Sources of Growth of Information Sector in India During 1983-84 to 1993-94

By

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Abstract

Of all the technologies of our time, progress in information technology (IT), no doubt, had and continues to have the greatest influence on the global economy, making it possible to collect, process, and transmit information at breathtaking speed and declining cost, thereby increasing productivity and improving quality and efficiency in all types of industries and services. Realizing such huge potential of information technology, the demand for information in every form seems to be steadily increasing throughout the world.
The Indian economy is no exception. Various government policies in the 1980s influenced the growth and structure of the Indian IT industry. India witnessed an impressive growth in information sector in the last decade. The performance of India's telecommunications sector got a shot in 1984. By 1999, India had an installed network of over 25 million telephone lines spread across 300 cities, 4869 towns, and 3,10,897 villages, making India's telecommunications network the ninth largest in the world. The computer software industry in India was identified as a major powerhouse for the incremental development of computer software. According to National Association of Software and Service Companies (Nasscom), the software industry in India was worth Rs.525 billion in 2001-02. The computer software and services exports rose from Rs.65 billion during 1997-98 to Rs.110 billion during 1998-99, a growth of about 70%, making it the single largest export item constituting nearly 86% of the total electronics export.

Realizing the importance of the Indian IT industry, we make an attempt in this paper to study the sources of growth of the information sectors of India during 1983-84 to 1993-94 with the help of input-output techniques.

1. Introduction

Of all the technologies of our time, progress in information technology (IT), no doubt, had and continues to have the greatest influence on the global economy, making it possible to collect, process, and transmit information at breathtaking speed and declining cost, thereby increasing productivity and improving quality and efficiency in all types of industries and services. Most industrialized countries and an increasing number of

Received April 2003, final version received October 2004.
This is a revised version of the paper presented at the "Fourteenth International Conference on Input-Output Techniques" held at Quebec University, Montreal, Canada, 10-15 October, 2002. Thanks are due to an anonymous referee for his valuable comments. Errors, if any, lie with the authors.

newly industrializing countries had been using new information technology in areas as diverse as education, health-care, manufacturing, finance and banking, transportation, commerce, publishing, energy conservation, and environmental management. Therefore, it can be asserted that the impact of information technology on society is tantamount to a second industrial revolution as momentous in its implications as the first [Miller, 2001].

Realizing such huge potential of information technology, the demand for information in every form seems to be steadily increasing throughout the world. Having surpassed the $2 trillion mark in 1999, the global information communication technology (ICT) industry was assumed to smash through the $3 trillion threshold in 2004. The global reach of the ICT revolution could be seen in the performance of both regions and individual nations. U.S. remained world leader in terms of ICT spending in 1999 with $762 billion, followed by Japan ($362 billion) and Germany ($139 billion). The top ten list was rounded out by the United Kingdom, France, Italy, Canada, China, Brazil and Australia. The view that developed countries clearly dominate the top ICT spending list, however, shifts dramatically when the emphasis is changed from 'total spending' to 'growth in spending'. The regions with smallest base of information communication technology (ICT) are out spacing North America and Western Europe, which are regions with mature ICT infrastructures. Eastern Europe and Latin America ICT spending both grew at 42% between 1997 and 1999 compared to North America and Western Europe, which edged up 15% and 13% respectively during the same period. The Middle East/Africa and Asia/Pacific stood the middle ground for spending growth in these years with the former moving up 26% and the latter 18%.

This acceleration among developing nations was also apparent among the top ten spending nations, where China's compound annual growth rate (CAGR) from 1992 to 1999 was approximately seven times that of France and almost nine times that of Italy; Brazil over four times the growth rate of those countries. Vietnam remained the world fastest growing ICT market, sprinting at an almost 35% CAGR over seven years, 1992-1999. Other countries growing at better than 10% included Poland, Colombia, India, Hungary, Romania and Slovakia.

This suggested that while the installed base for ICT remained in Northern economies, the "hot markets" for build out of ICT global infrastructure were the regions with smallest base of ICT.

In spite of the globalization of ICT, the top ten information economies represented 80% of global ICT market; the bottom ten in the rankings represented a collective share of less than 1%. This disparity came to be known as the "Digital Divide" —the gap between nations that could and could not afford technology investments. The top ten countries spending the most on ICT per capita were, respectively, Switzerland, Japan, U.S., Sweden, Denmark, Singapore, Norway, Netherlands, U.K. and Australia. Measured as a percentage of GDP, however, the list was topped by Sweden, New Zealand, U.K., Colombia, Australia, U.S., Czech Republic, Canada, Hong Kong and Singapore. On the opposite end were Indonesia, Russia, Romania, Bulgaria, Thailand, Turkey, other Middle East/Africa, Philippines, other Eastern Europe and Saudi Arabian Gulf States.

In spite of the "Digital Divide", countries like China and Brazil made the "divide" look much more like a digital opportunity. Since 1992, China's ICT spending had experienced a compound annual growth rate of approximately 30%. Were this rate of growth to be continued over the next five years, China would represent a $177 billion ICT marketplace by 2004. This strong positive momentum —the digital opportunity— presented itself in other measures as well. In comparative terms, China's share of worldwide ICT spending increased more than any other country. Back in 1992, China accounted for just 0.6% of global ICT spending. By 1999, this percentage jumped four fold to 2.2%, while nations like, Germany slipped from 8.2% of world ICT spending to 6.5% during the same period; France, moved down from 5.9% to 4.8% and Italy went down from 3.5% to 2.6%.

Thus, we see that regions with smallest base of information communication technology (ICT) were also becoming fastest growing ICT region. The Indian economy was no exception. She too had been aspiring to modernize its infrastructure, transform its industry and join the global economy.

Government policies have been highly influential in shaping the development agenda of the Indian information economy. The realization of the importance of informatization of the economy was reflected in the computer policy of November 1984, which signaled a substantial liberalization of import policy on complete computers, computer kits and components. The period 1987 to 1990, however, witnessed a steady reversal of some earlier import liberalizations because of concerns about impact of earlier liberalizations and changes in political economy of the state. So the policy at the end of this period was a compromise between the relative extremes of protectionism and liberalization. Following the severe balance of payment crisis of 1991, computer industry policy was again subject to a familiar set of liberalizations.

The policy changes in the eighties had positive impact on the growth and structure of the Indian IT industry. Along with other Asian countries such as Philippines, Malaysia and Hong Kong, India witnessed an impressive growth in information sector in the last decade. The performance of India's telecommunications sector got a shot in 1984. In 1985, the Ministry of Post and Telegraphs was reorganized and a Department of Telecommunication was formed under a new Ministry of Communications to focus exclusively on the telecommunications sector. There after a sea change occurred in the telecommunications scenario. By 1999, India had an installed network of over 25 million telephone lines spread across 300 cities, 4869 towns, and 3,10,897 villages, making India's telecommunications network the ninth largest in the world.

The computer software industry in India was identified as a major powerhouse for the incremental development of computer software. According to National Association of Software and Service Companies (Nasscom), the software industry in India was worth Rs.525 billion in 2001-02, whereas in 1995-96 its worth was not more than 42.4 billions. Various government policies identified software as thrust areas for exports, which already achieved a certain measure of success. The computer software and services exports rose from Rs.65 billion during 1997-98 to Rs.110 billion during 1998-99, a growth of about 70%, making it the single largest export item constituting nearly 86% of the total electronics export. According to a recent study conducted by Ernst and Young, and sponsored by the Manufacturers' Association for Information Technology (MAIT), the Indian electronics hardware industry was expected to reach $25 billion in export by 2010. Though the software industry was primarily export oriented, the Indian IT hardware industry was domestic market oriented. It grew at an average annual rate of 13% between 1995-96 and 2001-02.

The most important impact of the computer on the Indian economy was generated by the Internet. According to a survey conducted by Nasscom, India had an estimated 1.6 million Internet subscribers and about 4.8 million users in August 2000. With the favourable Internet service provision and policies of the government, these numbers were projected to explode to about 15 million subscribers or roughly 50 million users by 2003.

The Internet spawned the era of e-business (electronic business), which consisted mainly of e-marketing and e-commerce. India was still in the infant stages of e-commerce. In 1999-2000, only Rs.4500 million worth of e-commerce (both business-to -business [B2B] and business-to-consumer [B2C]) was transacted. McKinsey, the global consulting company, projected the e-commerce market in India at $10 billion by 2008.

Since the policy changes in the eighties had positive impact on the growth and structure of the Indian IT industry, in this paper we propose to identify the sources of growth of the Indian information sector during the period 1983-84 to 1993-94 with 1989-90 as the watershed year using Structural Decomposition Analysis (SDA). This technique is regarded as one of the useful tools to identify sources of growth.

The paper is arranged in the following manner: We begin with the description of two theoretical models developed in an input-output framework adopted for the present study. This is followed by coverage and analysis of data. The results of the decomposition analysis has been presented and analyzed next. The paper concludes with a synopsis of the findings and their implications.

2. Model

For the purpose of identifying the sources of growth in the various information sectors, a Model based on Structural Decomposition Analysis (SDA) has been developed. SDA are nowadays a common descriptive tool in studying changes over time. The central idea is that the change in some variable is decomposed, usually in an additive way, into the changes in its determinants. It thus becomes possible to quantify the underlying source of the changes. A good volume of literature with respect to SDA methodology and its application has developed in recent years. To name a few are Rose & Carter (1996), Albala-Bertrand (1999), Alcala et al. (1999), Mukhopadhyay & Chakraborty (1999), Dietzenbacher & Los (2000), Drejer (2000), During & Schnabl (2000), Shishido et al. (2000), Jacobsen (2000) and de Hann (2001).

Two models based on Structural Decomposition Analysis (SDA) have been developed which are presented below.

2.1 Model I

Model I starts from an accounting identity of demand and supply. In an open Leontief system, the basic material balance between demand and supply can be written as

$$X_i = u_i (D_i + W_i) + E_i \tag{1}$$

where

X_i = domestic production of commodity i

D_i = domestic final demand for commodity i

W_i = intermediate demand for commodity i

E_i = exports of commodity i

u_i = domestic supply ratio defined by $(X_i - E_i) / (D_i + W_i)$ i.e. the proportion of intermediate and final demand produced domestically in sector i

Noting that the intermediate demand is determined by production levels and input-output coefficient matrix, W = AX, equation (1) in matrix notation can be expressed as

$$\begin{aligned} X &= uD + uAX + E \\ \text{or } X &= (I - uA)^{-1}(uD + E) \\ &= R\,(uD + E) \end{aligned} \tag{2}$$

where

$R = (I - uA)^{-1}$

u = diagonal matrix of sector domestic supply ratio

A = the matrix of input-output coefficient (a_{ij}) and X, D and E are vectors

Using equation (2) we can transform the basic material balance equation into information balance equation as

$$eX = e[R(uD + E)] \tag{3}$$

where e is a diagonal matrix composed of ones and zeros. The ones appear in the column locations that correspond to information sectors and all the other elements of the matrix are zeros. The matrix selects the information rows from input-output table.

The change in output of information sectors between the base year (0) and the comparison year (1) can be written as

$$\begin{aligned} \Delta eX &= e\,(X_1 - X_0) \\ &= e\,[R_1\,(u_1D_1 + E_1) - R_0(u_0D_0 + E_0)] \end{aligned} \tag{4}$$

Adding and subtracting $eR_1u_1D_0$, eR_1E_0 and $eR_1u_0D_0$ in equation (4), we have

$$\begin{aligned} \Delta eX &= e\,[R_1u_1D_1 + R_1E_1 - R_0u_0D_0 - R_0E_0 + R_1u_1D_0 - R_1u_1D_0 \\ &\quad + R_1E_0 - R_1E_0 + R_1u_0D_0 - R_1u_0D_0] \\ &= e\,[R_1u_1(D_1 - D_0) + R_1(E_1 - E_0) + R_1(u_1 - u_0)D_0 \\ &\quad + (R_1 - R_0)u_0\,D_0 + (R_1 - R_0)E_0] \\ &= e\,[R_1u_1\Delta D + R_1\Delta E + R_1\Delta uD_0 + \Delta R(u_0\,D_0 + E_0)] \end{aligned} \tag{5}$$

Now $\Delta R = R_1 - R_0$

$$\begin{aligned} &= -R_1[(R_1)^{-1} - (R_0)^{-1}]R_0 \\ &= -R_1[I - u_1A_1 - I + u_0A_0]R_0 \\ &= R_1[u_1A_1 - u_0A_0]R_0 \end{aligned} \tag{6}$$

Adding and subtracting u_1A_0 in equation (6), we have,

$$\begin{aligned}\Delta R &= R_1 [u_1A_1 - u_1A_0 + u_1A_0 - u_0A_0]R_0 \\ &= R_1 [u_1(A_1 - A_0) + (u_1 - u_0)A_0]R_0 \\ &= R_1u_1\Delta AR_0 + R_1\Delta uA_0R_0 \end{aligned} \quad (7)$$

Substituting (7) in (5)

$$\begin{aligned}\Delta eX &= e[R_1u_1\Delta D + R_1\Delta E + R_1\Delta uD_0 + R_1u_1\Delta AR_0(u_0D_0 + E_0) \\ &\quad + R_1\Delta uA_0R_0(u_0D_0 + E_0)] \\ &= e[R_1u_1\Delta D + R_1\Delta E + R_1\Delta uD_0 + R_1\Delta uA_0X_0 + R_1u_1\Delta AX_0] \\ &= e[R_1u_1\Delta D + R_1\Delta E + R_1\Delta u(D_0 + A_0X_0) + R_1u_1\Delta AX_0]\end{aligned}$$

Thus the total output of information sectors can be decomposed into its sources by category of demand as

$$\Delta eX = e[R_1u_1\Delta D + R_1\Delta E + R_1\Delta u(D_0 + W_0) + R_1u_1\Delta AX_0] \quad (8)$$

The first term on the right hand side denotes the impact of the change in domestic final demand; the second one the impact of change in exports and the third term measures the import substitution effect on production of information goods and services as expressed by changes in domestic supply ratio. The fourth term denotes the impact of changes in input coefficients. This effect represents widening and deepening of interindustry relationship over time brought about by the changes in production technology as well as by substitution among various inputs, although one cannot separate these two causes.

Each term in the decomposition is multiplied by elements of the Leontief domestic inverse. The terms therefore capture both the direct and indirect impact of each causal expression on gross output of information sectors taking account the linkages through induced intermediate demand.

In the decomposition equation, import substitution is defined as arising from changes in the ratio of imports to total demand. This implicitly assumes that the imports are perfect substitute for domestic goods, since, the source of supply constitute an integral part of the economic structure.

The aggregate contribution of import substitution to growth, as defined here, is sensitive to the level of industry disaggregation. For example, it is possible to have positive import substitution in every industry but have the ratio of total imports to total demand increase because of changes in the industry composition of demand.

The effect of changes in input coefficient includes changes in the total coefficient and does not separately distinguish between imported and domestically produced goods. Thus, the input coefficients may remain constant ($\Delta a_{ij} = 0$) and hence the last term in (8) will be zero even though there are changes in domestic supply ratio. Changes in technology are defined as changes in the total coefficients while any changes in the intermediate domestic supply ratios are included in the import substitution term.

Assuming that changes in information use technologies and changes in noninformation technologies within each sector are separable, the effect of change in input coefficients or often termed as technological change can be further decomposed into the effect of technological changes in information use and the effect of technological changes in noninformation use . We can do so by partitioning and writing the changes in technical coefficients as

$$(A_1 - A_0) = (A_{1,I} - A_{0,I}) + (A_{1,N} - A_{0,N}) \quad (9)$$

where A_I represents the information rows of technical coefficient matrix and A_N represents the non-information rows. Thus,

$$\begin{aligned} & eR_I u_I \Delta A X_0 \\ &= eR_I u_I (A_1 - A_0) X_0 \\ &= eR_I u_I [(A_{1,I} - A_{0,I}) + (A_{1,N} - A_{0,N})] X_0 \\ &= eR_I u_I (A_{1,I} - A_{0,I}) X_0 + eR_I u_I (A_{1,N} - A_{0,N}) X_0 \end{aligned} \quad (10)$$

While the first term of equation (10) captures the effect of changes in information inputs, the second term shows the effect of changes in non-information inputs. This tells us that the change in intermediate information demand can be caused not only by changes in direct information inputs (A_I) but also by changes in direct non-information inputs (A_N). Furthermore, the changes in direct input requirements will be multiplied across the economy, through inter-industry input-output linkages, which are quantified by the total requirement matrix, R.

Domestic final demand can be further decomposed into growth effect and mix effect. If we define λ^D as the ratio of domestic final demand between any two periods, which is used to indicate the factor of proportional growth during the period i.e.

$$\lambda^D = \mu D_1 / \mu D_0$$

where D represents domestic final demand vector and
μ is a unit row vector
G_d is a diagonal matrix whose diagonal elements are λ^D
then the effect of domestic final demand change can be further decomposed into:

$$\begin{aligned} & eR_I u_I \Delta D \\ &= eR_I u_I [D_1 - D_0] \end{aligned}$$

Adding and subtracting $eR_I u_I G_d D_0$

$$= eR_I u_I [D_1 + G_d D_0 - G_d D_0 - D_0]$$

Rearranging terms then yields

$$eR_I u_I \Delta D = eR_I u_I \, [G_d - I] \, D_0 + eR_I u_I [D_1 - G_d D_0] \quad (11)$$

The first term of equation (11) shows the effect of growth in domestic final demand and the second term depicts the effect of mix in domestic final demand.

In addition, we can also calculate the information output changes that originate in individual domestic demand categories, such as, private final consumption expenditure (PFCE), government final consumption expenditure (GFCE), gross fixed capital formation (GFCF) and change in stock (CIS). Mathematically this is very simple, because final demand in the input-output system is additive. Thus

$$\begin{aligned} & eR_I u_I \Delta D = eR_I u_I \sum_h \Delta D^h \\ &= eR_I u_I \sum_h [(G_d - I) \, D_0 h + (D_1^h - G_d \, D_0^h)] \end{aligned} \quad (12)$$

where ΔD^h is the change in information output resulting from changes in domestic demand category h.

We summarize the hierarchial structure of the estimation equations in Table 1.

Table 1: Structural Decomposition of Change in Information Output Based on Sda (Model I)

Factors	Equation
Change in information output	$e\ (X_1 - X_0) = e\ [R_1\ (u_1 D_1 + E_1) - R_0\ (u_0\ D_0 + E_0)]$
Domestic final demand effect	$eR_1u_1[D_1 - D_0]$
Effect of mix	$eR_1u_1[D_1 - G_d\ D_0]$
Effect of growth	$eR_1u_1[G_d - I]\ D_0$
For demand source h	$eR_1u_1[(G_d - I)\ D_0^h + (D_1^h - G_d\ D_0^h)]$
Export effect	$eR_1(E_1 - E_0)$
Import substitution effect	$eR_1(u_1 - u_0)(D_0 + W_0)$
Technical coefficient effect	$eR_1u_1(A_1 - A_0)X_0$
Information input coeff.	$eR_1u_1(A_{1,I} - A_{0,I})X_0$
Non inf. input coeff.	$eR_1u_1(A_{1,N} - A_{0,N})X_0$

2.2 Model II

In the previous model the sources of import substitution have been ignored. Also, several authors like Chenery and Syrquin (1986) and Syrquin (1988) have pointed out that the role of the last factor i.e., technology has been underestimated for a long time. In this model, our aim is to investigate these two aspects of the structural transformation. The prime difference between the previous model and this is that in the latter import has been endogenized.

First, we define:

X_{ij}^d = element (i,j) of the matrix of intermediate deliveries supplied by domestic production

M_{ij}^d = element (i,j) of the matrix of intermediate imports by origin

so that

$X_{ij} = X_{ij}^d + M_{ij}^d$ = element (i,j) of the matrix of intermediate deliveries

Then, we define:

D_i^d = element i of the vector of domestic final demand supplied by domestic production

D_i^m = element i of the vector of imported domestic final demand

so that

$D_i = D_i^d + D_i^m$ = element i of the vector of domestic final demand

Next, we define

E_i = element i of the vector of exports

Then we have the input-output accounting identities

$$X_i = X^d_{ij} + D^d_i + E_i \tag{13}$$

where X_i denotes the i element of vector of gross output supplied by domestic production

Finally we define

u^f = a diagonal matrix with $u^f_i = D^d_i / D_i$ as the element on the main diagonal (i.e. u^f is the domestic supply ratio of the domestic final demand for product i)

A^d = the matrix of domestic input-output coefficient

$R^d = [I - A^d]^{-1}$ = the Leontief domestic inverse matrix

A^m = matrix of imported intermediate input coefficients with $a^m_{ij} = M_{ij} / X^d_j$ as element (i,j), and

$A = A^d + A^m$, i.e. the matrix of total (domestic plus imported) input-output coefficients

Then equation, in obvious notation reads: $X^d = A^d X^d + u^f D + E$ from which it easily follows that

$$X^d = R^d (u^f D + E) \tag{14}$$

Using equation (14) we can transform the basic material balance equation into information balance equation as

$$eX^d = eR^d (u^f D + E) \tag{15}$$

where e is a diagonal matrix composed of ones and zeros. The ones appear in the column locations that correspond to information sectors and all the other elements of the matrix are zeros. The matrix selects the information rows from input-output table.

The change in output of information sectors between the base year (0) and the comparison year (1) can be written as

$$\Delta e\ X^d = eR^d_1 (u^f_1 D_1 + E_1) - eR^d_0 (u^f_0 D_0 + E_0) \tag{16}$$

From the above equation (16) we can easily derive

$$\Delta e\ X^d = e[R^d_1 u^f_1 \Delta D + R^d_1 \Delta E + R^d_1 \Delta u^f D_0 + \Delta R^d (u^f_0 D_0 + E_0)] \tag{17}$$

The first term on the right hand side denotes the impact of the change in domestic final demand (supplied by domestic production), the second one the impact of the change in exports and the third one the impact of substitution of imports by local domestic final demand (import substitution of final products). The fourth term denotes the change in the Leontief domestic inverse matrix that will be decomposed below into impact of technological change and of import substitution of intermediate products.

Now $\Delta R^d = R^d_1 \Delta A^d R^d_0$

So equation (17) can be rewritten to

$$\Delta e\ X^d = e[R^d_1 u^f_1 \Delta D + R^d_1 \Delta E + R^d_1 \Delta u^f D_0 + R^d_1 \Delta A^d X^d_0] \tag{18}$$

Since it is clear that ΔA^d is caused by technological change as well as by import substitution of intermediate products, we have to separate these two effects from each other.

The ratio $a_{ij1} / a_{ij0} - 1$ is the change in the total technical coefficient which we will take to be the rate of technological change (=TC). Consequently, when we multiply a^m_{ij0} by (1+TC), we obtain a value of a^m_{ij} in period 1 (denoted by $a^m_{ij0}{}'$) that would have been observed if a^m_{ij} would only have been affected by technological change; i.e.

$$a^m_{ij0}{}' = (a_{ij1} / a_{ij0})\, a^m_{ij0} \qquad (19)$$

Consequently, $a^m_{ij1} - a^m_{ij0}{}'$ denotes that part of a^m_{ij} that is caused by import substituion of intermediate products only. Since $a^d_{ij1} = a_{ij1} - a^m_{ij1}$, $-(a^m_{ij1} - a^m_{ij0}{}')$ denotes the same effect on the domestic technical coefficients, in matrix notation:
$-(A^m_1 - A^{m\prime}_0)$ where $A^{m\prime}_0$ is the matrix with typical element $a^m_{ij0}{}'$

Now we have

$$\Delta A^d = \Delta A - \Delta A^m$$
$$= -(A^m_1 - A^{m\prime}_0) + [\Delta A - (A^{m\prime}_0 - A^m_0)] \qquad (20)$$

The typical element of $A^{m\prime}_0 - A^m_0$ is: $a^m_{ij0}{}' - a^m_{ij0}$. Since $a^m_{ij0}{}'$denotes the value of a^m_{ij} that would be observed in period 1 if a^m_{ij} was only affected by technological change, subtracting a^m_{ij0} from $a^m_{ij0}{}'$yields the change in a^m_{ij} caused by technological change only.

Substitution of (20) into (18), the resulting expression is

$$\Delta eX^d = e[R^d_1 u^f_1 \Delta D + R^d_1 \Delta E + R^d_1 \Delta u^f D_0 - R^d_1 (A^m_1 - A^{m\prime}_0)X^d_0$$
$$+ R^d_1 [\Delta A - (A^{m\prime}_0 - A^m_0)]\, X^d_0] \qquad (21)$$

In equation (21), the fourth term denotes the impact of substitution of intermediate products by domestic production and the fifth term denotes the impact of technological change.

Decomposition of the impact of technological change over sectors

It is clear that the last term in equation is equal to the sum of the effects of technological change in each sector j on i. For a more informative analysis of the impact of technological change, we therefore determine the individual impact of technological change in sector j on the growth of output of sector i.

Let us consider the last term of equation. Let $0\hat{}$ denote the vector of which all elements are equal to zero and let $\Delta a_j\hat{}$ denote the j^{th} column of ΔA (= $A_1 - A_0$) and let $c_j\hat{}$ denote the j^{th} column of $A^{m\prime}_0 - A^m_0$, and define the following matrices:

$$B_j = (0\hat{}\ldots.0\hat{}\ \Delta a_j\hat{}\ 0\hat{}\ldots..0\hat{})\quad j = 1,\ldots,n$$

and

$$C_j = (0\hat{}\ldots.0\hat{}\ c_j\hat{}\ 0\hat{}\ldots..0\hat{})\quad j =1,\ldots.,n$$

Then obviously

$$\Delta A= \sum_{j=1}^{n} B_j \text{ and } A^{m\prime}_0 - A^m_0 = \sum_{j=1}^{n} C_j$$

so that

$$R^d_0 [\Delta A - (A^{m\prime}_0 - A^m_0)]\, X^d_1 = \sum_{j=1}^{n} R^d_0 [B_j - C_j]\, X^d_1 \qquad (22)$$

The (nx1) vector $R^d_0 [B_j - C_j] X^d_1$ denotes the impact of the technological change in sector j only, on the output of each on the n sectors.

The matrix that contains the vectors $R_0^d[B_j - C_j]\ X_1^d$ (j = 1,...,n) will be called D. Obviously for the information sector we have:

$$eDi = eR_0^d\ [\Delta A - (A_0^{m\prime} - A_0^m)]\ X_1^d \tag{23}$$

where i = (1...1), i.e. the summation vector.

It is to be noted that the elements on the i^th line of eD can be interpreted as being the impact of technological change in each of the n sectors on the gross output growth of the i^th information sector. Alternatively, the elements on the j^th column of eD measures the impact of technological change in sector j on the gross output growth of each of the information sectors.

We summarize the hierarchial structure of the estimation equations of Model II in Table 2.

Table 2: Structural Decomposition of Change in Information Output Based on Sda (Model II)

Factors	Equation
Change in information output	$eR_1^d\ (u_1^f\ D_1 + E_1) - eR_0^d\ (u_0^f\ D_0 + E_0)$
Domestic final demand effect.	$eR_1^d\ u_1^f\ \Delta D$
Export effect	$eR_1^d\ \Delta E$
Import substitution effect (final demand)	$eR_1^d\ \Delta u^f\ D_0$
Import substitution effect (int. demand)	$eR_1^d\ (A_1^m - A_0^{m\prime})\ X_0^d$
Technical coefficient effect	$eR_1^d\ [\Delta A - (A_0^{m\prime} - A_0^m)]\ X_0^d$

3. Coverage and Analysis of Data

The basic data are the three input-output tables of the Indian economy for years 1983-84, 1989-90 and 1993-94 prepared by Central Statistical Organisation of India (1990, 1998, 2001). They are made comparable by suitable aggregation to 35 order. These 35 sectors are grouped into two broad categories: information and noninformation. Information activities are those which either intrinsically convey information process, produce or distribute information. The sectors that are clubbed under information sector are office computing, communication equipment, electronics equipment and communication. Those activities which do not satisfy the above criteria are termed as noninformation. The two tables are adjusted to 1993-94 prices level by using deflators. A detailed list of aggregation of sectors is provided in the Appendix.

4. Results

Before discussing the results, it is important to present a very brief account of the macro economy of India and its relation to the information sector. The Gross Domestic Product (GDP) growth of Indian economy in the post reform period has improved from an average of about 5.7% in the 1980s to an average of about 6.1% in the post liberalization period initiated in the mid 1991, making India one of the ten fastest growing countries in the world. The Tenth Five Year Plan proposes that Tenth Plan should aim at an indicative target of 8% GDP growth for the period 2002-2007.

This acceleration in the growth rate is not possible without tapping on the opportunities offered by the international economy in terms of markets, investment and technologies. Therefore, a sustained high rate of growth of exports is essential. The Government of India has singles out Information Technology (particularly software) as a high-priority thrust area for expansion.

4.1 Model I

For the purpose of identifying the sources of growth in the various information sectors, the Model I has been used. Table 3 gives the first substantive results of the analysis.

Table 3: Sources of Output Growth for Information Sector of India

Rs. Millions

	1983/84–1989/90	1989/90–1993/94
Change in output	50532.74 (100.00)	66294.22 (100.00)
1. Domestic final demand	45299.95 (89.64)	43694.55 (65.91)
Mix	4630.15 (15.10)	8403.85 (12.68)
Growth	37669.80 (74.55)	35290.70 (53.23)
2. Export	7179.34 (14.21)	6646.86 (10.03)
3. Import substitution	1779.68 (3.52)	–788.90 (–1.19)
4. Technical coefficient	–3726.24 (–7.37)	16745.92 (25.46)
Information input coeff.	1926.93 (3.81)	13066.59 (19.71)
Non information input coeff.	–5653.14 (–11.19)	3677.52 (5.55)

*Figures in the bracket show percentage contribution to the total change in output

Between 1983-84 and 1989-90, India's total information output increased by Rs.50532.74 million. The increase was even larger during 1989-90 to 1993-94. It was of order Rs.66294.22 million. The lower increase during 1983-84 to 1989-90 was an inevitable result of the increasing reversal of liberalization in the late Eighties, combined with hikes in excise and customs duties [Jain, 1992]. For example, in 1987-88 budget, the government raised most import duties and reimposed excise duty on computers at 10%. The next budget again imposed a uniform import duty of 98% on all computers and peripherals.

Whatever may be the magnitude of increase, the growth for both the periods was induced mainly by the domestic final demand. Most of the increase in domestic final demand during the Eighties was an outcome of increased demand for consumer electronics viz. colour TV, VCR, etc. For example, colour TV market grew steadily from 1985-86 to 1989-90, from 0.74 million sets to 1.3 million sets [Sundar, 1994]. After the buoyant growth in the Eighties, the Indian consumer electronics industry was hit by demand recession in the early Nineties. There was a marked drop in the domestic sales due to erosion of purchasing power caused by double-digit inflation, penal duties and stoppage of consumer credit by finance companies. The result was fall in domestic final demand share in the growth of information sector from 90% during 1983-84 to 1989-90 to 66% during 1989-90 to 1993-94. However, reduced sale of consumer electronics was not the only cause. The domestic IT industry, in particular the IT hardware, faced a traumatic year in 1991-92. While the IT industry as a whole grew by 22.7%, domestic sales grew by only 12.5% compared to the 22% growth record in 1990-91. Sales fell following the foreign exchange crunch after the Gulf War. This resulted in expenditure squeeze on government departments with the Finance Ministry's obsession with reducing the budget deficit, the deferred computerization plans of nationalized banks and the railways and the general stagnation in the Indian industry. The domestic hardware market remained in a state of uncertainty in 1992-93 too. The recession showed no signs of abating and the government expenditure still remained curtailed. Adding to all these troubles, communal disturbances towards the end of the year brought havoc on transport and hence on production.

Compared to the domestic final demand, the contribution of export was relatively low. It was 14% during 1983-84 to 1989-90. Certain inherent problems related to export of information goods and services could be identified behind this [Hanna, 1994]. For example, value addition norms under Duty Exemption Scheme for IT export production were too high. Secondly, duty drawback procedure for fixation of brand rates and all industry rates took long time, thus blocking the working capital limits. Thirdly policy changes very frequently affected production and exports. Lastly, export consolidation of cargo ex-India was not allowed resulting in high freight.

The contribution of export during 1989-90 to 1993-94 fell from 14%, achieved in the previous period, to 10%. The main reason for such reduced contribution of export in the later period could be traced back to the destination of Indian information goods and services. Majority of IT (hardware) products from India went to the USSR or other former eastern block countries, under bilateral trading agreements and were paid in rupees. The Eastern European countries bought IT products, mainly computers, from India only because this avoided the necessity to spend hard currency for new technology. But as the Eastern European economies were drawn into the international capitalized economic order in the early Nineties, such bilateral agreements were initially dropped as all payments had to be made in hard currency.

As far as changes in the domestic supply ratio were concerned import substitution for information goods and services took place only during 1983-84 to 1989-90. The change in domestic supply ratio had increased information output by 4%. But during 1989-90 to 1993-94, its contribution was negative (−1%). This implied that instead of substituting imports by domestic production, greater dependence on imports was seen to take place, although at a very marginal level. If computer industry in India was taken as a representative of the IT sector, it was found that the liberalized trade regime during this period, along with its domestic market orientation, resulted in the emergence of a predominantly kit-assembling industry, heavily dependent upon import of high-tech products and components. According to Bureau of Industrial Costs and Prices (BICP) analysis, even those components that were domestically produced had an in-built import bias in the form of raw materials such as silicon, germanium, electronic grade chemicals etc. to the extent of 35% of their prices. There were three major reasons behind the increased dependence on imports during 1989-90 to 1993-94. First, the cost of information goods and services that were domestically produced was very high compared with those imported. Hence, demand for import of information goods increased. Secondly, the requirement of information output for various sectors of the economy was largely guided by the advice of their technical collaborators or joint venture partners. As a result, domestic output of information goods and services remained low, but at the same time, substantial imports took place. Thirdly, the government was of the optimistic view that liberalization of imports and reduction in tariffs would enhance access to advanced technological platform and to the productive tools needed for an internationally competitive IT industry and for diffusing IT throughout the economy. Thus, there was an increase in imports during 1989-90 to 1993-94.

So far change in technical coefficient as a source of growth was concerned, it had retarding effect on the growth of information sector during 1983-84 to 1889-90. Though the technical coefficient change in the information sector increased information output during this period, the non information sector seemed to be very orthodox regarding the change in technology. On the other hand during 1989-90 to 1993-94 production technology changes acted as a boosting factor for the increase in the information output associated with final demand shifts. Compared with the information output requirements of using 1989-90 production technology to satisfy 1993-94 final demand, the adoption of 1993-94 production technology increased the output of information sector by Rs.16745.92 millions which was nearly 25% of the total change in information output. Almost all the change in information output brought about by change in production technology came from increased use of information as the input. This was reflected by the fact that direct information input coefficient increased the information output by Rs.13066.59 millions or nearly 20%. The contribution of non-information portion was relatively small (6%). Such slow response of non-information technological coefficient effect towards increment in the output of information sector was mainly because adoption of information technology involved huge investment and also alterations in production routines.

The domestic final demand effect could be viewed from two different dimensions:
(1) the effect of growth of domestic final demand for information output and the effect of mix (i.e. spending pattern of final users)
(2) the sources of domestic final demand such as private final consumption expenditure (PFCE), government final consumption expenditure (GFCE), gross fixed capital formation (GFCF) and change in stock (CIS).
The two dimensions intercepted one another and were different aspects of the same domestic final demand shifts. However, each provided a unique insight into the relationship between domestic final demand and information output in the Indian economy.

Almost all the increase in information output resulting from domestic final demand shift during both the period came from the changes in growth of domestic final demand. While in the initial period it resulted in India's information output to increase by 75%, for the latter it was 53%. Changes in spending mix of domestic final demand led to an additional 15% and 13% growth in information output for the two periods respectively.

Table 4: Sources of Growth of Domestic Final Demand for Information Sectors of India During 1983-84 to 1989-90

Rs. Millions

	Mix Effect	Growth Effect	Total
Domestic Final Demand	7630.15 (15.10)	37669.80 (74.55)	45299.95 (89.64)
PFCE Effect	366.86 (0.73)	1566.52 (3.10)	1933.38 (3.83)
GFCE Effect	2525.94 (5.00)	12390.63 (24.52)	14916.57 (29.52)
GFCF Effect	4149.36 (8.21)	21173.22 (41.90)	25322.57 (50.11)
CIS Effect	585.64 (1.16)	2541.80 (5.03)	3127.44 (6.19)

*Figures in the bracket show percentage contribution to the total change in output

Table 5: Sources of Growth of Domestic Final Demand for Information Sectors of India During 1989-90 to 1993-94

Rs. Millions

	Mix Effect	Growth Effect	Total
Domestic Final Demand	8403.85 (12.68)	35290.70 (53.23)	43694.55 (65.91)
PFCE Effect	1695.02 (2.56)	6118.96 (9.23)	7813.98 (11.79)
GFCE Effect	9070.45 (13.68)	5310.17 (8.01)	14380.62 (21.69)
GFCF Effect	9694.54 (14.62)	15943.76 (24.05)	25638.30 (38.67)
CIS Effect	−12053.88 (−18.18)	7915.53 (11.94)	−4138.35 (−6.24)

*Figures in the bracket show percentage contribution to the total change in output

Table 4 shows the relative contribution of various sources of domestic final demand. Investment expenditure (GFCF) and government consumption (GFCE) were the main forces behind the increase in information output associated with domestic final demand shift during 1983-84 to 1989-90. While contribution of GFCF was 50% that of GFCE was 30%. Contribution of private expenditure (PFCE) was merely 4%. The use of IT by private organization was limited particularly among small and medium enterprises. Awareness of the potential benefits of IT among the enterprises was low. They were almost unaware of the technological options and of the best practices to realize the benefits, such as, the needs to adopt new managerial practices and business process, to undertake complementary investments in relevant training and supports services and identify and pilot strategic application. These private organizations were also unwilling to pay for 'intangible services' such as technical assistance or consultancy services for planning information systems, redesigning business process, analyzing information requirements, educating senior staff in information resource management or providing professional advice on hardware or software acquisition [Hanna, 1994].

Like the previous period, investment demand played the lead role towards the increase in output due to domestic final demand during 1989-90 to 1993-94 (table 5). It contributed nearly 39%. Government expenditure was also quite effective in increasing information output during this period. The experience of the most successful industrializing countries suggests that governments can influence the use of IT through its role as an investor and consumer, and as catalyst, strategist or regulator. As an investor, the government continues to have an important role in the development of information technology manpower, telecommunications infrastructure, specialized R&D institutions, and other IT related infrastructures and institutions. Government are dominant consumers of IT in all countries, and their procurement practices are influential in determining standards, domestic competition, common adoption practices, and in general, the pace and character of IT use. As catalysts, governments have designed mechanisms and programs to speed up the learning and diffusion process through demonstration projects, subsidized consultancy services, and training and information services. Most OECD countries and newly industrialized economies (NIEs) have introduced a special set of programmes that focused on the modernization of small- and medium firms. India has followed the footsteps of the these developed nations [Hanna, 1994]. Government expenditure, hence, contributed nearly 22% towards the growth of information sector during 1989-90 to 1993-94.

During this period, the demand for information goods and services from the private sector increased to roughly 12%, which was much higher than the previous year's contribution of 4%. The inducement to incur expenditure on information goods and services by private sector was largely due to the role played by the government. By coordinating the different facets of IT, the government captured externalities and hence encouraged the private expenditure in the development and diffusion of IT. In East Asian newly industrialized economies, in particular, governments have played such a role by investing simultaneously in specialized education and training, demonstration projects (such as civil service-wide computerization, inter-ministry networking, trade and financial networks), telecommunications infrastructure and technology diffusion institutions [Hanna, 1994]. By acting on a broad and coherent strategy, governments in these economies have sought to create an environment conducive to private investment in and effective adoption of IT. The different implementing agencies (public and private) were able to act in concert, exerting significant peer pressure.

Tables 6 and 7 divide the information output changes into changes in output of four information sectors. While the electronics equipment and communication equipment were the major information industries during 1983-84 to 1989-90, the communication sector remarkably grew into prominence leaving behind other information industries during 1989-90 to 1993-94. Nearly 60% of the growth of information output was due to communication sector. If number of telephone lines was taken as an index of expansion of telecommunication in India, then it can be seen that it increased from 5 million in 1990 to 12 million in 1995, an increase of 7 million. But the increase was of only 1.5 million during 1985 to 1990. The growth of communication and communication equipment industries were primarily due to the New Economic Policy (NEP) initiated by the government during 1991. Under the NEP, changes regarding deregulation of industries including telecom sector was effected. Manufacture of telecom equipment was delicensed and thrown open to the private sector with the objective to increase production and improve quality.

Among the demand side causes, the main factor responsible for this change was the domestic final demand expansion. Though for the information sector as a whole, the domestic final demand growth effect was more powerful than the mix effect for both the periods, there were exceptions to this at sectoral level. For example, during 1883-84 to 1989-90 the mix effect was stronger than growth effect for office computing machines, electronics equipment and communication equipment industries. However, during 1989-90 to 1993-94 the growth effect dominated the mix effect in all the industries except in office computing machines.

The output of office computing machines declined during both the periods under study. Reduced domestic demand and lower information input requirement (as reflected by technical coefficient changes) were the principal factors that caused output of this sector to decline during both the periods.

Table 6: Sources of Output Growth for Individual Information Sectors of India, 1983-84 to 1989-90

Rs. Millions

	Office Computing Machines	Communication Equipment	Electronics Equipment	Communication	Total
Domestic final demand	−2773.13 (−5.49)	9949.84 (19.69)	28530.47 (56.46)	9592.78 (18.98)	45299.95 (89.64)
Mix	−5527.35 (−10.94)	5042.61 (9.98)	23366.16 (46.24)	−15251.27 (−30.18)	4630.15 (15.10)
Growth	2754.21 (5.45)	4907.23 (9.71)	5164.30 (10.22)	24844.05 (49.16)	37669.80 (74.55)
Export	−1085.35 (−2.15)	3613.57 (7.15)	3413.55 (6.76)	1237.58 (2.45)	7179.34 (14.21)
Import substitution	3313.06 (6.56)	−1059.57 (−2.10)	1122.82 (2.22)	−1596.63 (−3.16)	1779.68 (3.52)
Technical coeff.	−1326.64 (−2.63)	−537.89 (−1.06)	434.99 (0.86)	−2296.70 (−4.54)	−3726.24 (−7.37)
Information input coeff.	36.18 (0.07)	60.59 (0.12)	66.72 (0.13)	1763.43 (3.49)	1926.93 (3.81)
Non information input coeff.	−1362.81 (−2.70)	−598.47 (−1.18)	368.27 (0.73)	−4060.13 (−8.03)	−5653.14 (−11.19)
Total	−1872.07 (−3.70)	11965.95 (23.68)	33501.82 (66.30)	6937.03 (13.73)	50532.74 (100.00)

*Figures in the bracket show percentage contribution to the total change in output

Table 7: Sources of Output Growth for Individual Information Sectors of India, 1989-90 to 1993-94

Rs. Millions

	Office Computing Machines	Communication Equipment	Electronics Equipment	Communication	Total
Domestic final demand	−1586.97 (−2.39)	8588.89 (12.96)	16001.24 (24.14)	20691.40 (31.21)	43694.55 (65.91)
Mix	−2480.54 (−3.74)	2057.27 (3.10)	6100.77 (9.20)	27263.51 (4.11)	8403.85 (12.68)
Growth	893.57 (1.35)	6531.62 (9.85)	9900.46 (14.93)	17965.05 (27.10)	35290.70 (53.23)
Export	80.09 (0.12)	864.19 (1.30)	280.26 (0.42)	5422.32 (8.18)	6646.86 (10.03)
Import substitution	−383.06 (−0.58)	−457.43 (−0.69)	−470.69 (−0.71)	522.74 (0.79)	−788.90 (−1.19)
Technical coeff.	−464.80 (−0.70)	4362.16 (6.58)	1710.39 (2.58)	11135.97 (16.80)	16745.92 (25.26)
Information input coeff.	−485.10 (−0.73)	4309.12 (6.50)	1670.61 (2.52)	7569.53 (11.42)	13066.59 (19.71)
Non information input coeff.	20.31 (0.03)	49.93 (0.07)	40.80 (0.06)	3566.48 (5.38)	3677.52 (5.55)
Total	−2354.74 (−3.55)	13356.47 (20.15)	17520.07 (26.43)	37772.43 (56.98)	66294.22 (100.00)

*Figures in the bracket show percentage contribution to the total change in output

Table 8: Sources of Growth of Domestic Final Demand for Individual Information Sectors of India During 1983-84 to 1989-90

Rs. Millions

	Office Computing Machines	Communication Equipment	Electronics Equipment	Communication	Total
Domestic final demand	−2773.13 (−5.49)	9949.84 (19.69)	28530.47 (56.46)	9592.78 (18.98)	45299.95 (89.64)
PFCE	−168.69 (−8.05)	906.46 (0.56)	11539.37 (10.00)	2639.42 (1.31)	14916.57 (3.83)
GFCE	−4067.01 (−0.33)	282.66 (1.79)	5053.48 (22.84)	664.24 (5.22)	1933.38 (29.52)
GFCF	−777.62 (−1.54)	7841.33 (15.52)	12390.24 (24.52)	5868.63 (11.61)	25322.57 (50.11)
CIS	2240.19 (4.43)	919.40 (1.82)	−452.63 (−0.90)	420.48 (6.45)	3127.44 (6.19)

*Figures in the bracket show percentage contribution to the total change in output

Table 9: Sources of Growth of Domestic Final Demand for Individual Information Sectors of India During 1989-90 to 1993-94

Rs. Millions

	Office Computing Machines	Communication Equipment	Electronics Equipment	Communication	Total
Domestic final demand	−1586.97 (−2.39)	8588.89 (12.96)	16001.24 (24.14)	20691.40 (31.21)	43694.55 (65.91)
PFCE	107.75 (0.16)	2236.60 (3.37)	−1912.58 (−2.88)	7382.21 (11.14)	7813.98 (11.79)
GFCE	−116.21 (−0.18)	235.02 (0.35)	5563.51 (8.39)	8698.30 (13.12)	14380.62 (21.69)
GFCF	−1867.62 (−2.82)	9117.08 (13.75)	12107.92 (18.26)	6280.93 (9.47)	25638.30 (38.67)
CIS	289.11 (0.44)	−2999.81 (−4.52)	242.39 (0.37)	−1670.03 (−2.52)	−4138.35 (−6.24)

*Figures in the bracket show percentage contribution to the total change in output

Almost similar pattern was observed regarding contribution of different categories of domestic final demand for both the periods, with the exception of communication sector. While nearly 12% of the increase in output in communication sector was induced by investment expenditure during 1983-84 to 1989-90, government consumption expenditure (13%) and private consumption expenditure (11%) were the main growth inducing factors in the latter period.

Export effect, as evident from tables 6 and 7, though had an impact much less than domestic final demand, had its presence felt in communication equipment (7%) and electronics equipment (7%) industries during 1983-84 to 1989-90 and in communication sector (8%) during the following period.

So far changes in domestic supply ratio was concerned it had a mixed impact on various information sectors. Import substitution, though in small degree, had been possible in sectors viz. office computing machines and electronics equipment in the initial period and in communication during the later period.

The growth reducing effect of technical coefficient change during 1983-84 to 1989 -90 for the information sector was primarily due to negative technical coefficient effect in office computing machines (3%), communication equipment (1%) and communication (5%) sectors. However, growth due technical coefficient change during 1989-90 to 1993-94 was induced through communication sector (17%), communication equipment (7%) and electronics equipment industry (3%).

4.2 Model II

In Table 10 we present the empirical findings of the decomposition analysis following Model II over the period 1989-90 to 1993-94. This Model separates the effect of technological change and the effect of import substitution of intermediate products present in the technical coefficient change.

Before analyzing the findings of the model it would be helpful to recall certain facts. The Bhabha Committee Report, published in the late Sixties, set the stage for the development of the industry. The authors of the Report, with research background and conditioned by a political philosophy that was relevant and popular at that time, naturally placed considerable emphasis on Science and Technology, as was then known. Self-reliance at any cost was seen as a national goal. But with the passing of time, these national goals changed and government policies were tuned accordingly.

The period 1989-90 to 1993-94 was a phase with two different sets of policies overlapping (discussed at the beginning of the paper). While the years 1989 and 1990 experienced reversal of import liberalization in the past years, the years ahead of 1990 saw renewed liberalization.

The figures for import substitution effect of Model II (table 10) reflected this picture. Though import substitution took place with respect to intermediate demand, accounting 9% of the growth in information sector, this was not the case for final demand. Instead, to meet the final demand, the economy increasingly depended on import of information goods and services. Approximately 12% of the domestic output of information sector was reduced due to this. But this increased import for final demand was mainly in the form of foreign investment. The share of capital formation in the total import of information goods and services increased from 33% in 1989-90 to 74% in 1993-94 [Central Statistical Organization (C.S.O.) 2002], though both private consumption expenditure and government expenditure shifted towards domestic production during this period. Most of the foreign investment took place in communication equipment and electronics equipment industries. For example, as the demand for telecommunication became higher with the passage of time, the state owned Indian telephone industry was not able to manage with its slender resources and support from Department of Telecommunications (DOT). This left no choice for the government but to induce foreign companies to expand the telephone network. The companies which were inducted were Alcatel (France), which collaborated with Indian Telephone Industries Limited (ITI) for the manufacture of switching equipment at Mankapur, Fujitsu (Japan), Simens (Germany), Ericcson (Sweden) and American Telephones and Telegraphs [The Hindu, 1994].

Import substitution in intermediate demand was probably the result of danger felt by various industries associated with import dependency on foreign suppliers, especially those required on recurring basis. They feared that import of information items might lead to a situation where for routine repairs foreign technicians had to be invited. It was also likely that manufacturers would likely squeeze the network operators while supplying spares. There might even be a situation when spares would not be available because either they migrated to other technologies or the product was no longer in their manufacturing programme. Therefore, various industries felt safe to use input produced domestically. However, not all users averted import. Industries that used communication equipment and electronics equipment intensively as their intermediate inputs depended more on imports than on domestically produced goods. Output of communication equipment and electronics equipment was reduced to the extent of 2% and 3% respectively due to this. One such sector is medical and health. Imports of medical electronic equipment by hospital and other medical organizations were always liberally allowed by the government. A large number of medical equipment characterized as live saving was imported by medical agencies at zero import duty. Whole body scanners, ultrasound scanner, specialized portable and non portable X-ray machines, implantable pacemakers, radiography and radiotherapy equipment constituted the major items of imports by the medical and health sector. Statistics on import of radar and allied items by defence industry also indicated substantial increase of imports over time. While during 1990-91 the figure was Rs.96 millions, it was Rs.953 millions during 1993-94 [Department of Electronics, 1996]. This was mainly because imported items were competitively priced and qualitatively superior.

Table 10: Sources of Output Growth for Individual Information Sectors of India, 1989-90 to 1993-94 (Model II)

Rs. Millions

	Office Computing Machines	Communication Equipment	Electronics Equipment	Communication	Total
Domestic final demand	–2252.70 (–3.40)	9186.56 (13.86)	16320.16 (24.62)	18765.93 (28.30)	42018.95 (63.38)
Export	112.70 (0.17)	2718.06 (4.10)	974.53 (1.47)	3089.31 (4.66)	6893.60 (10.40)
Import substitution (final dd.)	–218.77 (–0.33)	–4448.34 (–6.71)	–1763.43 (–2.66)	–1584.43 (–2.39)	–8014.97 (–12.09)
Import substitution (int. dd.)	682.83 (1.03)	–1239.70 (–1.87)	–1942.42 (–2.93)	8293.41 (12.51)	5794.11 (8.74)
Technological change	–676.20 (–1.02)	7093.48 (10.77)	3931.25 (5.93)	9208.27 (13.89)	19602.53 (29.57)
Total	–2354.74 (–3.55)	13356.47 (20.15)	17520.07 (26.43)	37772.43 (56.98)	66294.22 (100.00)

*Figures in the bracket show percentage contribution to the total change in output

Complete import substitution (whether for final demand or for intermediate demand) would be possible only if quality of domestic products was improved. This would require technological change in the mode of production. The Seventh Plan aimed at the long term economic development through planned and progressive restructuring of industry. It stated that, "The trends of shift from traditional industries to basic metals, fertilizers and industrial manufactures will have to continue with an increasing share for the emerging technology intensive industries. In the evolution of an industrial structure capable of meeting domestic needs and competing in world markets, 'sunrise' industries have a special role to play. The investment pattern and policy frame-work should facilitate structural change within the industrial sector towards high-technology, high value added and knowledge-based industries like electronics, advanced machine tools and telecommunications" [Planning Commission[1], 1985]. The main objective of the restructuring process both in Seventh and Eighth Plan was to usher in a pattern of industrial development which would take India into the ranks of leading industrial country of the world. In order that achievements of science and technology were systematically absorbed in the industrial sector, the plans emphasized that suitable incentives should be provided to encourage investment in modernization. The government should create an economic environment which rewarded technological upgradation and penalized inadequate effort. Encouraging modernization and technological upgradation together with injecting a substantial degree of competition would bring about a reduction in costs and improvement in quality [Planning Commission, 1992].

During 1989-90 to 1993-94 technological changes increased demand for information goods and services by nearly 30%. The change in technology was made possible by substitution of information goods for labour in response to the rise of the prices of labour relative to price of information goods. For example, in banking and insurance sector clerical jobs were replaced by computers which were supposed to be more productive than labour.

Another possible way through which technological changes increased demand for information output was by changing the output mix of industries from primary input intensive goods to those requiring more high-tech intermediate inputs for their production. Recognizing that electronics could make various significant contributions towards improvement, the Eighth Plan envisaged rapid introduction of electronics in almost all sectors of the economy. For example, the communications sector should largely be based on electronic switching system. Power generation and transmission network should make increasing use of electronics. Thermal power plants should depend on electronic control and instrumentation systems. High Voltage direct current transmission using high power thyristor controls should be introduced during the Plan period. Operation of steel plants should be optimized through the introduction of on-line computers for a more effective and dynamic control and monitoring of the production facilities and integrated operation of the different units of the plant. Use of computers in freight operation, information system and in passenger reservation should be introduced in railway transport network. Setting up model coal mines using electronics equipment for communications, safety and other activities were also emphasized in the plan. Electronics was expected to change radically the organizational and physical set up of coal mines in the country. Other capital-intensive sectors where programmes for introduction of electronics were targeted were fertilizers, oil exploration and production and textiles. System engineering organizations were expected to play a vital role in the application of electronics in diverse sectors by stimulating electronics production through their backward and forward linkages with the manufacturers and the using sectors.

A new dimension in the five year plans was the introduction of electronics in services. The plans emphasized wide use of electronic diagnostic aids in the health services. The extension of communication and broadcasting services to the rural population was expected to assist substantially the programmes for rural development. As it is known that timely information is a vital input to the planning and the executing agencies, the national information set-up based on computerization was to be extended right up to the district level to facilitate exchange of information on monitoring and implementation of schemes and timely collection of various statistics on economic performance. The use of computers as an aid to the education system should also be evaluated.

Implementation of the above directives, as laid down in the Seventh and Eighth Plan, led to change in output mix during 1989-90 to 1993-94. The share of output of sectors like transport services, electricity, banking and insurance, education and research, communication and other services in the Indian economy increased during this period [C.S.O. 1998, 2000]. Again, these were the industries that were demanding high

-tech inputs during this period for rapid technological changes in their production process. The result was increase in output of information sector through increased intermediate demand for information goods and services by these industries (table 6.3). For example, demand for information goods and services was increased through communication services, electricity, communication equipment, transport services, other services and banking and insurance by 7%, 5%, 5%, 4%, 3% and 3% respectively.

So far sectoral sources of the impact of technological change on information output change were concerned table 11 provided the results. The technological change effect on office computing machines was negative during 1989-90 to 1993-94. Change in technology in sectors like construction (sector 22), medical and health (sector 27), other services (sector 28), coal and lignite (sector 4), agriculture (sector 1), textiles (sector 9), rubber and plastic products (sector 12), metal and metal products (sector 17) and electrical machines (sector 19) had negative impact on the output growth of this sector.

The net effect of technological change on communication equipment industry was positive. This was mainly caused by the changes in technical coefficients in communication (sector 34), electricity (sector 23), transport (sector 25) and other services (sector 28). Nearly 11% of the total increase in output of information sector due to technological change was jointly contributed by these sectors. However, unfavourable technological change in leather and leather products (sector 11) and non-metallic products (sector 16) industries lowered the communication equipment production by nearly 1.16% and 0.12% respectively.

Technological changes in sectors like banking and insurance, communication equipment and electricity were primarily responsible for the growth of the electronics equipment industries. Of all the information sectors it was the communication sector

Table 11: Sectoral Sources of Technological Change During 1989-90 to 1993-94 (Percentage)

Sectors	1	2	3	4	5	6	7	8	9
Office computing Machines	−0.02	0.01	−0.03	−0.17	0.00	0.01	0.01	0.00	−0.02
Communication Equipment	0.01	0.01	0.00	0.05	0.00	0.00	0.02	0.00	0.00
Electronics Equipment	−0.02	0.00	−0.01	0.04	0.00	0.00	0.08	0.04	0.13
Communication	0.49	0.06	0.00	−0.11	0.04	0.09	0.14	0.00	−0.06
Total	0.46	0.07	−0.04	−0.19	0.04	0.10	0.25	0.04	0.05

Sectors	10	11	12	13	14	15	16	17	18
Office computing Machines	0.00	0.00	−0.02	0.01	0.00	−0.01	0.00	−0.01	0.01
Communication Equipment	0.00	−1.16	0.04	0.01	0.01	0.02	−0.12	0.01	0.07
Electronics Equipment	0.03	0.01	0.00	0.01	0.01	0.09	0.01	1.04	−1.82
Communication	0.06	−0.01	−0.37	0.14	0.06	−0.13	0.08	0.05	0.35
Total	0.09	−1.16	−0.36	0.17	0.08	−0.03	−0.03	1.09	−1.39

Sectors	19	20	21	22	23	24	25	26	27
Office computing Machines	−0.01	0.01	0.10	−0.76	0.00	0.00	0.08	0.05	−0.12
Communication Equipment	0.77	−0.05	0.07	−0.09	3.07	0.00	2.58	0.01	0.01
Electronics Equipment	0.25	−0.14	0.48	0.39	1.02	0.00	0.40	2.00	0.00
Communication	−0.01	−0.40	0.65	−0.32	1.36	0.05	1.26	1.11	0.28
Total	1.00	−0.58	1.30	−0.78	5.45	0.05	4.32	3.17	0.17

Sectors	28	29	30	31	32	33	34	35	Total
Office computing Machines	−0.21	−0.01	0.00	0.02	0.02	0.01	0.02	0.01	−1.02
Communication Equipment	1.00	−0.01	0.01	−0.01	0.08	0.06	4.32	0.01	10.77
Electronics Equipment	0.01	0.01	0.02	0.01	1.11	0.32	0.40	0.01	5.93
Communication	2.44	−0.11	0.14	0.04	4.11	0.10	2.08	0.23	13.89
Total	3.24	−0.12	0.17	0.06	5.32	0.49	6.82	0.26	29.58

that felt the maximum benefit of technological changes that took place in the economy during 1989-90 to 1993-94. Technological changes in communication equipment (sector 32), communication (sector 34), other services (sector 28), electricity (sector 23), transport services (sector 20) and banking and insurance (sector 26) primarily led the output of communication sector to grow. Their contributions are nearly 4%, 2%, 2%, 1% and 1% respectively.

Other findings of this model were more or less same as those derived from Model I. As in the previous model, here too, the domestic final demand was the important factor for the growth of information sector. It contributed nearly 63% of the total growth as against its 66% in the previous model. The share of export remained same at 10% in both the models. Though the model developed in this chapter helped us to identify the areas of import substitution, summing up the effects of import substitution for final demand and those for intermediate demand led to negative net effect (−3%). This was, more or less, in conformity with the finding of the previous model where the import substitution effect during the period 1989-90 to 1993-94 was approximately −1%.

5. Conclusion

The growing importance of the IT industries both in India and abroad has aroused interest in IT in almost all spheres of the economy. Though a good volume of literature has developed in recent years which have dealt with IT, not many studies in India can be traced till date that throws some light on various aspects of information sectors. The present study makes an attempt to identify the sources of growth of this sector during pre liberalization period and liberalization period.

The driving force behind the growth of information sector during 1983-84 to 1993 -94 was the domestic final demand. Increase in demand for exports of information goods and services did induce growth of this sector but it was much less than the domestic final demand. Technical coefficient change effect showed a dramatic change between the two periods. From its negative effect in the initial period it became the second most important contributor towards the growth of information sector. Though substitution of imports by domestic production was possible during 1983-84 to 1989-90, greater dependence on import was observed during the latter period.

Industries in general preferred to satisfy input requirement of information goods and services by those produced indigenously rather than going for imported ones, in spite of the liberal import policies adopted during 1989-90 to 1993-94. However, there were exceptions to this. Industries using electronics or communication equipment intensively in their production process went for imported inputs mostly because of their price competitiveness and superior quality. Dependency of final demand on imports was mainly due to increased foreign participation in the form of foreign investment. Consumption expenditures, whether private or government, were in favour of domestic production.

Note

1. Planning Commission is an apex body of Government of India which formulates the Five Year Plans.

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