INFORMATION TECHNOLOGY AND AGRICULTURAL EXPORTS IN INDIA

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ABSTRACT

This paper investigates the impact of Information and Communication Technology (ICT) on the agricultural sector of the Indian economy. While agriculture constitutes 25 percent of India's GDP, it employs approximately seventy percent of the population. Over the last decade, GDP has consistently grown at rate in excess of 6 percent, but per capita GDP growth in the agricultural sector has been low. Using national level data on agricultural output, exports, investment in technology, and GDP, we examine the role of ICT on India's agricultural exports. Our analysis indicates that agricultural production directed towards export markets is positively affected by investment in ICT. *Keywords: Information Technology, Economic Growth, Agriculture. JEL Classifications: L86, O11, Q100*

INTRODUCTION

Modern agriculture is increasingly dependent upon information technology. Timely and accurate information can improve production and profits, minimize environmental impacts and keep the farm a vibrant enterprise. The internet, modern computers, and a new generation of cellular technologies provide the backbone for the delivery of new information tools to the agricultural sector especially in the developing world.

Agriculture and allied sectors in India contribute nearly 25 percent of gross domestic product (GDP) and approximately 72 percent of the country's population is dependent upon agriculture for their livelihood. Out of a total land area of 329 million hectares in the country, 143 million hectares is cultivated. As of 2009, India's population stood at approximately 1.16 billion people, with approximately 112 million farm households spread over 127 agro-climatic zones of the country with a variety of crop and animal production system. Current GDP (International Monetary Fund, 2009) is estimated to be $1.185 trillion, and per capita GDP is $981. The rural per capita income is approximately $ 0.40 per day.

The literacy rate in the country is 65.38 %. Use of computers and Internet is increasing day by day in rural India with the help of various ICT projects. Presently India has about 12 million Internet subscribers. Broad-band service is becoming more common and readily available across the country, with fiber connectivity available in almost every town, and all villages lie within a 15 to 20 kilometer radius of these towns. Telecommunications density in the country as a whole is 7.02 per 100 households, and 1.7 per 100 households in rural areas. Additionally, there are over 62 million mobile telephones and 2 to 2.5 million more are added per month.

The Indian software industry is globally competitive, growing from exports of $25 million in 1985 to over $12.8 billion by 2003-04 (NASSCOM, 2005). Software exports grew at 41 percent annually in the 1980s and 47 percent in the 1990s (in current rupees) and 33 percent and 39.6 percent respectively (in current dollars). Overall growth rates over the last two decades have been 43.7 percent (in current rupees) and 34.4 percent (in current dollars). The IT software and services industry registered a growth of 55 per cent, reaching $21.5 billion in revenues in 2003-04 and $28.2 in 2004-05 (NASSCOM, 2005).

Over the last century, Indian agriculture has undergone major transformation, moving from a production environment principally reliant upon manpower to mechanization. Mechanization has enabled farmers to efficiently and systematically farm more land and increase the level of output per acre of farmland. Concomitantly, government enacted land reforms were put in place to try and reduce the negative impacts of marginal or subsistence farming and to facilitate intensive farming. Government farm support programs and a growing demand for food from a rapidly growing population in the post-independence years has fueled a search for new types of technologies to relieve the constraints on the existing agricultural production complex. Agricultural output has increased due to factors such as bringing additional area under cultivation, extension of irrigation facilities, use of better quality seeds, water management, and plant protection. Information technology has the potential to further revolutionize the agricultural sector by enhancing the efficiency of managerial resources and allowing producers to network more effectively throughout the market.

Globalization and new technological changes brought on by the last seventeen years of economic reforms have made Indian farmers more vulnerable to global competition. While farmers now have access to potentially expensive but promising biotechnology, they still must contend with the myriad of traditional concerns such as commodity prices, access to financing, and adequate crop insurance. Modified seeds can cost nearly twice as much as ordinary ones. This has led many farmers towards taking on ever larger loans, often from moneylenders charging exorbitant interest rates. According to one government report, over 17,107 farmers committed suicide in 2003 (Segupta, 2006). According to the government study, 86.5 percent of farmers who took their own lives were indebted, with an average debt of $835, and 40 percent had suffered crop failure.

An evolving and increasingly powerful ICT infrastructure has fundamentally changed the nature of global relationships, sources of competitive advantage and opportunities for economic and social development. Technologies such as the Internet, personal computers, broadband and wireless telephony have created an interconnected global network of individuals, firms and governments. While there is substantial evidence that new information technologies are in many ways transforming how modern economies operate, the impacts on productivity and economic growth have been much harder to detect. Especially in countries where the dominant sector of the economy is still agriculture.

Recent literature about the role of ICT on economic growth has been mixed. Among the country level studies, Kraemer and Dedrick (1994) found a significant relationship between IT investment and productivity growth with the data from 12 Asia Pacific countries. Dewan and Kraemer (1998) used a data set from 36 countries for the period 1985-1993 and showed that IT investment is positive for developed countries but not significant for developing countries. Matti Pohjola (2000, 2002) performed cross-country studies with the data from 39 and 42 countries covering the periods 1980-1995 and 1985-1999 respectively. The results confirmed Dewan and Kraemer's (2000) conclusion that IT plays a significant role in economic growth in developed countries but no substantiated role in developing countries.

Therefore, in this paper we study the relationship between ICT and Agriculture sector to understand how technology can contribute to growth in a country where 70% of the population still depends on agriculture. The case of India for ICT to be an engine of growth and development must rest mainly on standard economic criteria, such as comparative advantage, complementarities, and the dynamic of the global economy (Singh, 2004). The IT sector can be an important source of growth for India if the country has a comparative advantage in providing certain kinds of IT-related advantages to the agricultural sector, if the global demand for Indian agricultural products and services is likely to grow rapidly, and if the growth of the sector has positive spillover benefits to the rest of the domestic economy. One of the most interesting issues is the spillover benefits or positive externalities that arise leading to economic growth in general. This is the area where the ICT sector may be special, and not just another export enclave. Are the spillover effects of entry of large MNCs, by way of technology transfer, training of personnel and export growth, significant such that the inflow of relatively small quantum of capital is supplemented by significant intangible gains? I.e. signaling to others that investment in India is worthwhile. What are the potential mechanisms by which ICT can accelerate India's agricultural growth? Is there a causal relationship between ICT, agricultural exports and economic growth in India?

ICT – INDIAN AGRICULTURE: AREAS OF ICT – AGRICULTURE CONVERGENCE

According to Richardson (1997) information technology applications supporting agricultural and rural development fall into five main areas, economic development of agricultural producers, community development, research and education, small and medium enterprises development, and media networks. Development services that can be provided using ICT include automatic language translation technologies, low-cost telephone and e-mail integration, distance education, management information, voice/text-based government services, banking, local weather prediction, and agricultural extension services. The second 'plank' of the ICT platform would be intensification of ICT use in resource based industries and manufacturing. In this domain there is likely to be a more intensive use of imported know-how, but the ability to integrate and improve ICT use in these existing industries is critical to their development. The third 'plank' of the ICT strategy would be the use of earth observation (satellite and aerial) data to support government, industry and agricultural extension centers in key areas such as, disaster prevention, monitoring and remediation, mapping and GIS services, agriculture services, land-use and urban development services.

The use of information technology and electronic mass media is a high priority for agricultural extension and dissemination of information to the farming community. Under a World Bank funded project, the National Agriculture Technology Project (NATP), Innovations in Technology Dissemination (ITD) was started in 1998. The project is currently operational in 28 districts of seven states (four districts in each) namely – Andhra Pradesh, Bihar, Himachal Pradesh, Jharkhand, Maharashtra, Orissa and Punjab. The project focuses on restructuring public extension services and testing new institutional arrangements for technology transfer. Under the project the Agriculture Technology Management Agency (ATMA) has been established in each of the 28 project districts. ATMA is a registered society of key stakeholders involved in agricultural activities for sustainable development in the district by integrating research-extension activities with the day to day operations of the Public Agricultural Technology Dissemination System. All the research, training, development and extension activities run by public, private and other organizations in the district are integrated under ATMA. A State Agriculture Management and Extension Training Institute (SAMETI) is also supported to meet training and capacity building requirement under the Project. The National Institute of Agriculture Extension Management (MANAGE) provides training and capacity building to the Project. The model of ATMA is now being implemented in 252 district of the country. There is intensive use of information technology and media back up.

Presently agricultural extension activity in India is being carried out through a number of public (government) extension services (Department of Agriculture and Cooperation of the Union Ministry of Agriculture and their counter parts in State Departments of Agriculture, Horticulture, Animal Husbandry, Fishery, Forestry, Livestock Development and other line departments for the development of agriculture and allied activities for the welfare of rural people), 38 SAU based Directorates of Extension, research stations and institute village linkage programs. A number of private agricultural extension services have arisen including, agri-clinics and agribusinesses by agriculture graduates, the Kisan (farmer) Call Centers (a countrywide common toll-free telephone number 1551 has been allocated to these centers), non-governmental organizations (NGOs) and farmer's organizations (FOs), input suppliers/dealers (pesticides, seeds, nutrients, farm implements, etc.), and the corporate sector. Mass media support for these programs is offered through radio, television, private cable channels, print media, audio and video materials, and regional and national fairs and exhibits.

Despite the huge potential to harness ICT for agricultural development, only a few isolated projects have been initiated in India and a few in other parts of the world. Interestingly, many of these projects were started by NGOs, private organizations, cooperative bodies and governmental organizations other than agricultural departments. This shows the apathy of agricultural development departments towards incorporating ICT into their day-to-day activities. To formulate a strategy for overall agricultural development, the isolated ICT projects need to be studied and the experiences generated must be documented in order to draw lessons for the future.

A number of other ICT initiatives related to agriculture and rural development also exist such as extension services through village based internet connected information kiosks. The main focus of ICT in agriculture is meeting the farmers' needs for information. While the specific information needs may vary, the Indian farmer generally needs information on the following types of issues, agricultural information (crop yields and seed availability), methods of cultivations, use of fertilizers and pesticides, use of technology and agricultural equipment, and current export market potential of various crops. Additionally, farmers need access to land records, banking/loan procedures, legal issues, and health and education related issues.

MODEL AND DATA

The Model

This paper uses the cointegration and error-correction models, to test the causal relationship between ICT, AG (agricultural exports) and economic growth. The analysis has to be done in a multivariate setting. We start by considering the three-variable vector autoregressive (VAR) model comprised of ICT, gross domestic product GDP, and AG, all expressed in natural logs. As shown in equation (1), all variables are systematically and endogenously considered at first.

$$\begin{bmatrix} ICT_t \\ GDP_t \\ AG_t \end{bmatrix} = A_0 + A_1 \begin{bmatrix} ICT_{t-1} \\ GDP_{t-1} \\ AG_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} ICT_{t-2} \\ GDP_{t-2} \\ AG_{t-2} \end{bmatrix} + \ldots\ldots\ldots\ldots + A_s \begin{bmatrix} ICT_{t-s} \\ GDP_{t-s} \\ AG_{t-s} \end{bmatrix} + \varepsilon_t \qquad (1)$$

where A_0 is a vector of constant terms, A_i are all matrices of parameters (i = 1, 2, ….., s), and $\varepsilon_t \sim IN(0, 1)$.

Testing for cointegration among the three variables, ICT, real GDP, and AG (expressed in logarithmic form), is accomplished in two steps. First, following Engle and Granger (1987), the time series properties of each variable are examined by unit root tests. In this step, it is tested whether ICT, GDP, and AG are integrated of order zero, $I(0)$, or in other words, that the three series are stationary. This is accomplished by performing the augmented Dickey-Fuller (ADF) test. The ADF test is based on the regression equation with the inclusion of a constant and a trend of the form

$$\Delta X_t = \beta_0 + \mu t + \theta_1 X_{t-1} + \sum_{j=1}^{p} \beta_j \Delta X_{t-j} + \varepsilon_t \qquad (2)$$

Where $\Delta X_t = X_t - X_{t-1}$ and X is the variable under consideration, p is the number of lags in the dependent variable (chosen so as to induce a white noise term), and ε_t is the stochastic error term.

When the variables are found to be both integrated of degree $I(1)$, and cointegrated, then either unidirectional or bi-directional Granger causality must exist in at least the $I(0)$ variables. If the variables are cointegrated then there must exist an error-correction representation that may take the following form:

$$\Delta \ln ICT_t = \phi_0 + g\delta_{t-1} + \sum_{i=1}^{k} \phi_{1i} \Delta \ln ICT_{t-i} + \sum_{i=1}^{k} \phi_{2i} \Delta \ln GDP_{t-i} + \sum_{i=1}^{k} \phi_{3i} \Delta \ln AG_{t-i} + \varepsilon_{2t} \qquad (3)$$

$$\Delta \ln GDP_t = \pi_0 + h\rho_{t-1} + \sum_{i=1}^{k} \pi_{1i} \Delta \ln GDP_{t-i} + \sum_{i=1}^{k} \pi_{2i} \Delta \ln ICT_{t-i} + \sum_{i=1}^{k} \pi_{3i} \Delta \ln AG_{t-i} + \varepsilon_{3t} \qquad (4)$$

$$\Delta \ln AG_t = \gamma_0 + f\,\upsilon_{t-1} + \sum_{i=1}^{k}\gamma_{1i}\,\Delta \ln AG_{t-i} + \sum_{i=1}^{k}\gamma_{2i}\,\Delta \ln ICT_{t-i} + \sum_{i=1}^{k}\gamma_{3i}\Delta \ln GDP_{t-i} + \varepsilon_{1t} \quad (5)$$

Where δ_{t-1}, ρ_{t-1} and υ_{t-1} are the error-correction terms. If the series are cointegrated, then the error-correction models given in equations (3), (4) and (5) are valid and the coefficients g, h and f are expected to capture the adjustments of $\Delta \ln ICT_t$, $\Delta \ln GDP_t$ and $\Delta \ln AG_t$ towards long-run equilibrium, while $\Delta \ln ICT_{t-i}$, $\Delta \ln GDP_{t-i}$ and $\Delta \ln AG_{t-i}$ are expected to capture the short-run dynamics of the model.

Data

Quarterly data for the period 1990-2005 are used for estimation. Investment in telecommunications is taken as a proxy for ICT, and agricultural exports is taken as proxy for AG. Data on ICT, gross domestic product (GDP) and agriculture exports (AG) for India are from International Telecommunication Union's, *World Telecommunication Indicators Database*; several issues of the UNCTAD, *World Investment Report*; a*nd Ministry of Agriculture, Government of India reports, and* International Monetary Fund's *International Financial Statistics Yearbook* respectively. Nominal figures of AG, ICT, and GDP were deflated by the GDP deflator (1990=100) for India to express them in real terms. The GDP deflator was collected from the International Monetary Fund's *International Financial Statistics Yearbook.*

EMPIRICAL RESULTS

The cointegrating properties of the variables involved are examined and the empirical results are discussed in this section. Table 1 presents the results of unit root tests obtained using the augmented Dickey-Fuller test. The results support the presence of unit roots in all of the series for India. This is confirmed by the fact that the null hypothesis that the series are non-stationary is not rejected at the levels for all variables. However, the null hypothesis is rejected in favor of the alternative hypothesis that the series are stationary when the first difference of the variables is taken. Thus, their first differences are found to be stationary and hence, are all integrated of order one; in all cases, the null hypothesis that the series has unit roots cannot be rejected. The tests of unit roots support the unit root hypothesis at the 1%, 5% or 10% levels of significance for all data series.

Having confirmed the existence of unit roots for all the data series, the next step is to check the results of Johansen-Juselius cointegration tests presented in Table 2. The Johansen-Juselius cointegration test provides evidence for the existence of one cointegration vector implying that the three variables are cointegrated. Thus, the results of Johansen-Juselius cointegration test imply a long-run association between ICT, real GDP, and AG for India. Therefore, equations (3), (4) and (5) have been estimated including the error-correction terms.

The empirical results of the estimated error-correction models are presented in Table 3. Beyond the analysis of the long-run relationship among the three variables in the system for India, the short-run dynamics is also explored performing multivariate Granger causality tests for the vector error-correction model.

TABLE 1
AUGMENTED DICKEY-FULLER UNIT ROOT TEST

Level

Country	$\ln ICT$		$\ln GDP$		$\ln AG$	
	ADF_1	ADF_2	ADF_1	ADF_2	ADF_1	ADF_2
India	-2.7273	-0.4401	-1.6243	-0.6739	-2.2456	-2.4152

First Difference

Country	$\Delta \ln ICT$		$\Delta \ln GDP$		$\Delta \ln AG$	
	ADF_1	ADF_2	ADF_1	ADF_2	ADF_1	ADF_2
India	-4.2171***	-4.0886***	-3.2814***	-4.1201**	-4.1833***	-3.8039**

Notes:

ADF_1 tests $H_0 : \theta_1 = 0$ in $\Delta \ln X_t = \beta_0 + \theta_1 \ln X_{t-1} + \sum_{j=1}^{m} \beta_j \Delta \ln X_{t-j} + \varepsilon_t$ (6)

ADF_2 tests $H_0 : \theta_2 = 0$ in $\Delta \ln X_t = \varphi_0 + \varphi_1 t + \theta_2 \ln X_{t-1} + \sum_{j=1}^{m} \varphi_j \Delta \ln X_{t-j} + \varsigma_t$ (7)

*, **, and *** denote statistical significance at the 10% 5%, and 1% levels, respectively.

TABLE 2
JOHANSEN MULTIVARIATE COINTEGRATION TESTS

Trace Test			
Country	**Null Hypothesis**		
	$r = 0$	$r \leq 1$	$r \leq 2$
India	39.03***	12.02	1.13
Maximum Eigenvalues Test			
Country	**Null Hypothesis**		
	$r = 0$	$r = 1$	$r = 2$
India	23.67**	11.31	1.12

Cointegration Equations Normalized on $\ln AG_t$				
Country	Constant	$\ln ICT_t$	$\ln GDP_t$	Log Likelihood
India	22.7395	0.9812 (3.074)	0.3672 (0.022)	54.01

Note: *, **, and *** denote statistical significance at the 10% 5%, and 1% levels, respectively. Figures in parentheses are standard errors.

The F-statistics and probability (in parentheses) for the Granger causality tests are presented in columns 2-4 in Table 3. It also includes the t-statistics for error-correction terms for each of the three equations. For each variable in the system, at least one channel of Granger causality is active, either in the short-run through the joint tests of the lagged-differences or in the long run through statistically significant error-correction term.

TABLE 3
RESULTS OF ERROR CORRECTION MODELS

India

Dep. Variable	Source of causation ΔICT	ΔGDP	ΔAG	EC_{t-1} (t-value)	Causal inference
ΔICT	-	7.3282 (0.006)	7.117 (0.002)	-0.0040** (-2.551)	$GDP \xrightarrow{SR} ICT$; $AG \xrightarrow{SR} ICT$ $GDP, AG \xrightarrow{LR} ICT$
ΔGDP	7.1642 (0.003)	-	10.8924 (0.001)	-0.1831 (-1.299)	$ICT \xrightarrow{SR} GDP$; $AG \xrightarrow{SR} GDP$
ΔAG	7.3668 (0.001)	4.1052 (0.018)	-	-0.3031 (-0.701)	$ICT \xrightarrow{SR} AG$; $GDP \xrightarrow{SR} AG$

Notes:
EC denotes the error-correction term. *, ** and *** indicate the statistical significance at the 10%, 5% and 1% levels of significance respectively. Figures in parentheses are t-values. The symbols “ $\xrightarrow{SR}$ ” and “ $\xrightarrow{LR}$ ” represent unidirectional causality in the short run and long run respectively.

The first interesting observation from our results is that India shows evidence of bi-directional causality for ICT and economic growth (GDP). These finding are different from what the empirical literature shows, but consistent with the theory on ICT and growth indicating positive spillovers and ICT is an engine of economic growth. The second observation from our results is that India shows evidence of bi-directional causality for AG and economic growth (GDP). These findings are consistent with standard literature in this field. A third important observation of this study is that there is a two-way causality between ICT and AG indicating that ICT is an important determinant of AG and that AG promotes ICT. Bi-directionality in this context is quite surprising. AG promotes ICT though is not consistent with existing literature and the Indian context; the results can be explained in terms of the agricultural proxy in this paper being agricultural exports. Had the proxy been some other variable like agricultural growth rates, agricultural employment, or share of agriculture in GDP it is possible the results may not be the same. This is left for future exploration.

The results of this study find evidence to support the claim that ICT is a strong engine of growth in this region. In India, there is some evidence of either ICT-led growth or growth-led ICT; ICT led AG or AG led ICT; and AG led growth or growth led AG Granger causality in the short-run. Summary of our findings are presented in Table 4.

TABLE 4
COMPARATIVE EVALUATION OF MAJOR FINDINGS

CAUSATION	INDIA
ICT ↔ GDP	√
ICT → GDP	√
GDP → ICT	√
AG ↔ GDP	√
AG → GDP	√
GDP → AG	√
ICT ↔ AG	√
ICT → AG	√
AG → ICT	√

Notes:
√ denotes the presence of causality and blank spaces indicate no evidence of causality

While the findings of our study are decidedly different from those of studies by Dewan and Kraemer (1998; 2000), Matti Pohjola (2000; 2002), and Addison and Heshmati (2003), they are however more consistent with theory with one exception. Our analysis for India shows positive results with regard to a complementary relationship between Growth, AG and ICT.

CONCLUSION

In this paper the cointegration and error-correction modeling techniques used indicate that there is significant bi-directional causality between the three variables ICT, AG and GDP. The outcome of our India study shows bi-directionality in all situations and is not consistent with theory.

The growing importance of India's ICT sectors share in exports, in GDP; in technology spillovers or in the labor force participation is now a fact rather than just a promise. It has allowed India to leapfrog vintage technologies thereby accelerating economic growth. The notion that unlike in developed countries where there already exist a built up ICT capacity which causes higher agricultural productivity, in developing countries like India, ICT capacity must be build up first and there has to be a trickle down to the grass root level to see productivity changes, especially since 2/3rd of the country is agriculture dependent. The causal relationship between ICT and AG indicates that ICT sector has matured enough that this sector is making dents into the agricultural sector all by itself, very much like the green revolution in the late 1960s. This sector seems to have developed a virtuous cycle between the three ICT, AG and GDP. Rather than making generalizations of a strong relationship, it should be understood that the trends are in the positive direction but there needs to be concerted effort from all sides before this information revolution can make a dent in the India's subsistence farming.

At the same time, there are many concerns with the IT boom in India. Linear projections of future growth extrapolating from the past should be treated with skepticism. And if it were to turn out to be true, it would create a new set of macroeconomic problems for India. IT related exports alone could well exceed all current account payments by the end of the decade, completely dominating all other parts of the economy. This could put strong upward pressure on the Indian currency with inimical consequence on other sectors of the economy, especially the terms of trade for agricultural exports. The more troubling effect is that the inordinate focus on the IT sector will only amplify India's inequality – Income inequality and urban-rural divide.

Despite the fact that rest of the Indian economic sectors are still in a developing country context and India is ranked lower in the Human Development Index, the growth of ICT sector and its role in economic growth has proved that it is now dynamic and globally competitive. The nature of the ICT puts it in a category called "general purpose technologies (GPTs)" with large spillover effects in other sectors like bio-informatics, pharmaceuticals, media and entertainment in specific and higher productivity for all others sectors of the economy in general. The floodgates seem to have been opened up; there are already signs of new investments into other sectors of the economy. All of this will have little impact if the trickle down to the agricultural sector is not appropriate.

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