of the short-term cooperative credit structure. They are intended to improve connectivity among credit cooperative banks, streamline accounting, obtain standardized consolidated information, and enhance efficiency and transparency of the cooperative credit institutions. Cost efficiencies are expected because computerization may enable the pooling of costs related to back office transactions (World Bank 2007: 9). The World Bank thus agreed to finance the acquisition, ongoing maintenance and enhancement of software applications; the acquisition of hardware; roll-out services, including data entry of the initial database; and user training (ibid.).

IV. Data, Methodology and Model

Data and Methodology

Data for empirical estimation were compiled from a recent ICT survey conducted in India and the published account data of the DCCBs. The DCCB account data are published every year by the National Federation of State Cooperative Banks (NAFSCOB) of India, including information of the banks' financial performances directly collected from the DCCBs. The 2006 DCCB data, which was published in June 2007, contain the performance statistics during 2005-2006.

The survey on ICT usage of DCCBs was conducted in 2007 by Saral Services (Hyderabad) as part of the EPSRC funded collaborative research project on "Rural e-services: Participatory co-design of Sustainable Software and Business Systems in Rural Co-operatives" of Sheffield Hallam University, Oxford University, the Overseas Development Institute and Saral Services. One of the key institutions selected by the survey in the delivery of rural financial services in rural India is the District Central Cooperative Banks (DCCBs). It studies their usage of ICT applications at different organizational levels. The population size of DCCBs was 366 based on the national list of DCCBs, which is available on the website of India's National Bank for Agriculture and Rural Development (NABARD). 160 DCCBs of different sizes responded from 17 out of 28 states, resulting in a response rate of 43.7 per cent. The survey was voluntary and conducted by means of telephone interviews following a set questionnaire with 14 questions. Three attempts were made to contact each institution and to make an appointment with a suitable member of staff to complete the survey. After the first round of interviews, the data were checked for any unclarities, and the

interviewers contacted the DCCB to resolve them. Please see Gupta *et al.* (2008) for more details of the survey.

The survey examined the availability and usage of ICT at different levels of cooperative banks, including head offices (HO), local branches, and field staff. Furthermore, it investigated the existing ICT support structures, constraints to ICT adoption or expansion, and levels of priority given to ICT inside these organizations. In this survey, the term ICT refers to all information and communication technologies which exist for financial enterprises, including computer hardware (desktop computers, file servers, hand-held devices, smart cards, ATM), network technologies (LAN, WAN, Internet connectivity, wireless and mobile networks) and software applications (e.g. for payroll, deposit and loan tracking, risk assessment, management information systems).

Empirical Models

In this paper we investigate the short-run effects of ICT penetration on the performance of rural credit institutions (in the form of cooperative banks) with a social as well as for-profit nature, i.e. a double bottom line (Copestake 2005). For these institutions, financial self sufficiency is an important objective to achieve economic sustainability (Cull et. al. 2007), and profitability is commonly used as a performance indicator. Although financial sustainability is an important requirement for the success of a microfinance institution, it is definitely not the only, or even the principal objective. Compared to commercial banks, rural cooperative banks and other microfinance institutions are set up as a tool to enhance agricultural and rural development. We therefore adopt two categories of indicators,

profitability and efficiency, to measure the performance of DCCBs. In line with common practice, banking profitability is captured by return to equity (ROE). Efficiency is measured by the output efficiency indexes using the DEA method. We use three kinds of indicators to measure the ICT penetration: (1) ICT investment, measured by IT budget; (2) ICT factors, a vector of factors summarizing the variations in all the ICT indicators in the survey based on the factor analysis; and (3) some important individual indicators of different ICT usages. Therefore, we respectively estimate six regression models according to the dependent and main explanatory variables.

For the profitability models, we estimate the following three equations.

$$ROE_{it} = \alpha + \beta_1 IT_i + \beta_2 ROE_{it-1} + \beta_3 CAP_i + \beta_4 RISK_i + \beta_5 GVN_i + \beta_6 ORT_i + \beta_7 DIS_i + \beta_8 RGN_i + \varepsilon \quad (1)$$

where i = 1, 2,…, N refers to institutions; *ROE* indicates banking profitability; *IT* is information technology adoption measured by the IT budget (*it_bgt*), the ICT factors (*Fs*), or the ICT usages *(ITuse*), depending on the model. The selection of control variables included in the model follows the common practice used in studies on profitability in the banking sector. *CAP* refers to the bank size; *RISK* measures the risk of asset; *GVN* proxies the governance of the DCCBs; *ORT* represents the business orientation of the DCCBs; *DIS* captures the outreach and the remoteness of the DCCBs; and *RGN* is the regional dummies for different states. We use lagged *ROE* to control for the unobserved and/or unavailable variables.

With regard to the efficiency analysis, in addition to bank size, governance, business orientation and outreach, IT skills of bank staff and education levels of local community may also have important effects on the efficiency of the DCCBs as labor skills and absorptive

capacity are important determinants of the efficiency of rural organizations (e.g. Fu and Balasubramanyam 2003). Therefore, we employ the following equation,

$$EFF_i = \alpha + \beta_1 IT_i + \beta_2 CAP_i + \beta_3 GVN_i + \beta_4 ORT_i + \beta_5 DIS_i + \beta_6 ITL_i + \beta_7 LIT + \beta_8 URB_i + \varepsilon \quad (2)$$

where *ITL* = IT training measured by the number of staff who receive IT training per year; *LIT* = the literacy rate of the district, and *URB* = the degree of urbanization of the district in which the DCCB is located.

For the estimation of efficiency, the efficiency scores have an upper bound of 100 and a lower bound of 0. Since an OLS estimator would thus be inconsistent the regression model for efficiency is specified in form of the following Tobit model,

$$EFF_i = \begin{cases} \alpha + \beta X_i + \varepsilon \text{ if } \alpha + \beta X_i + \varepsilon < 1 \\ 1 \text{ otherwise} \end{cases} \quad (3)$$

where X_i refers to a vector of all the independent variables listed in equation (2).

Measurement

Profitability is measured by the return to equity (ROE), which is defined as the ratio of profit to total assets.

We estimate the efficiency using the non-parametric data envelopment analysis (DEA). DEA is a performance measurement technique that allows evaluating the *relative* efficiency of decision-making units (DMU), which is formally developed in Charnes *et al.* (1978). For a

sample of n firms, if X and Y are the observations on inputs and outputs, assuming variable returns to scale, the firm's efficiency score, θ, is the solution to the linear program problem,

$$
\begin{aligned}
& Min_{\theta,\lambda} \ \theta \\
& \text{st.} \quad \theta x_i - X\lambda \geq 0 \\
& \qquad -y_i + Y\lambda \geq 0 \\
& \qquad \lambda_i \geq 0 \\
& \qquad \sum \lambda_i = 1 \qquad i = 1,\ldots,n.
\end{aligned} \tag{4}
$$

where θ is a scalar and λ is a nx1 vector of constants. The efficiency score ranges from 0 to 1. If $\theta_k = 1$, the kth decision making unit is deemed to be technically efficient.

The strength of the programming approach lies not only in its lack of parameterization but also in that no assumptions are made about the form of the production function. Instead, a best-practice function is built empirically from observed inputs and outputs. The main shortcoming of this technique is that there is no provision for statistical noise or measurement error in the model (Greene 1997; Norman and Stoker 1991). The econometric approach has its main advantage in that measurement error can be minimized and hypotheses can be tested with statistical rigor. It is restricted by the main drawback that the production function is assumed to be known and to be homogeneous across firms or sectors.

The input variables in our DEA analysis are "deposits", "borrowing", "number of employers" and "number of offices", while the output variables are "agriculture loan", "non-agriculture loan" and "investment". We apply the following weight restriction for the outputs,[14]

$$W_{\text{Agriculture loan}} \geq W_{\text{Non-agriculture loan}} \geq W_{\text{Investment}}$$

The first indicator of ICT penetration is ICT investment measured by the ICT budget for IT hardware and software. The second group of ICT penetration includes seven ICT factors constructed from factor analysis. There are more than 50 variables, mostly qualitative, in the ICT survey data that measure the different aspects of ICT penetration in the DCCBs. Factor analysis summarizes these measurements into a smaller number of factors, without losing too much information. Factor analysis thus allows us to remove redundancy or duplication from a set of correlated variables, and represents correlated variables with a smaller number of derived factors. Table 1 reports the main information embedded in the estimated factors.

[Insert Table 1 here]

We select the original variables as the third group of explanatory variables, which measure different aspects of ICT usage. They cover the extent of computer usage, the number of staff receiving ICT training, ICT literacy, staff usage of mobile, usage of computers, usage of networks, the type of network communications, number of staff receiving IT trainings, etc. Except for the number of trained staff, most of them are qualitative ordinal variables, ranking from 1 to 6. We select reasonable thresholds and re-define those variables using dummies, with 1 indicating there are such usages in DCCBs.

With regard to the control variables, the size of banks (*CAP*) is measured by working capital. Asset risk (*RISK*) is measured by the ratio of overdue loans to total demand. Governance (*GVN*) is measured by the ratio of cooperative share to the total share; business orientation (*ORT*) is proxied by the percentage of short term agriculture loans to the total loans; and the

business outreach (*DIS*) is captured by the distance of the DCCB to state capital. Governance, business orientation and geographical location are commonly of interest in microfinance studies. For example, since microfinance institutions often operate in low-income areas the relationship between financial sustainability and business outreach is a central topic of research (Copestake *et al.* 2005; Cull *et al.* 2007). Similarly, business orientation is also important because microfinance institutions are supposedly established for the purpose of social (and often rural) development and poverty reduction. The IT literacy of staff (*ITL*) is partly reflected by the number of staff receiving IT training. In addition, we divide the 17 states in the sample into three groups according to the 2005 per capita income data of India and define three regional dummies. Region 1 represents the lowest income states group, region 2 the intermediate income states group, and region 3 the highest income states group. Table 2 reports the descriptive statistics of the main variables in our empirical analyses and Table 3 provides the correlation matrix. Table 4 compares some characteristics of the regions observed in this paper.

[Insert Tables 2-4 here]

The data in table 2 reveal very sharp regional variations among India's different states in terms of per capita income, urbanization ratios, and literacy rates. These differences are also reflected in the performance of the states' cooperative banks. Bihar, the state with the lowest per capita income (Rs. 6,771), lowest literacy rate (46 per cent) and very low rate of urbanization (9.7 per cent) has some of the most efficient yet unprofitable District Central Cooperate Banks. By contrast, Haryana, the most urban and industrialized state in our sample, with the highest per capita income, has the highest efficiency and provides relatively

little IT training. Due to these highly regionally-specific effects, we have included regional dummies in the DEA model.

Several specification tests are employed to ensure the model is correctly specified. First, the regression specification error test (RESET) suggests that the model has not included any irrelevant variables or omitted any important determinants. Second, since a nonlinear relationship is found between profitability and IT investment and asset size, we take the log of IT investment and asset size in the estimation. Third, significant heteroskedasticity is detected thus we use white heteroskedasticity corrected estimates in the estimation of profitability. There is also potential endogeneity between ICT investment and profitability. To allow for the potential endogeneity of ICT expenditure, we apply a two-stage least square (2SLS) approach. The main econometric problem is to find appropriate instruments for ICT expenditure. We employ four excluded instrumental variables including two regional characteristics and two firm characteristics, i.e. regional urbanization, regional literacy rate, number of offices, and cost of management per employee. Other explanatory variables in the models are also used to instrument ICT expenditure. We employ different combinations of the four excluded instruments into the regression. The Sargan test and Basmann test of over-identification restrictions broadly show that the instruments are valid. However, the Wu-Hausman F test and Durbin-Wu-Hausman chi-2 test do not reject the hypothesis that ICT expenditure can be treated as exogenous. Therefore, the OLS results are consistent and efficient. We also apply a Tobit model with endogenous regressors to allow for the potential endogeneity of ICT expenditure. Again the Hausman test suggests exogeneity of ICT expenditure. Therefore, we only report the standard Tobit model results in the paper.

IV. Results

Impact of ICT Penetration on Profitability

Table 5 reports the OLS estimation results of profitability effects of IT penetration using IT budget (lnit) and ICT factors (f1-f7). The estimated results show that IT expenditure has a positive and significant impact on the profitability of the DCCBs. The coefficient (14.172) reflects the elasticity of IT expenditure on the profitability, i.e. a 1 per cent increase in IT expenditure will result in about a 14 per cent increase in profitability of the DCCBs. Amongst the seven factors, only factor 5 is found to have a constantly positive and significant coefficient, indicating that the usage of IT application for business and management functions in parts of organization will increase the profitability of DCCBs. The estimated coefficient of the risk orientation is negative and significant in one of the models suggesting that high risk does not bring about high return in the DCCBs. Profitability in previous years appears to be a significant determinant of current profitability, which is consistent with prior expectation. The average profitability of DCCBs in the middle income regions is significantly higher than that in the low income regions. However, the estimated coefficients of other control variables are not statistically different from zero.

[Insert Table 5 here]

Table 6 reports the results for the impact of individual ICT usages on profitability. Models 1 and 2 present the results with the computer usage, Models 3 and 4 with the network usage and Model 5 with the type of network communication. For the computer and network usages, we consider the usages at the head office as well as at the branches; while for the usage type of network communication, we only report the results including LAN usage at branch

levels.[15] The results demonstrate that computer usages at the head offices and branch levels both increase the profitability of the DCCBs. However, network usage only significantly increases the profitability at the branch levels. A possible explanation is that network is broadly used in most DCCB head offices in India. Similarly, we find a positive and significant coefficient on the LAN usage in the branch offices. The results of the control variables are similar to those in previous tables[16].

[Insert Table 6 here]

Impact of ICT Penetration on Efficiency

Table 7 shows the Tobit model results with ICT expenditure and factors as determinants of efficiency, respectively. The estimated coefficients suggest that ICT expenditure does not have a significant impact on the efficiency of the microfinance institutions. However, amongst the seven factors, factors 2 and 4 both have a positive and significant impact on the efficiency index. This result suggests that mobile phone usages and skills and Net/LAN usages are important determinants of the efficiency of the DCCBs. The increase of usage in these techniques, skills and applications may lead to an improvement in the efficiency of the DCCBs. The coefficients of other factors vary in sign and magnitude and none of them are statistically significant.

With regard to the control variables, small banks appear to be more efficient (but only significant at the 10 per cent level) when considering the impact of IT expenditure in models 1 and 2. Business orientation towards agriculture also exerts a significant negative effect on the efficiency of DCCBs, indicating that the DCCBs with more short-term agriculture loans

is less efficient than those with more non-agriculture loans. In contrast, the estimated coefficient of the governance variable is positive and statistically significant suggesting that strong collective ownership of the DCCB, i.e. more shares owned by the members of the DCCB, is associated with better efficiency performance. This result is consistent with the findings from China's township and village enterprises (Fu and Balasubramanyam 2003), testifying that collective ownership can effectively reduce the agency problem in the management of DCCBs. Staff IT training also exerts the expected significant positive effects on the efficiency of the DCCBs, indicating the importance of complementary labor skills in improving the institution's efficiency. The coefficient on the distance of the DCCB to the capital is positive but not statistically different from zero. Finally, urbanization and literacy levels in the region both significantly increase the efficiency of the DCCBs suggesting that the development level and human capital of the local community increase the efficiency of the rural credit institutions.

[Insert Table 7 here]

Table 8 reveals the relationship between different ICT usages and efficiency. The results suggest that usage of stand alone computers at head offices and branches has a positive and significant impact on output efficiency. However, usage of networked computers is not statistically significant at any level[17]. This result is different from that on profitability. This may be due to the possible reason that more advanced IT facilities increase the profitability of the rural banks, but since this also involves more investment, it may not enhance efficiency significantly. Another possible reason is the time lag that is necessary for IT technology to take effect on bank's performance. Since we are using a cross section of data, this is a limitation of this study and the results should be interpreted with caution. Again,

small DCCBs appear to be more efficient than the larger ones. Staff IT training and regional urbanization and literacy rate also remain positive and significant across different model specifications, suggesting the robustness of the results. However, the estimated coefficients of governance, business orientation, and outreach variables are not statistically significant.

[Insert Table 8 here]

V. Conclusions

The current push for computerization and the introduction of other ICT equipment are re-shaping the organizational and operational processes of Indian cooperative banks, from head offices to the smaller branches of PACS. This paper investigated the short-run effects of ICT penetration on the performance of these microfinance institutions. Using DEA for a survey of 160 DCCBs across 17 states of India, we find that modern information technology serves to enhance both the efficiency and profitability of the rural credit institutions. Efficiency is significantly enhanced by the usage of moderate technology at the lower organizational level, such as stand-alone computers at the branch level, mobile phone usage at PACS and field level. However, profitability appears to be associated with more advanced and sophisticated usage of information technology at branch or lower organizational level. For example, the usage of computers at the level of head and branch offices, the usage of LAN at the branch level, and the usage of IT applications in parts of DCCBs. Complementarities in skills and human capital, training in IT skills of the bank staff, absorptive capacity of the customers and community and education level of the community, are of crucial importance for the efficiency of rural cooperative banks. Evidence from this study also suggests that using investment in ICT as a measure of the usage and advancement level of information

technology may not reveal the full story of the impact of ICT on the efficiency of organizations.

The finding that modern technology can work for rural communities has important policy implications. Encouraging investment into information technology will be an effective way for the revival of rural cooperative banks and enhance their economic and social performance. Information technology may also be a useful tool to enhance the impact and performance of other microfinance institutions in rural areas of developing countries. These information technologies include not only advanced networks but also other appropriate tools such as mobile phone technologies. Finally, given the importance of complementarities between the effectiveness and efficiency with which ICT can be used and of the human capital and absorptive capacity of the local communities, greater investment in education and IT training is a crucial and probably fundamental policy tool. Further research is needed using longitudinal data to capture the lagged effects of ICT investments and wider social effects on the rural client communities. In order to gain a better understanding of the social impact of ICT investments in rural microfinance banks a more inclusive framework should be developed for measurement and analysis, complementing quantitative with more qualitative research methods.

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Table 1 Factors Used for Analysis

Factor	Content
1	ICT usages and skills at HO and branch level
2	Mobile Phone Usages and skills at HO and branch levels
3	Mobile and landline phone usage at PAC/field level, external ICT support
4	Net/LAN at branch level;
5	Usage of IT application in parts of organization for internal accounting/Deposit Tracking/Loan Tracking/Transaction
6	Dial-up internet at HO level; limited IT support by in-house team
7	Telephone support only

Table 2 Variable Description and Summary Statistics

Measure	Variable and Definition	Obs	Mean	Std. Dev.	Min	Max
Profitability	roe_06: return to equity in 2006(%)	148	12.74	66.00	-222.20	189.70
	roe_03: return to equity in 2003(%)	148	3.15	106.94	-522.40	412.20
Efficiency	eff_s1w: eff. index, weight 1 (%)	148	74.42	21.72	19.48	100
	eff_s1w2: eff. index, weight 2 (%)	148	77.28	21.69	19.90	100
IT Investment	it_bgt: expenditure on IT (10^5 INR)	85	23.58	38.34	0.3	185
IT Usages	cpt_h: computer usage in head office	148	0.95	0.21	0.00	1.00
	cpt_b: computer usage at branches	148	0.56	0.50	0.00	1.00
	net_h: network usage at head office	148	0.24	0.43	0.00	1.00
	net_b: network usage at branches	148	0.33	0.47	0.00	1.00
	lan_b: LAN usage at branches	148	0.33	0.47	0.00	1.00
Bank Size	wcap06: working capital (10^8 INR)	148	34.14	42.61	1.395	351.88
	dpt06: deposit (10^8 INR)	148	24.62	38.38	15.60	276.77
Asset Risk	odue_to_dmd_06: overdue to demand (%)	148	34.35	22.05	1.05	94.31
	eow_06: equity to working capital (%)	148	4.58	4.88	0.3	44
Governance	gvn_06: coop. share to total share (%)	148	74.21	19.58	16.9	100
Orientation	ort_06: agriculture loan to total loan (%)	147	57.91	27.29	0	100
Outreach	dis_sc: distance to state capital (km)	145	280.38	165.11	0	915
IT training	em_it: number of staff receiving IT training (person)	135	1.31	0.92	0.00	6.90
Literacy	lit: literacy rate (T)	147	63.29	10.73	35.10	93.20
Urbanization	urb: % of urban to rural population ratio	147	25.07	15.60	3.810	80.43
Regions	rgn1	148	0.34	0.48	0	1
	rgn2	148	0.39	0.49	0	1
	rgn3	148	0.26	0.44	0	1

Table 3 Correlation Matrix

	roe_06	roe_03	eff_s1w	it_bgt	f1	f2	f3	f4	f5	f6	f7	cpt_h	cpt_b	net_h	net_b	lan_b
roe_06	1.00															
roe_03	0.62	1.00														
eff_s1w	0.43	0.18	1.00													
it_bgt	0.29	0.05	0.07	1.00												
f1	-0.14	-0.11	-0.07	-0.44	1.00											
f2	0.24	0.07	0.25	0.02	-0.18	1.00										
f3	-0.05	0.25	-0.07	-0.27	0.10	-0.25	1.00									
f4	-0.03	-0.01	0.30	-0.10	-0.11	-0.01	0.05	1.00								
f5	0.30	0.10	0.06	0.49	-0.04	0.03	-0.21	-0.06	1.00							
f6	-0.15	0.04	-0.06	-0.30	0.08	-0.18	0.20	0.06	-0.01	1.00						
f7	-0.19	-0.11	-0.07	-0.48	0.26	-0.14	0.01	0.34	0.04	0.04	1.00					
cpt_h	0.40	0.13	0.20	0.09	-0.03	0.08	-0.13	-0.05	0.14	-0.09	-0.15	1.00				
cpt_b	0.28	-0.05	0.17	0.51	-0.32	0.45	-0.58	-0.08	0.67	-0.25	-0.24	0.17	1.00			
net_h	0.13	-0.14	0.19	0.38	-0.45	0.18	-0.41	-0.17	-0.02	-0.69	-0.21	0.07	0.40	1.00		
net_b	0.26	0.04	0.10	0.54	-0.20	0.12	-0.24	-0.06	0.80	-0.46	-0.01	0.13	0.73	0.36	1.00	
lan_b	0.25	0.04	0.12	0.62	-0.35	0.10	-0.32	-0.11	0.76	-0.40	-0.16	0.14	0.78	0.41	0.95	1.00
wcap06	0.11	0.08	0.11	0.28	-0.67	0.07	-0.34	0.19	0.07	-0.31	0.16	0.11	0.29	0.52	0.29	0.31
odue_to_d~06	-0.35	-0.21	-0.44	-0.19	-0.01	-0.13	0.00	-0.22	-0.25	0.11	-0.06	-0.40	-0.10	0.10	-0.20	-0.15
gvn_06	0.14	0.14	0.14	0.13	-0.25	0.19	-0.20	-0.17	0.06	-0.33	-0.05	0.02	0.16	0.27	0.22	0.23
ort_06	-0.13	-0.16	-0.20	-0.04	0.09	0.24	0.00	0.03	-0.11	0.02	-0.11	0.04	0.01	-0.13	-0.12	-0.16
dis_sc	0.10	0.05	0.12	0.18	-0.20	-0.09	-0.40	-0.20	0.03	-0.03	-0.08	0.03	0.19	0.27	-0.04	0.11
em_it	0.08	0.04	0.35	-0.12	0.31	-0.33	0.22	-0.06	0.05	0.19	0.04	0.08	-0.29	-0.21	-0.10	-0.14
urb	0.29	0.14	0.26	0.12	-0.15	0.23	-0.10	0.04	0.14	-0.27	-0.16	0.19	0.23	0.24	0.26	0.23
lit	0.32	0.31	0.30	0.23	-0.39	0.12	-0.24	0.02	-0.05	-0.17	-0.21	0.18	0.18	0.36	0.11	0.22
rgn1	-0.32	-0.11	-0.35	-0.22	0.29	-0.51	0.61	0.01	0.07	0.33	0.14	-0.14	-0.43	-0.50	-0.10	-0.16
rgn2	0.36	0.16	0.33	0.01	0.10	0.48	-0.41	0.12	-0.01	-0.18	0.03	0.11	0.24	0.22	0.00	-0.04
rgn3	-0.03	-0.06	0.07	0.35	-0.61	0.10	-0.37	-0.20	-0.10	-0.25	-0.27	0.06	0.33	0.47	0.16	0.32

Table 4 Descriptive Statistics

Region	# of DCCBs	Income*	Profitability (roe_06)	Efficiency 1 (eff_s1w)	IT expenditure (it_bgt) in Rs. 100,000	IT training (em_it)**	Urbanisation (urb) (urban/total population)	Literacy (lit) in %
Andhra Pradesh	6	19884	-32.233	62.345	15.350	0.861	22.137	59.895
Bihar	5	6771	-10.880	88.602	8.000	1.590	9.658	46.336
Gujarat	5	23761	27.600	76.488	155.000	0.951	44.008	72.036
Haryana	4	28119	34.375	93.327		0.581	33.440	73.345
Jharkhand	2	14850	-57.850	68.385	7.500		30.460	61.215
Kerala	3	24217	78.700	84.347	150.000	0.903	37.177	90.047
Karnataka	5	20260	36.540	83.080		1.636	20.904	67.004
Maharashtra	11	27040	2.800	60.631	52.000	0.503	33.672	74.679
Madhya Pradesh	9	12011	37.811	76.069	20.429	0.488	33.629	67.663
Orissa	2	13329	12.300	72.935		2.448	7.705	65.795
Punjab	4	27851	44.450	87.515	0.650	0.668	36.675	65.665
Rajasthan	26	14947	35.262	82.914	7.063	1.232	21.914	58.549
Tamil Nadu	7	22835	-47.529	69.427	8.000	1.944	41.014	72.440
Uttar Pradesh	46	10224	-9.507	64.746	20.261	1.419	21.236	56.965
Uttaranchal	9	18780	91.900	92.272	35.389	2.173	20.542	72.893
West Bengal	4	19174	1.850	84.540		1.700	10.195	64.375

Notes: * income: per capita income in 2004-2005 at 1990-00 constant price, in Rupees.
** in no. of staff per bank who receive training per year
All the values are mean values.
Source: Income data was retrieved from www.indiastat.com. Urbanisation and literacy rates are Census data (2001).

Table 5 Effects of IT Budget and Factors on Profitability

roe_06	Model 1	Model 2	Model 3
lnit	15.361 (4.00)***	14.172 (3.30)***	
f1			-13.791 (1.55)
f2			1.311 (0.21)
f3			6.932 (0.61)
f4			-2.780 (0.44)
f5			15.830 (2.76)***
f6			-6.511 (1.14)
f7			-3.236 (0.79)
roe_03	0.356 (4.86)***	0.329 (4.63)***	0.289 (3.66)***
odue_to_dmd_06		-0.499 (1.30)	-0.617 (2.04)**
lncap		-7.294 (0.55)	-9.104 (0.86)
gvn_06		0.319 (0.68)	0.310 (0.68)
ort_06		0.054 (0.20)	0.135 (0.53)
dis_sc		0.018 (0.46)	0.026 (0.74)
rgn2		48.105 (3.61)***	46.891 (2.15)**
rgn3		10.645 (0.57)	27.900 (1.02)
Constant	-25.120 (2.13)**	18.128 (0.17)	58.447 (0.53)
Obs.	85	84	122
R^2	0.399	0.508	0.484

Note: Robust t-statistics in brackets; ***, **, * indicate significant at 1%, 5% and 10%, respectively.

Table 6 Effects of ICT Usages and Factors on Profitability

roe_06	Model 1	Model 2	Model 3	Model 4	Model 5
cpt_h	63.765				
	(2.09)**				
cpt_b		22.515			
		(2.46)**			
net_h			12.314		
			(0.83)		
net_b				32.702	
				(2.75)***	
lan_b					30.839
					(2.64)***
roe_03	0.294	0.294	0.300	0.299	0.293
	(5.03)***	(4.96)***	(4.83)***	(5.17)***	(5.02)***
odue_to_dmd_06	-0.291	-0.405	-0.442	-0.356	-0.402
	(1.44)	(1.76)*	(1.84)*	(1.55)	(1.73)*
lncap	4.647	2.552	2.465	-2.517	-2.439
	(0.70)	(0.36)	(0.32)	(0.34)	(0.32)
gvn_06	0.053	0.069	0.048	-0.021	0.018
	(0.20)	(0.25)	(0.19)	(0.08)	(0.07)
ort_06	0.013	-0.01	0.026	0.091	0.075
	(0.07)	(0.06)	(0.14)	(0.49)	(0.41)
dis_sc	0.001	0.003	0.001	0.009	0.002
	(0.05)	(0.13)	(0.04)	(0.32)	(0.08)
rgn2	34.132	32.278	33.301	42.655	42.019
	(3.27)***	(3.10)***	(3.19)***	(3.87)***	(3.82)***
rgn3	18.908	8.886	10.28	21.114	20.591
	(1.27)	(0.61)	(0.71)	(1.42)	(1.39)
Constant	-109.671	-33.289	-22.242	9.299	11.242
	(1.60)	(0.53)	(0.32)	(0.14)	(0.17)
Obs.	144	144	144	144	144
R^2	0.394	0.386	0.363	0.400	0.397

Note: Robust t-statistics in brackets; ****, ***, * indicate significant at 1%, 5% and 10%, respectively.

Table7 Effects of IT Budget and Factors on Efficiency

eff_s1w	Model 1	Model 2	Model 3	
lnit	2.319	2.645		
	(1.29)	(1.48)		
f1			-1.068	0.358
			(0.43)	(0.14)
f2			10.533	10.837
			(4.85)***	(5.09)***
f3			-0.491	0.269
			(0.21)	(0.12)
f4			4.930	5.053
			(2.38)**	(2.46)**
f5			1.767	2.588
			(0.93)	(1.35)
f6			-2.136	-2.194
			(0.97)	(1.02)
f7			-0.983	-0.307
			(0.49)	(0.15)
lncap	-10.661	-11.011	-3.495	-3.015
	(1.93)*	(1.99)*	(0.79)	(0.72)
gvn_06	0.417	0.451	0.273	0.280
	(2.38)**	(2.60)**	(1.87)*	(1.93)*
ort_06	-0.181	-0.064	-0.138	-0.071
	(1.77)*	(0.60)	(1.66)*	(0.80)
dis_sc	0.024	0.018	0.008	0.008
	(1.58)	(1.20)	(0.61)	(0.64)
em_it	7.843	8.382	12.361	13.273
	(2.09)**	(2.27)**	(3.66)***	(4.05)***
urb	0.453		0.212	
	(2.56)**		(1.50)	
lit		0.738		0.503
		(2.75)***		(2.05)**
Constant	125.595	85.043	74.154	37.231
	(2.50)**	(1.76)*	(1.69)*	(0.86)
Obs.	77	77	120	120
R^2	-302.072	-301.563	-462.054	-461.094

Note: Robust t-statistics in brackets; ****, ***, * indicate significant at 1%, 5% and 10%, respectively.

Table 8 Effects of IT Usages on Efficiency

roe_06	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
cpt_h	21.670	24.316						
	(1.89)*	(2.10)**						
cpt_b			11.583	12.550				
			(2.76)***	(2.99)***				
net_h					0.910	0.619		
					(0.15)	(0.10)		
net_b							-1.303	-0.271
							(0.27)	(0.06)
lncap	-7.248	-7.271	-8.536	-8.726	-7.204	-6.711	-6.601	-6.451
	(1.92)*	(1.87)*	(2.27)**	(2.26)**	(1.67)*	(1.53)	(1.64)	(1.54)
gvn_06	0.184	0.182	0.199	0.198	0.179	0.179	0.176	0.178
	(1.29)	(1.27)	(1.42)	(1.40)	(1.23)	(1.22)	(1.22)	(1.21)
ort_06	-0.073	-0.014	-0.074	-0.019	-0.075	-0.022	-0.082	-0.025
	(0.93)	(0.16)	(0.95)	(0.22)	(0.91)	(0.26)	(1.01)	(0.29)
dis_sc	-0.007	-0.008	-0.008	-0.010	-0.009	-0.012	-0.010	-0.012
	(0.51)	(0.66)	(0.64)	(0.78)	(0.72)	(0.91)	(0.74)	(0.90)
em_it	6.879	7.065	7.821	8.126	7.322	7.679	7.427	7.721
	(2.35)**	(2.37)**	(2.62)***	(2.69)***	(2.44)**	(2.52)**	(2.48)**	(2.53)**
urb	0.352		0.319		0.357		0.361	
	(2.34)**		(2.14)**		(2.32)**		(2.35)**	
lit		0.528		0.490		0.481		0.483
		(2.07)**		(1.97)*		(1.84)*		(1.86)*
Constant	102.570	72.813	128.559	104.073	123.493	94.578	118.629	92.293
	(2.84)***	(2.12)**	(3.74)***	(3.20)***	(3.16)***	(2.48)**	(3.25)***	(2.64)***
Obs.	130	130	130	130	130	130	130	130
R^2	-510.815	-511.360	-508.873	-509.205	-512.557	-513.516	-512.530	-513.519

Note: Robust t-statistics in brackets; ***, **, * indicate significant at 1%, 5% and 10%, respectively.

[1] A wide range of such case studies is available at the World Resources Institute (http://www.nextbillion.net/resources/casestudies).

[2] Excellent reviews of this literature are provided by Dedrick et al. (2003), Melville et al. (2004), and Draca et al. (2006).

[3] There are several case study-based reports on the usage of ICT in microfinance (Hernandez and Mugica 2003, Firpo 2005, Magnette and Lock 2005). However, there is a lack of theoretical frameworks guiding the assessment and evaluation of the impact of ICT on the performance of microfinance providers.

[4] From a resource-centred perspective (Penrose 1959; Dierickx and Cool 1989; Barney 1991; Rumelt and Lamb 1984; Wernerfelt 1984) information technology may be considered as a strategic resource which can directly influence organisational performance if suitably combined with other strategic resources. Methodologically, it allows us to focus both on the size of IT investment and penetration (Im et al. 2001, Barua et al. 2004) as well as on the scope of IT resources in terms of their properties, nature or uniqueness (Bharadwaj 2000, Caldeira and Ward 2003). The analytical framework of a contingency-based approach, which would analyse the "fit" between business strategy and IT resources, was less appropriate because our survey could not gather data on business strategies (for studies with this perspective, see for example Chan et al. 1997; Croteau and Bergeron 2001; Sabherwal and Chan 2001).

[5] Notable exceptions include Harris and Katz (1991) and Becchetti et al. 2003.

[6] X-efficiency frontiers may be used to reflect the effects of IT on operational productivity. X-efficiency measures (Leibenstein 1966) may provide a more inclusive picture of banking performance. Beccetti (2007) uses cost efficiency and profit efficiency to complement the standard accounting measures of ROE and ROA to analyse various impacts of ICT investments on the performance of European banks.

[7] For a review of empirical studies on the productivity paradox see Dedrick et al. (2003).

[8] Micro finance has been defined as the 'provision of thrift, credit and other financial services and products of very small amounts to the poor in rural, semiurban or urban areas for enabling them to raise their income levels and improve living standards' (NABARD 1999 Para 1.12.1). Rural cooperative banks, providing financial services to small farmers and dealing with relatively small loans and savings, have been recognized as such by NABARD ('institutions like NGOs, federations of SHGs, Mutually Aided Cooperative Societies (MACSs), State and National Cooperatives and NBFCs which provide specified financial services targeted to the poor, may be classified as MFIs' (NABARD 1999: Para 1.13.2)).

[9] PACS data is not available from NABARD but only from the National Federation of State Co-operative Banks (NAFSCOB), based on information provided by the states governments and the CCS.

[10] For a brief overview of the different committees and their recommendations, see Government of India (2005: 15-17) and Ministry of Finance (2007: 35). For a good overview and discussion of agricultural credit reforms, see Satish (2007).

[11] NABARD has set up a new department to oversee and implement the project, viz. the Department for Cooperative Revival and Reforms (DCRR).

[12] Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Nagaland, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh and West Bengal. Dialogue is in progress with other states which have conveyed their interest in participating.

[13] A critique of this reform is beyond the scope of this paper. Please see Sarma and Kumar (2008)

[14] We have also experimented with $W_{\text{Agriculture loan}} = W_{\text{Non-agriculture loan}} \geq W_{\text{Investment}}$. The estimated results and distributions are similar and consistent with each other. So we only report the results using the first weights in this paper. Results of the second weights are available from the authors upon request.

[15] For the types of network communication, the survey data reveal a discrepancy between the head office and branch level or below. All the head offices have been equipped with LAN, wireless LAN, wireless service to mobile services, and dedicated wide area network for internal communications, and high speed internet, ADSL, dial-up 56k internet for external communications. However, almost none of the branch offices have those types of network communications, except for LAN usage, and they largely depend on mobile phone and land-line connection. We only include the branch level LAN usage because other variables do not show enough variation.
[16] Following the same methodology, we also examine the effects of other ICT usages and ICT penetration on the profitability of DCCBs, including staff IT training, IT literacy among staff members, mobile phone usage, and different uses of ICT applications. However, none of them show any significant impact on the profitability level of the DCCBs, hence the results are not reported in the main text.

[17] We also examine the effects of other ICT usages and ICT penetrations, especially at branch levels, including IT literacy among staff members, mobile usage, and different uses of ICT applications. However, none of them report any significant impact on the efficiency of the DCCBs.