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For a developing country like India where socio-economic problems such as poverty, unemployment and inequality influence policy decisions, it becomes important to study inter-linkages among the constituent sectors so that positive growth impulses emerging among the sectors could be identified and fostered to sustain the growth momentum. An in-depth understanding of inter-sectoral dynamics becomes all the more important for policy makers so that effective monetary, credit and fiscal policies could be designed in order to be able to achieve the broader objective of inclusive development. In this backdrop, the present paper endeavors to study inter-sectoral linkages in the Indian economy both through input-output (I-O) approach and econometric exercises using co-integration and state-space models. Co-integration analysis is carried out both at sectoral and sub-sectoral levels since mid-1980s. At the broad sectoral level, primary, secondary and tertiary (excluding community, social and personal services) sectors display strong long-run equilibrium relationship amongst each other. These sectors also display strong long-run equilibrium relationship with one another in a bivariate framework. At the sub-sectoral level, existence of long-term equilibrium was found between 'trade, hotels, transport & communication' and 'manufacturing' sectors. Further, the financial sector activity in the 'banking & insurance' sector was found to be co-integrated with the 'manufacturing' and 'primary' sectors. The sectors, which displayed long-run equilibrium relationships, were re-estimated through state space model using Kalman filter. This also corroborated that variation in one sector influenced the other sector's performance over time. In view of the prevailing sectoral inter-relationships, the paper explores policy options so that positive growth impulses developing among the sectors are fostered.

JEL Classification : O11, D57

Keywords : Macroeconomic analysis of economic development, Input–Output Tables, Inter-sectoral Linkages, Agriculture, Industry, Services.

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Introduction

The process of economic development in an economy results in distinct structural changes. As a country progresses and the gross domestic product (GDP) basket enlarges, a shift in economic activity occurs away from agriculture towards services and manufacturing sectors, owing to higher elasticity of the latter two sectors than that of former sector (Fisher, 1939 and Clark, 1940). The process in turn leads to structural shifts, and consequent diminishing significance of primary activities and growing dominance of secondary and tertiary activities. This process brings with it significant changes in the production process, consumption pattern and various other social indicators.

As per the standard literature on the subject, services sector experiences an accelerated growth only after a certain level of development has taken place in agriculture and industry. Experiences of the economies over-time, in this regard, have been varied. For instance, in most of the developed economies, economic development followed a sequence wherein sectors *viz.* agriculture, industry and services sector developed in that order. On the contrary, the experience of some of countries such as India bears out that subsequent to the development of the primary sector, tertiary sector developed without a successful transition to an industrialised economy.

From a traditional agro-economy till the 1970s, the Indian economy has transformed into a predominantly services-oriented economy, especially since the mid 1980s. Economic reforms initiated in the mid-eighties and their execution from early nineties has seen the share of services sector in GDP rising continuously for the Indian economy. The shift in composition of GDP has brought about substantial changes in the inter-sectoral production and demand linkages. Further, with the growing tertiarisation of the economy, there has been a phenomenal growth in distributive, communication, consumer and financial services, which, in turn, drives from increased demand from the commodity producing sectors. This brings to fore the issue as to how the tertiary sector is linked up with the two commodity-producing sectors in the economy.

Investigation of structural relationships among the sectors becomes important from the policy perspective. It helps one understand not only the evolution and progression of such relationships but also the inter-sectoral adjustments over time. A clear perspective on the inter-sectoral dynamics could be useful in devising a conducive and appropriate development strategy. Further, sharp divergences in growth rates of different sectors are found to have serious implications for income distribution, inflation and current account deficit of an economy. A proper comprehension of the characteristics and trend of sectoral linkages also assumes importance in designing socially-just policies as also effective monetary/credit policies. The study of sectoral inter-linkages is all the more important for a developing country like India so that positive growth stimuli among sectors could be identified and fostered to sustain the economic growth momentum. This would go a long way in redressing various socio-economic problems such as poverty, unemployment and inequality.

In this backdrop, the present paper focuses on examining the inter-linkages among the sectors of the economy. Scheme of the paper is as follows: Section I documents the literature on inter-linkages among the sectors. Section II highlights some of growth attributes of the Indian economy. Section III analyses the framework of inter-linkages among various sectors based on Input-Output (I-O) table. Section IV outlines time period for the empirical analysis and the data sources. Section V examines the existence of long-run equilibrium and short-run dynamic relationship amongst primary, secondary and services sectors using co-integration and error correction mechanism. Estimates based on state-space model using Kalman filtre are discussed in Section VI. Section VII discusses some of policy implications emanating from the study. Finally, Section VIII marks concluding observations.

Section I
A Survey of Extant Literature

In an economy, the dynamics of inter-linkages among the sectors can, in general, be examined in three ways. First is through the I-O tables, which reveal the broad trends in structural shifts and at the same time provide valuable insights into the interdependence among the sectors. The second technique is purely statistical in nature and involves analysis of causality among the sectors. The third approach is based on econometric modeling exercises among various sectors of the economy.

In the context of Indian economy, a good deal of literature documents the sectoral inter-linkages. Researchers have attempted the aforementioned techniques extensively. Dhawan and Saxena (1992) and Hansda (2001) used the I-0 approach. Both causality tests and econometric models have been used by a plethora of researchers [Rangarajan, 1982; Ahluwalia and Rangarajan, 1989; Bhattacharya and Mitra, 1989, 1990 and 1997; Sastry *et al*, 2003; Bathla, 2003]. A brief summary of the some of the studies is presented below (Table 1).

Table 1: Literature survey relevant to present study

Study	Main findings
Rangarajan (1982)	➢ It established a strong degree of association between agriculture and industrial sectors. ➢ An important finding of the study is that the consumption linkages are much more powerful than production linkages. ➢ Another significant conclusion which emerged from the paper is that addition of one percent growth in the agricultural sector stimulates the industrial sector output to the extent of 0.5 per cent.
Bhattacharya and Mitra (1989)	➢ It found that the relationship between agriculture and industry depends on the relative growth of income and employment both in the industrial and the services sectors.
Bhattacharya and Mitra (1990)	➢ This paper concluded that though the share of the tertiary sector in total national income has been increasing, its share in total employment has been lower than the other two sectors, which along with an increasing deviation between the growth rates of the tertiary, primary and secondary sectors may have a negative impact on inflation, balance of payments and income distribution.
Bhattacharya and Mitra (1997)	➢ It found that many services activities are significantly associated with the agricultural and industrial sectors and this helps in employment generation.

Table 1: Literature Survey relevant to present study

Study	Main findings
Hansda (2001)	➢ In analysing the complementarity between industrial and services sectors, it conducted a detailed I-O analysis (using 1993-94 data) and found that linkages from services to industry were strong reflecting the use of services sector inputs in industry.
Banga and Goldar (2004)	➢ In order to assess the contribution of services sector to the industrial growth, it estimated a capital, labour, energy, material and services (KLEMS) production function for Indian manufacturing sector for the period 1980-81 to 1999-2000. ➢ Empirically, it found that the contribution of services to output growth increased substantially to 2.07 per cent per annum during the 1990s from a meager 0.06 per cent per annum during the 1980s. The relative contribution of services to output growth was about one per cent in the 1980s and increased significantly to about 25 per cent in the 1990s.
Sastry *et al* (2003)	➢ The inter-sectoral relationships and production linkages in the paper corroborate that in about a quarter of a century, agriculture modernized and this enhanced dependence of agriculture on the industry for inputs. ➢ As for the services sector, the paper shows movement of production linkages from late 1960s to early 1990s moderately in favour of agriculture and sharply in favour of services sector. ➢ On demand linkages, the paper asserts that a fall in agricultural income reduces demand for agricultural machinery and other industrial products, resulting in fall of aggregate demand and *vice-versa*. ➢ It found that dependence of industry on agriculture and services is presently much more than it used to be in the 1970s and the 1980s. Further, a fall in aggregate demand either in agriculture or services sector is likely to cause serious production constraints in the industrial sector, thereby affecting both demand and production linkages.
Bathla (2003)	➢ It carried out a comprehensive analysis of the inter-sectoral linkages in the Indian economy for the period 1950-51 to 2000-01. ➢ Under the granger causality framework, no evidence of relationship was found between primary and secondary sectors, while primary sector was found to have a unidirectional causation with 'trade, hotels, restaurants, communication services' and 'financing, insurance, real estate & business services' sectors. Further, the secondary sector was found to have bi-directional causality both with 'trade, hotels, restaurants, communication' and 'financing-insurance-real estate and business' services. ➢ Under the co-integration framework, strong evidence of existence of long-run equilibrium relationship was found among the primary, secondary and the specialised services sectors.

Section II
India's Growth Story: Some Attributes

Before analysing the inter-sectoral linkages in the Indian economy, it would be useful to review sectoral growth trends and altering sectoral composition of the GDP. To start with, decade-wise analysis reveals that the GDP accelerated remarkably to 5.6 per cent during the 1980s from 2.9 per cent during the 1970s (Table 2). The pick-up in GDP growth was supported by all the sectors with a marked acceleration. Since the eighties, the growth trend of industrial and services sectors have ratcheted upwards, while that of agriculture and allied activities has followed a downward trend.

Performance of services sector in the Indian economy has been exemplary. First, in contrast with agricultural and industrial sectors, except for the interregnum of the 1970s, the growth in services sector has trended upwards, accelerating from 4.0 per cent in 1950s to 8.8

Table 2: Sectoral Growth Trends - Average

(Per cent)

	1950s@	**1960s**	**1970s**	**1980s**	**1990s***	**2000-01 to 2007-08**
1	2	3	4	5	6	7
Agriculture, forestry & fishing	**2.7**	**2.5**	**1.3**	**4.4**	**3.8**	**2.9**
Industry	**5.7**	**6.5**	**3.6**	**6.1**	**6.2**	**7.9**
Mining & Quarrying	4.6	6.2	3.1	8.9	4.9	5.2
Manufacturing	5.8	5.9	4.3	5.7	6.5	7.7
Electricity, Gas & Water Supply	10.7	11.4	6.9	8.3	7.0	4.6
Construction	5.8	7.2	2.0	5.5	6.0	10.6
Services	**4.0**	**4.8**	**4.4**	**6.4**	**7.6**	**8.8**
Trade, Hotels, Transport and Communication	5.0	5.4	4.8	5.9	8.0	10.7
Financing, Insurance, Real Estate & Business Services	3.1	3.2	4.3	8.4	7.7	8.8
Community, Social & Personal Services	3.5	5.2	4.1	5.8	6.9	5.6
GDP at factor cost	**3.6**	**4.0**	**2.9**	**5.6**	**6.2**	**7.3**

* : Excluding the crisis year 1991-92.

@ : Average for the growth during the 1950s is the average of nine years, *i.e.*, from 1951-52 to 1959-60.

Source : Central Statistical Organisation, Government of India.

per cent in 2000s (2000-01 to 2007-08). On the contrary, while the growth in primary sector remained volatile with no clear trend, growth in industrial sector in the 1980s and 1990s (6.1 per cent and 6.2 per cent, respectively) remained even lower than 6.5 per cent growth of the 1960s (3.6 per cent in 1970s).

Second, as measured by the coefficient of variation, services sector remained the least volatile sector of GDP as opposed to primary and secondary sectors (Table 3). Consistent and high growth of the services sector has added a dimension of stability to India's growth process through a decline in volatility of output (Rath and Rajesh, 2006).

In respect of comparison of sectoral shares in GDP since the 1950s, a skewed pattern emerges wherein the relative share of agriculture is declining over time, with industry remaining nearly

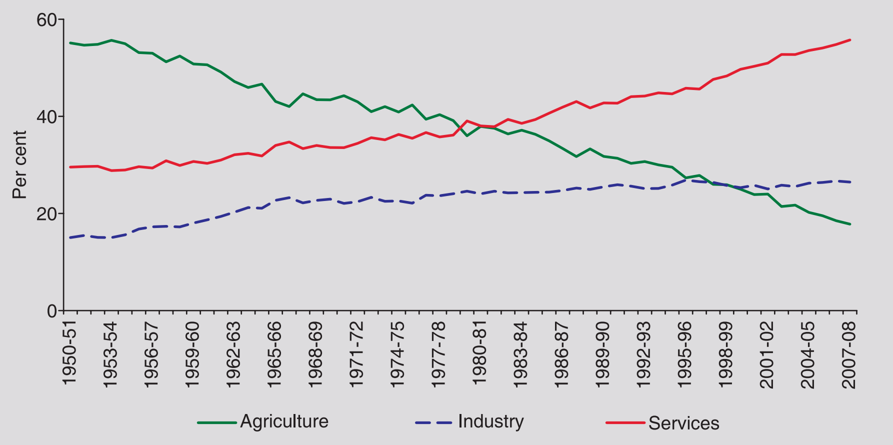
Table 3: Volatility in Growth as measured by Coefficient of Variation

(Per cent)

	1950s@	**1960s**	**1970s**	**1980s**	**1990s***	**2000-01 to 2007-08**
1	2	3	4	5	6	7
Agriculture, forestry & fishing	**168.2**	**286.3**	**643.0**	**142.1**	**99.2**	**180.6**
Industry	**64.7**	**41.1**	**103.3**	**39.1**	**44.3**	**34.2**
Mining & Quarrying	72.2	78.2	154.4	58.5	81.7	58.3
Manufacturing	33.4	65.3	96.8	55.4	74.9	34.1
Electricity, Gas & Water Supply	32.9	27.3	62.8	20.9	16.8	42.5
Construction	172.3	57.7	363.6	92.5	62.3	41.7
Services	**22.9**	**23.8**	**31.7**	**20.1**	**23.0**	**22.6**
Trade, Hotels, Transport and Communication	36.7	37.4	59.1	16.8	29.9	18.2
Financing, Insurance, Real Estate & Business Services	34.4	30.8	62.2	33.3	33.7	37.4
Community, Social & Personal Services	22.1	21.9	35.9	34.1	42.2	22.4
GDP at factor cost	**73.2**	**92.5**	**142.0**	**40.9**	**18.2**	**32.1**

* : Excluding the crisis year 1991-92.
@ : Average for the growth during the 1950s is the average of nine years, *i.e.*, from 1951-52 to 1959-60.
Source : Central Statistical Organisation, Government of India.

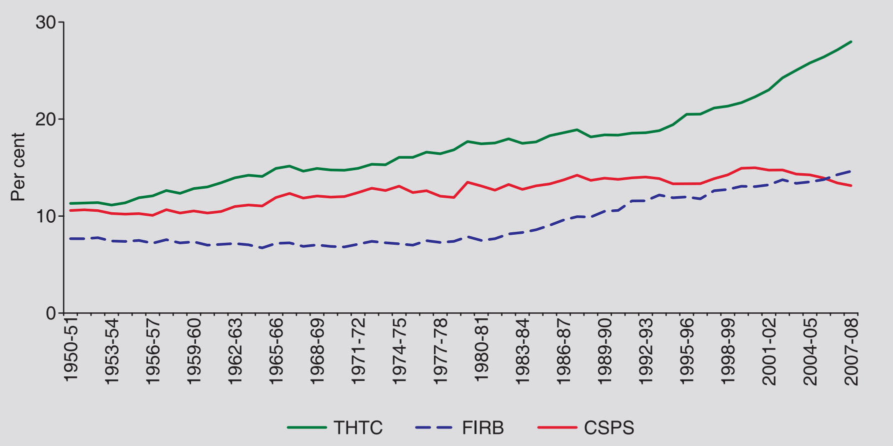
Chart 1: Sectoral Share in GDP



constant and services sector share rising in the GDP (Chart 1). Since the early 1950s, share of services sector in GDP exceeded that of the industrial sector, but the same remained smaller than that of the agricultural sector till the 1970s.

As per the components of services sector, it is found that ‘community, social and personal services’ (CSPS) and ‘trade, hotel, transport & communication’ (THTC) had almost the same share in GDP during the period from 1950-51 to 1954-55 (Chart 2). In 1955-56, THTC overtook the CSPS sector. The sector ‘financing, insurance,

Chart 2: Share of Different Services Sectors in GDP



real estate and business services' (FIRB) has seen its share expanding sharply since the early 1980s and in 2006-07, its share in GDP has become almost equal to that of the CSPS. Nationalisation of banks and introduction of post office deposits along with the gradual liberalisation in the insurance sector may have contributed to financial deepening leading to a rise in the share of FIRB in the overall GDP.

Section III
Sectoral Linkages in the Indian Economy

Considering inter-dependence among the three sectors of an economy *viz.* agriculture & allied activities (primary), industry (secondary) and services (tertiary), it may be presumed that demand for one sector in a closed economy is a function of outputs generated in the other two sectors. In an open economy, however, the relationship can be captured by incorporating some other variables, which integrate the external economy.

To begin with, agriculture sector enjoys both production and demand linkages with industrial and services sectors. Agriculture sector has demand linkage with the industrial sector as it depends on the latter for agricultural implements and other inputs such as fertilizers and pesticides. Thus, a good harvest (in turn giving a boost to agricultural income) results in increased demand for industrial products. Similarly, a good agricultural year is also likely to raise demand for services like trade, transport, banking and insurance services. On the supply side, agricultural inputs are used in the production of various chemical and pharmaceutical products; consumer items, especially non-durable food products, *etc*. Thus, a fall in aggregate supply in agriculture sector is likely to cause a serious constraint in production of the industrial sector.

Similarly, there is a positive and significant association between manufacturing and services sectors, which becomes stronger at advanced stages of industrialisation. With the expansion of the economy, particularly in the manufacturing sector, demand for services like trade, transport, hotel, banking and social services such as education, hospitals and other infrastructure increases. In turn, the service sector growth depends on the development of manufactured inputs. Given the high-income elasticity of demand for services, as the economy develops with rising per capita income, the growth linkages between manufacturing and services sectors become stronger through increased demand for each other's output. In recent years, there has been a phenomenal growth in respect of distributive, communication and financial services. Abetted liberalisation communication sector has been one of the fastest growing sectors, which has enhanced the productivity in the commodity producing sectors through sharing of recent and update knowledge about the current market and demand conditions. Financial services have consistently recorded double-digit growth in the last four years benefiting from substantial expansion in the economic activity. Transportation sector also witnessed substantial expansion and benefited from the burgeoning activity in commodity-producing sectors as well as growing external orientation of the Indian economy.

In the present study, we have relied upon both I-O approach and econometric modeling exercise using co-integration and state space models to study the inter-sectoral linkages in the Indian economy. I-O approach has been attempted to examine whether there have been some broad changes or shifts in the production and demand inter-linkages amongst the sectors over time. Co-integration analysis has been carried out to check long-run equilibrium relationship between and amongst the sectors. Having established co-integrating relationships, we have extended the estimation exercise by estimating state space model using Kalman filter. The basic objective behind this is to gauge the extent to which change in one sector(s) influences the other sector's performance over time.

III.1. Analysis based on the I-O Tables

An input-output table reflects inter-industry relations in an economy. It captures the dynamics of how output of one industry goes into another industry where it serves as an input, and thereby shows inter-dependence of the sectors, both as buyer of output and as supplier of inputs. Each column of the I-O table reports monetary value of an industry's inputs, while each row represents value of an industry's outputs. Assuming that there are three industries in an economy, then column 1 reports value of inputs to industry 1 from industries 1, 2, and 3. Columns 2 and 3 do the same for respective industries. Row 1 reports value of outputs from industry 1 to industries 1, 2, and 3. Rows 2 and 3 do the same for the other industries. Hence, both production and demand linkages among the sectors can be examined from the I-O matrices. I-O tables also enable us to examine the nature and extent of changes in inter-dependence of various sectors over the years. Nevertheless, a major limitation of this approach is that it involves extensive data collection, which is generally not available on an annual basis. As a consequence, results based on these tables remain static and relate mainly to the reference period.

III.1.1. Production Linkages

Production linkages among various sectors of the Indian economy basically arise from inter-dependence of sectors for meeting their productive inputs needs. The production linkages between the sectors can be best illustrated through the available I-O tables for 1968-69, 1979-80, 1989-90, 1993-94, 1998-99 and 2003-04.

The sectoral share matrix (production linkage) based on the I-O table is presented in Table 4. The I-O table reveals that during 1968-69, to produce one unit of services output, it required 0.017 units of agricultural input, 0.132 unit of industrial input and 0.096 unit of services sector input itself. In 2003-04, one unit of services sector output required 0.029 unit of agricultural input, 0.213 unit of industrial input and 0.129 unit of services input. It is observed that input dependence of services sector is more aligned with the industrial sector than with agriculture sector. In respect of industry in 1968-69, input requirements for producing one unit of industrial sector output were 0.127 units from agriculture, 0.333 units from industry itself and 0.135 units from the services sector. Input dependence of industrial sector remains the maximum with itself and this is found to be increasing from 0.333 during 1968-69 to 0.455 during 2003-04.

Coming to agriculture, it is observed that input usage from the industrial sector (such as agricultural implements) is increasing, though in 2003-04 it shows a slight decline from the 1998-99 level. Increased dependence of agriculture on Industry for inputs is suggestive of the growing mechanisation of Indian agriculture. In fact, input usage from the industrial sector has been showing an

Table 4: Sectoral Share Matrices (Production Linkages)

	Agriculture	Industry	Services
1	2	3	4
1968-69			
Agriculture	0.182	0.127	0.017
Industry	0.043	0.333	0.132
Services	0.016	0.135	0.096
1979-80			
Agriculture	0.160	0.130	0.039
Industry	0.068	0.345	0.105
Services	0.020	0.149	0.096
1989-90			
Agriculture	0.166	0.042	0.035
Industry	0.144	0.373	0.172
Services	0.047	0.188	0.185
1993-94			
Agriculture	0.146	0.038	0.037
Industry	0.144	0.422	0.231
Services	0.027	0.101	0.117
1998-99			
Agriculture	0.118	0.033	0.025
Industry	0.195	0.421	0.211
Services	0.029	0.101	0.132
2003-04			
Agriculture	0.196	0.028	0.029
Industry	0.180	0.455	0.216
Services	0.045	0.108	0.129

Note : Data upto 1993-94 have been taken from Sastry *et al* (2003). Data for 1998-99 and 2003-04 are based on authors' calculations.

Source : Sastry *et al* (2003) and Central Statistical Organisation.

increasing trend for all the three sectors, indicating the growing importance of industrial inputs for the other sectors, as the economy progresses.

III.1.2. Demand Linkages

In the preceding section, we examined production linkages using input-output coefficient matrix, say A, for each specific years. The matrix $[I — A]^{-1}$ can be used to examine the demand inter-linkages among the sectors. Such matrices for the years 1968-69, 1979-80, 1989-90, 1993-94, 1998-99 and 2003-04 are presented in Table 5.

Table 5: Sectoral Demand Matrices $[(I - A)^{-1}]$ (Demand Linkages)

	Agriculture	**Industry**	**Services**
1	2	3	4
1968-69			
Agriculture	1.230	0.247	0.059
Industry	0.087	1.562	0.230
Services	0.035	0.237	1.141
1979-80			
Agriculture	1.214	0.260	0.083
Industry	0.135	1.601	0.191
Services	0.049	0.269	1.139
1989-90			
Agriculture	1.220	0.104	0.074
Industry	0.319	1.729	0.378
Services	0.144	0.404	1.318
1993-94			
Agriculture	1.189	0.091	0.074
Industry	0.326	1.838	0.495
Services	0.074	0.213	1.191
1998-99			
Agriculture	1.152	0.075	0.051
Industry	0.420	1.831	0.457
Services	0.087	0.216	1.207
2003-04			
Agriculture	1.265	0.077	0.061
Industry	0.466	1.958	0.501
Services	0.123	0.247	1.213

Note : Data upto 1993-94 have been taken from Sastry, *et al* (2003). Data for 1998-99 and 2003-04 are based on authors' calculations.

Source : Sastry, *et al* (2003) and Central Statistical Organisation.

I-O table (based on the matrix $[I-A]^{-1}$) for different years indicates major shifts in demand linkages. It is well established that an increase in agricultural income enhances the demand for industrial goods. Further, a good harvest year is also likely to raise the demand for various services such as the transport, *etc.* It is found that during 1968-69, a rise in demand in agriculture by one unit was likely to raise demand for industrial goods by 0.087 units and demand for services by 0.035 units. It is found that over the years, a rise in the income of agricultural households had made a positive impact on industrial and services sectors through the demand channel. The demand linkage of agricultural sector was found to be stronger with industrial sector than with services sector. Over the years, demand for industrial goods arising from agricultural sector has increased more than five-folds (from 0.087 in 1968-69 to 0.466 in 2003-04). Similarly, over the years a rise in agricultural income has increased the demand for services sector by more than three-folds (from 0.035 in 1968-69 to 0.123 in 2003-04).

During the same period, demand linkage of the industrial sector with the agriculture sector declined from 0.247 in 1968-69 to a mere 0.077 in 2003-04. On the contrary, demand linkage of industry with the services sector has remained intact, it increased initially from 0.237 in 1968-69 to 0.404 in 1989-90, and thereafter declined to 0.213 in 1993-94 before increasing to 0.247 in 2003-04. Demand linkage of services sector with industrial sector improved significantly from 0.230 in 1968-69 to 0.501 in 2003-04, indicating rising importance of industry for services sector, though it remained almost static in case of agriculture.

On the whole, I-O analysis reveals well-built production and demand linkages of services sector with industrial sector and of agriculture sector with industrial sector, respectively.

Section IV
Empirical Analysis and Data Sources

The empirical analysis in the paper focuses on the period since the mid-1980s. This is guided by two developments that reinvigorated India’s economic growth since the 1980s. First, a number of reforms, which were initiated in the 1980s, brought about the structural transformation in the economy to a certain extent. By the early 1980s, the Government had realised that licensing and other restrictions had limited the level of investment activity in the economy. It was felt that opening up the economy to foreign investment could enhance efficiency by bringing in superior technologies and better work practices. This changed the policy perspective and led to liberalisation in the Industrial Policy Statements of 1980 and 1982. For instance, foreign equity restrictions and licensing procedures for Monopolies and Restrictive Trade Practice (MRTP) companies were simplified. Furthermore, some of the industries earlier reserved exclusively for the small-scale industries (SSIs) were opened up for large and medium-scale industries. By 1983, import policies were also liberalised. Further, in 1985, establishment of four additional export-processing zones was announced with a view to attracting export-oriented foreign direct investment (FDI). In addition, by the mid-1980s, non-resident Indians (NRIs) were allowed to invest in Indian companies through equity participation. Second, as documented in Section III, growth trend in the Indian economy broke away from the past in the 1980s. This high growth phase of the economy since the 1980s was, by and large, led by the services sector, which being not a commodity producing sector depends on both industry and services sectors for its growth. This development is likely to have added a new dimension to the inter-sectoral linkages in the Indian economy.

As per the data sources, annual data from 1950-51 to 1999-00 on GDP along with its constituent sectors have been collected from ‘National Accounts Statistics: Back Series 1950-51 to 1999-00’ (CSO, 2007). For the subsequent periods the data have been taken from the web-site of the CSO. Data on rainfall are sourced from India Meteorological Department (IMD), Government of India. The US GDP data have been gathered from the website of Bureau of Economic Analysis, US Department of Commerce (http://www.bea.gov).

Section V
Co-integration Tests and Error Correction Model

Co-integration tests are conducted to examine the existence of long-run equilibrium relationship among a set of economic time series variables. Since co-integration can be done only with those variables that are integrated of the same order, initially we tested all the log-transformed variables for presence of unit roots or non-stationarity using Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, 1981). The empirical results related to ADF test are presented in Table 6**.** All the variables, except the rainfall index, are found to be first difference stationary. Rainfall index is found to be stationary at level.

Mathematically, two or more variables are said to be co-integrated if they are individually integrated of the same order, say I(p), and a linear combination of the variables exists such that their linear combination is stationary, *i.e.* I(0). Generally, existence of co-

Table 6: Unit Root Test using Augmented Dickey Fuller (ADF) Test

Sector	Description	At Level		At First Difference		Conclusion
		Optimum Lag length	ADF test statistic	Optimum Lag length	ADF test statistic	
1	2	3	4	5	6	7
Primary Sector	PRI	1	-2.822	0	-12.360**	I(1)
Secondary Sector	SEC	0	-0.766	0	-5.684**	I(1)
Manufacturing	MFG	0	-2.341	0	-5.737**	I(1)
Tertiary Sector	TER	1	1.817	0	-4.855**	I(1)
Tertiary Sector excluding Community, Social & Personal Services	TER_EX_CSPS	0	2.743	0	-5.402**	I(1)
Trade, Hotels, Transport & Communication	THTC	1	1.652	0	-3.506**	I(1)
Banking and Insurance	BNKI	0	-1.273	0	-7.916**	I(1)
Gross Domestic Product (India)	GDP	0	0.447	0	-7.722**	I(1)
Rainfall Index	RAINFALL	0	-5.530**	–	–	I(0)
USA Gross Domestic Product	USGDP	0	-2.227	0	-7.200**	I(1)

Note : 1. The critical values for ADF test statistic are -4.122 (at 1%), -3.488 (at 5%) and -3.172 (at 10%) at level. Similarly, the critical values for ADF test statistic are -3.546 (at 1%), -2.912 (at 5%) and -2.593 (at 10%) at first difference.

2. ** indicates significance at 1% level of significance.

integration is examined by two alternative approaches, *viz.*, the Engle-Granger two step method proposed by Engel and Granger (1987) and Johansen-Juselius method proposed by Johansen (1988) and later expanded by Johansen and Juselius (1990). The Engle-Granger method is basically for tests for a unique co-integrating relationship, while the Johansen-Juselius method can be applied to test for existence of more than one co-integrating relationship. The number of co-integrating vectors based on Johansen-Juselius method is determined based on two test statistics, *viz.*, the Trace Statistic and the Maximal Eigenvalue Statistic. The Trace Statistic examines the null hypothesis that the number of distinct co-integrating vectors is less than or equal to 'r' against a general alternative. The Maximal Eigenvalue Statistic tests the null hypothesis that the number of co-integrating vectors is 'r' against the alternative of 'r+1' co-integrating vectors.

To begin with, as documented earlier, we would confine our analysis from mid-1980s onwards (from 1985-86 to 2007-08). Initially, we attempted to establish co-integrating relationship among the major sectors, *viz.*, primary, secondary and tertiary sectors and then tried to explore the relationship of certain sub-sectors of the secondary and tertiary sectors with other sectors. The empirical results of the co-integration tests based on Johansen-Juselius method are presented in Annex-I. Both the Trace Statistic and Maximum Eigenvalue Statistic indicate existence of co-integrating relationship among the sectors. In the process, we have made the following nine co-integrating relationships among various sectors and sub-sectors of the economy.

V.1. Primary Sector and Secondary Sector

At the outset, we attempted to explore the relationship between primary and secondary sectors. As the output of the primary sector in India depends heavily on rainfall, we have incorporated the rainfall index as an additional variable in the short-run dynamic equation. Both the Trace Statistic and Maximal Eigenvalue Statistic reject the null hypothesis of no cointegration.

The estimate of long-run equation along with short-run dynamic ECM equation for the period 1985-86 to 2007-08 is presented below. The estimated coefficient of the error term ECM_{t-1} indicates speed of adjustment of the primary sector towards the equilibrium state. The state corrects approximately 46 per cent of their error during one year.

Long-run Equation:

$$\log(PRI_t) = 1.430 + 0.510 \log(SEC_t)$$

ECM equation:

$$\Delta \log (PRI_t) = -0.46ECM_{t-1} - 0.35\, \Delta \log (PRI_{t-1}) - 0.18\, \Delta \log (PRI_{t-2}) - 0.04\, \Delta \log (SEC_{t-1}) - 0.28\, \Delta \log (SEC_{t-2}) + 0.32 \log (RAINFALL_t)$$

Adjusted R^2 =0.83

V.2. Primary Sector and Manufacturing Sector

We further attempted to explore for existence of relationship between the primary and manufacturing sectors. Both the Trace Statistic and Maximal Eigenvalue Statistic suggest existence of one cointegrating relationship. The ECM equation indicates that approximately 45 percent of previous year error is corrected in the current year. The estimates of both long-run as well as short-run ECM equations are presented below:

Long-run Equation:

$$\log(PRI_t) = 1.491 + 0.512 \log(MFG_t)$$

ECM equation:

$$\Delta \log (PRI_t) = -0.45ECM_{t-1} - 0.32\, \Delta \log (PRI_{t-1}) - 0.14\, \Delta \log (PRI_{t-2}) - 0.02\, \Delta \log (MFG_{t-1}) - 0.32\, \Delta \log (MFG_{t-2}) + 0.33 \log (RAINFALL_t)$$

Adjusted R^2 =0.85

V.3. Primary Sector and Tertiary Sector

Next, we explored for existence of long-run equilibrium relationship between the primary and tertiary sectors. The rainfall index has also been included as an additional variable in the short-run ECM equation. Both the Trace Statistic and Maximal Eigenvalue Statistic suggest existence of one cointegrating relationship.

The estimate short-run dynamic ECM equation indicates that approximately 33 percent of the error is being corrected during the current year. The estimates of both the equations are presented below.

Long-run Equation:

$$\log(PRI_t) = 0.90 + 0.45 \log(TER_t)$$

ECM equation:

$$\Delta \log (PRI_t) = -0.33ECM_{t-1} - 0.44\, \Delta \log (PRI_{t-1}) - 0.24\, \Delta \log (PRI_{t-2}) - 0.08\, \Delta \log (TER_{t-1}) - 0.39\, \Delta \log (TER_{t-2}) + 0.36 \log (RAINFALL_t)$$

Adjusted R^2 =0.83

V.4. Primary Sector and Tertiary Sector (excluding CSPS)

In line with above, we further attempted to explore for the existence of relationship between the primary and tertiary sector, excluding community, social & personal services. Both the Trace Statistic and Maximal Eigenvalue Statistic indicate the existence of one long-run equilibrium relationship. The estimate of both the equations is presented below.

Long-run Equation:

$$\log(PRI_t) = 1.430 + 0.447 \log(TER\_EX\_CSPS_t)$$

ECM equation:

$$\Delta \log (PRI_t) = -0.40ECM_{t-1} - 0.38\, \Delta \log (PRI_{t-1}) - 0.19\, \Delta \log (PRI_{t-2}) - 0.35\, \Delta \log (TER\_EX\_CSPS_{t-1}) - 0.54\, \Delta \log (TER\_EX\_CSPS_{t-2}) + 0.35 \log (RAINFALL_t)$$

Adjusted R^2 =0.84

V.5. Secondary Sector and Tertiary Sector

Next, an attempt was made to explore the relationship between the secondary and tertiary sector. Since the mid-1980s, the secondary and tertiary sectors display strong long-run equilibrium relationship with each other. The USGDP has also been added as an additional variable in the short-run dynamic equation. Both the Trace Statistic and Maximal Eigenvalue Statistic indicate the existence of one long-run equilibrium relationship.

The short-run dynamic ECM equation indicates that the state corrects approximately 40 percent of their error during one year.

Long-run Equation:

$$\log(SEC_t) = 0.33 + 0.90 \log(TER_t)$$

ECM equation:

$$\Delta \log (SEC_t) = -0.40ECM_{t-1} + 0.86\, \Delta \log (SEC_{t-1}) + 0.10\, \Delta \log (SEC_{t-2}) - 0.33\, \Delta \log (TER_{t-1}) - 0.77\, \Delta \log (TER_{t-2}) + 0.02 + 0.94\, \Delta \log (USGDP_t)$$

Adjusted R^2 =0.64.

V.6. Secondary Sector and Tertiary Sector (excluding CSPS)

Further, we tried to explore the relationship between secondary and tertiary sectors, after excluding the Community, Social & Personal Services (CSPS) from the tertiary sector. Since the mid-1980s, secondary and tertiary sectors (excluding CSPS) indicate strong long-run equilibrium relationship, as indicated by the Trace Statistic as well as by the Maximal Eigenvalue Statistic. Estimate of the long-run cointegrating relationship between the two sectors for the period 1985-86 to 2007-08 is as follows:

Long-run Equation:

$\log(SEC_t) = 0.84 + 0.85 \log(TER\_E\_CSPS_t)$

ECM equation:

$$\Delta \log (SEC_t) = -0.41 ECM_{t-1} + 0.88 \Delta \log (SEC_{t-1}) + 0.10 \Delta \log (SEC_{t-2}) - 0.28 \Delta \log (TER\_E\_CSPS_{t-1}) - 0.87 \Delta \log (TER\_E\_CSPS_{t-2}) + 0.75 \Delta \log (USGDP_t)$$

Adjusted R^2 =0.64.

V.7. Primary Sector, Secondary Sector and Tertiary Sector

After establishing the existence of bivariate long-run relationship between different sectors, we further attempted to explore for existence of cointegration relationship among all the three major sectors, *viz.*, primary, secondary and tertiary sectors. Mathematically, both the Trace Statistic and Maximal Eigenvalue Statistic indicate existence of at most two cointegrating relation among the three sectors. The estimate of the long-run relationship is found to be

$$\log(PRI_t) = 2.85 - 0.22 \log(SEC_t) + 0.68 \log(TER_t)$$

Sign of the estimated coefficient in respect of the secondary sector is found to be negative, which suggests that the secondary sector and primary sector move in the opposite direction in the long-run. This finding is against the belief that all the sectors in an economy will move in the same direction, at least in the long-run.

Further, we explored for existence of long-run relationship among the three sectors, after excluding the CSPS sector from the tertiary sector. The rationale for exclusion of CSPS from the tertiary sector in our analysis emanates from the fact that a major part of the CSPS comprises wages and salaries of the Government administrative departments, which is policy driven and as such does not directly enter the productive activities of the economy. The Trace Statistic suggests the existence of at most two cointegrating relationship, while the Maximal Eigenvalue Statistic suggest existence of at most one cointegrating relationship among the three sectors, after excluding the CSPS sector from the tertiary sector. Thus, based on both the statistics, we can infer for existence of long-run equilibrium relationship among the primary, secondary and tertiary sectors (excluding CSPS) for the period from 1985-86 to 2007-08. The short-run ECM equation includes USGDP and rainfall index as exogenous variables. The co-efficient for both these variables are found to be positive and significant. The positive sign in respect of rainfall index supports the assumption that a good monsoon plays a vital role in the agricultural growth of the Indian economy. Further, growth in the Indian economy is found to depend on the state of the US economy, which alone accounts for about a quarter of the global GDP. This is in sync with fact that though the export as well as import orientation of Indian economy is diversifying to other markets, the US continues to be one of its largest trading partners.

The estimate of the long-run cointegrating relationship among the three sectors is presented below. The ECM equation indicates that approximately 35 percent of the previous year error is corrected in the current year.

Long-run Equation:

$$\log(PRI_t) = 2.83 + 0.005 \log(SEC_t) + 0.19 \log(TER\_E\_CSPS_t)$$

ECM equation:

$$\begin{aligned}\Delta \log(PRI_t) = &- 0.35ECM_{t-1} - 0.48\Delta \log(PRI_{t-1}) - 0.23\Delta \log \\ &(PRI_{t-2}) + 0.38\Delta\log(SEC_{t-1}) + 0.15\Delta \log(SEC_{t-2}) \\ &- 0.30\Delta \log(TER\_E\_CSPS_{t-1}) \\ &- 0.34\Delta \log(TER\_E\_CSPS_{t-2}) - 0.58 \\ &+ 0.32 \log(RAINFALL_t) + 0.37\Delta \log(USGDP_t)\end{aligned}$$

Adjusted R^2 =0.83

V.8. Banking & Insurance Sector, Manufacturing Sector and Primary Sector

Next we explored for existence of any long-run relationship among the banking & insurance, manufacturing and primary sectors. Though the Trace Statistic indicates existence of a single long-run cointegrating relationship, Maximal Eigenvalue Statistics suggests non-existence of any cointegrating relationship among the three sectors. The ECM equation indicates that approximately 38 percent of previous year error is corrected in the current year.

Estimate of the long-run equation (as suggested based on the Trace Statistic) is found to be:

Long-run Equation:

$$\log(BNKI_t) = -9.60 + 0.22 \log(MFG_t) + 2.09 \log(PRI_t)$$

ECM equation:

$$\begin{aligned}\Delta \log (BNKI_t) = {} & -0.38ECM_{t-1} + 0.16\, \Delta \log (BNKI_{t-1}) \\ & + 0.12\, \Delta \log (BNKI_{t-2}) + 0.05\, \Delta \log (MFG_{t-1}) \\ & + 0.05\, \Delta \log (MFG_{t-2}) - 0.03 \Delta \log (PRI_{t-1}) \\ & - 0.42\, \Delta \log (PRI_{t-2}) + 0.03\end{aligned}$$

Adjusted $R^2 = 0.32$

V.9. Trade, Hotels, Transport & Communication Sector and Manufacturing Sector

Finally, we attempted to explore for the existence of long-run equilibrium relationship of 'trade, hotels, transport & communication' (THTC) sector with other sectors of the economy. Empirically, THTC sector is found to be cointegrated with the manufacturing sector, as suggested by both Trace Statistic and Maximal Eigenvalue Statistic. The USGDP is found to have a significant impact on India's trade growth in the short-run, which, in turn, is a testimony of the fact that the US is India's largest trade associate.

The estimate of the long-run equilibrium equation along with the short-run ECM equation is presented below. Co-efficient of the ECM term in the short-run equation is found to be 0.16. This indicates that, if the deviation in the long-run equation, *i.e.*, 'log(THTC) - 1.05 – 0.83 log(MFG)' is positive, then value added in the manufacturing sector will rise and the value added in the trade sector will fall. In case the deviation in the long-run equation is negative, then value added in the manufacturing sector will fall and in the trade sector will rise.

Long-run Equation

$\log(THTC_t) = 1.05 + 0.83 \log (MFG_t)$

ECM equation:

$$\Delta\log(THTC_t) = 0.16ECM_{t-1} - 0.15\Delta\log (THTC_{t-1}) - 0.61\Delta\log (THTC_{t-2}) + 0.38\Delta\log (MFG_{t-1}) + 0.14\Delta\log (MFG_{t-2}) + 0.04 + 0.73\Delta\log (USGDP_t)$$

Adjusted R^2 =0.68

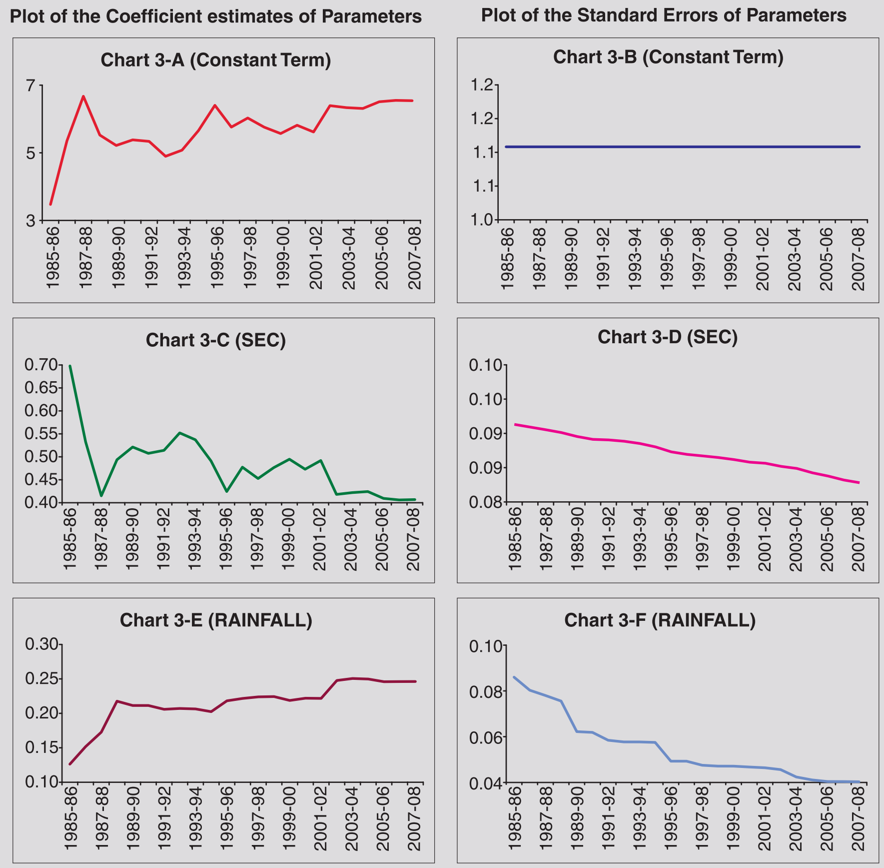
Section VI
State Space Model Framework

Having established long-run equilibrium relationship among the variables, we extended our empirical exercise and made some estimations through the state space model using Kalman filter and test the stability of the model. The basic objective behind this exercise is to gauge the impact of changes in one sector(s) over the other sector over time. The estimates of state space model are obtained by maximising the log-likelihood function through a recursive algorithm (Annex– II). Towards this endeavor, we have considered the following seven frameworks, based on the cointegrating relationships as found in the preceding section. Formulation of the state space model is described in Annex – III.

VI.1. Primary Sector and Secondary Sector

The first state-space model is premised on primary sector output being dependent only on the secondary sector output as also on the rainfall (Chart 3). The standard errors for the constant term as well as both for secondary sector and rainfall index are found to be quite small, implying stability in estimate of the parameters (Chart 3-B, Chart 3-D and Chart 3-F). The coefficient of the constant term shows an increasing trend (Chart 3-A) suggesting possibly that productivity in agriculture sector might have increased over the years. The coefficient of the manufacturing sector shows a declining trend in the last decade or so,

Chart 3: Plot of the Estimates and Standard Errors of Parameters (state series) for PRI = f(SEC, RAINFALL)

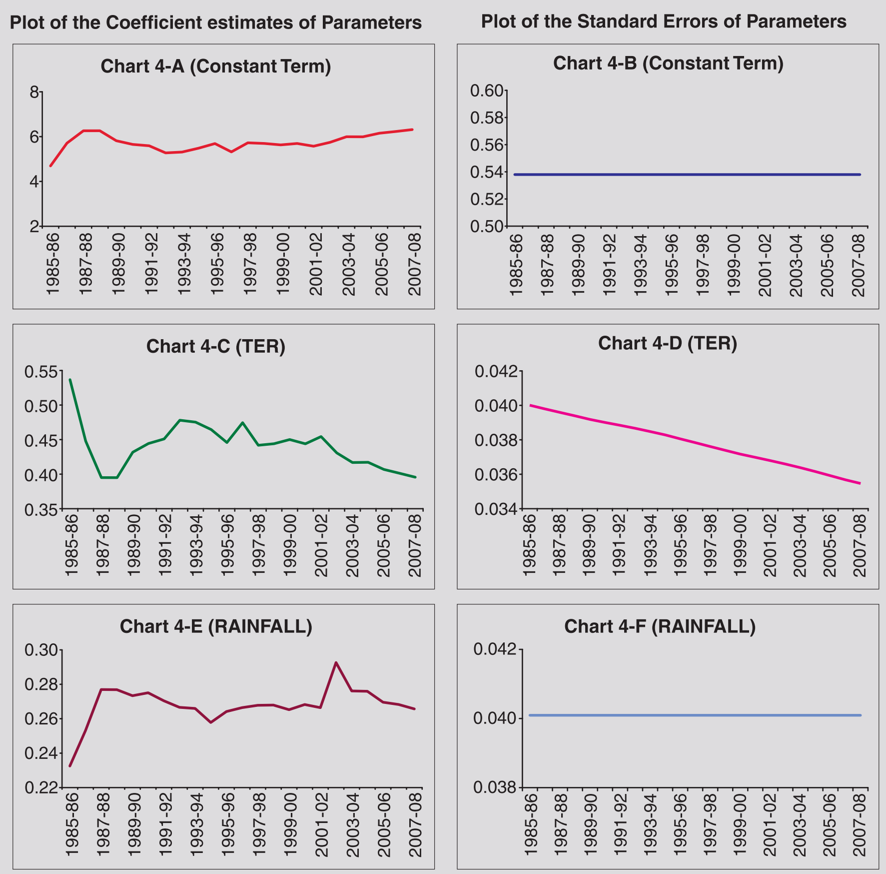


indicating the lower dependence of the agriculture and allied sector on the manufacturing sector. Interestingly, this fact is to an extent supported by the I-O Table (Table 3) also, wherein one unit agricultural sector output required 0.195 unit of industrial inputs in 1998-99, which subsequently declined to 0.180 units in 2003-04. The coefficient of rainfall index shows a rising trend indicating a stronger influence of the rainfall still on agricultural and allied sector output.

VI.2. Primary Sector and Tertiary Sector:

The second state-space model formulates the primary sector on tertiary sector. Further, the primary sector is assumed to be dependent on rainfall also. Estimates of the coefficient along with the standard errors of parameters are presented in Chart 4. The estimate of near zero standard errors for all the parameters indicates stability in the estimate of the co-efficient. Coefficient of the constant term is showing an increasing trend (Chart 4-A), which supports the empirical finding obtained in the previous section. The coefficient of the tertiary sector shows a declining trend in the last decade or so, which is suggestive of the fact that of late the dependence of the agriculture & allied activities on tertiary sector has declined (Chart 4-C).

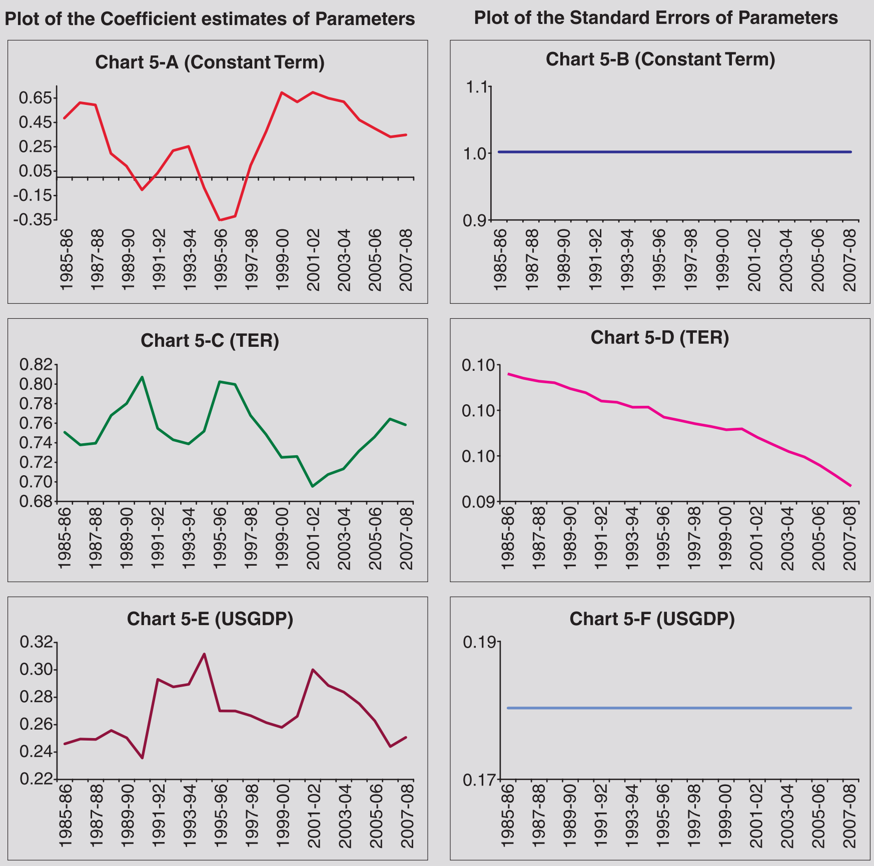
Chart 4: Plot of the Estimates and Standard Errors of Parameters (state series) for PRI = f(TER, RAINFALL)



VI.3. Secondary Sector and Tertiary Sector:

In the third analysis, secondary sector output is considered to be a function of the tertiary sector. Further, the USGDP has also been considered as an additional explanatory variable in the model. Estimates of the coefficient of the parameters along with the standard errors over the period are presented in Chart 5. Estimates of standard errors for all the parameters are found to be small indicating stability of estimates of the parameters. Coefficient of the tertiary sector is showing an increasing trend since the early 2000s, suggesting that tertiary sector, of late, has been abetting the secondary sector output. Further, the I-O Table (Table 3) also supports

Chart 5: Plot of the Estimates and Standard Errors of Parameters (state series) for SEC = f(TER, USGDP)

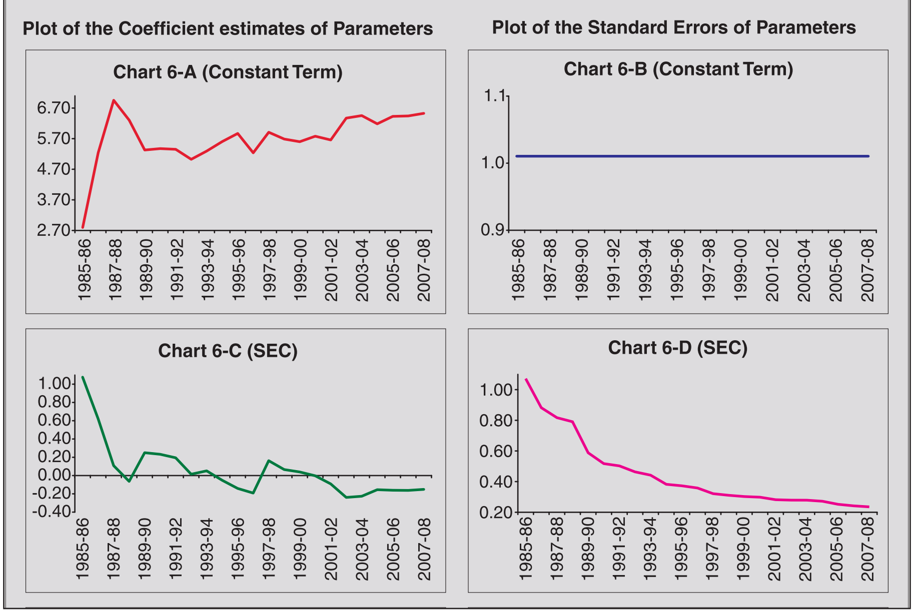


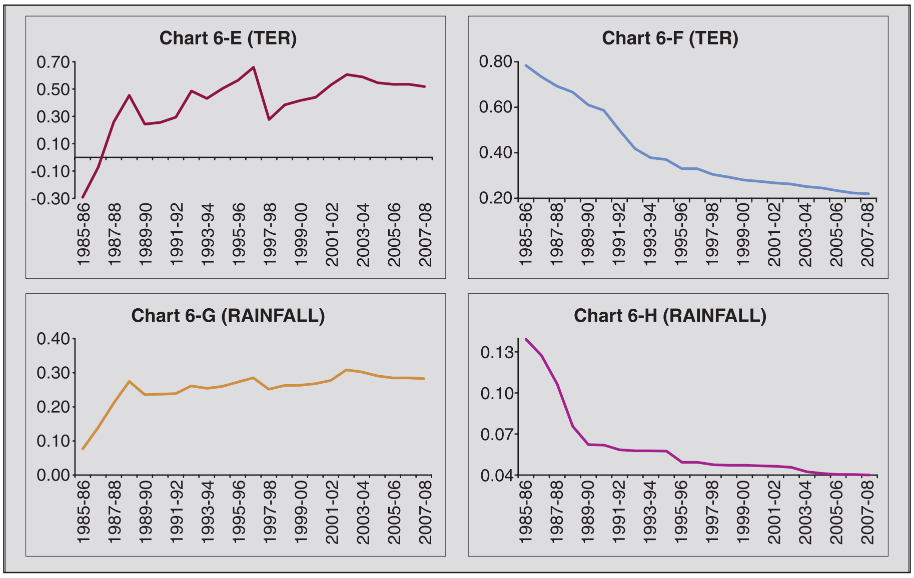
this finding, wherein one unit of industrial sector output required 0.421 units of services inputs in 1998-99, which increased to 0.455 units in 2003-04. The coefficient of USGDP shows a declining trend in the recent period, thereby suggesting declining influence of the USGDP on the secondary sector's performance (Chart 5-E). The diversification in the of India's exports to other destinations in the last couple of years may be a potential cause for this decline.

VI.4. Primary Sector, Secondary Sector and Tertiary Sector

In the fourth analysis, primary sector output is considered to be a function of secondary sector, tertiary sector and rainfall index. The near zero estimate of the standard error over the time period for all the parameters indicate the tendency towards stability in estimate of the coefficients. Coefficient of the constant term shows a rising trend (Chart 6-A). Coefficient of the secondary sector shows a declining trend thereby suggesting its declining influence on the primary sector performance (Chart 6-C). Coefficient of the rainfall index shows a

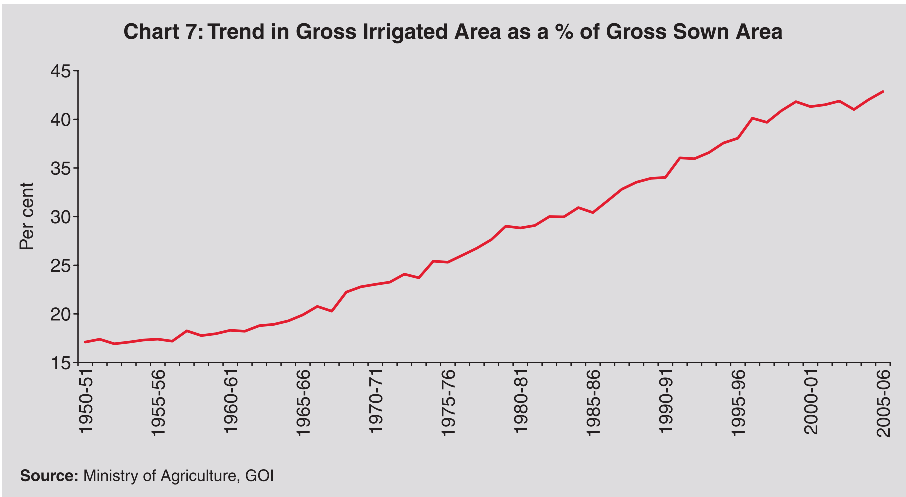
Chart 6: Plot of the Estimates and Standard Errors of Parameters (state series) for PRI =f(SEC, TER, RAINFALL)





declining trend since 2000-01 suggesting that the impact of rainfall on the agricultural production has decelerated in the recent period.

It is offered that the agricultural sector in India, even after six decades since independence is, by and large, dependent on the monsoon rainfall. About 43.0 per cent of gross sown area remained irrigated in 2005-06, while a large chunk of close to 57.0 per cent of gross cropped area remained reliant on rainfall (Chart 7)**.**



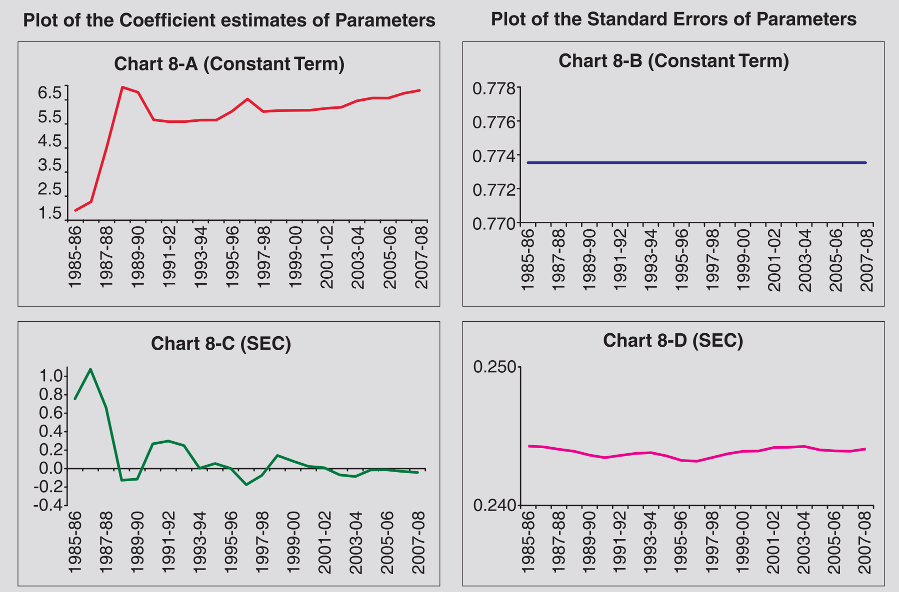
VI.5. Primary Sector, Secondary Sector and Tertiary Sector (excluding CSPS)

The fifth state-space model is estimated based on the relationship among the primary, secondary and the tertiary sectors (excluding CSPS). Small values of the estimated standard error over the time period for all the parameters indicate the tendency towards stability in the estimate of coefficients. Coefficient of the constant term shows a rising trend (Chart 8-A). Coefficient of the secondary sector shows a declining trend, thereby suggesting its declining influence on the primary sector performance (Chart 8 C).

VI.6. Banking & Insurance Sector, Manufacturing Sector and Primary Sector:

We further attempted to explore the relationship among Banking & Insurance Sector (BNKI), manufacturing sector[1] and

Chart 8: Plot of the Estimates and Standard Errors of Parameters (state series) for PRI =f(SEC, TER_EX_CSPS, RAINFALL)



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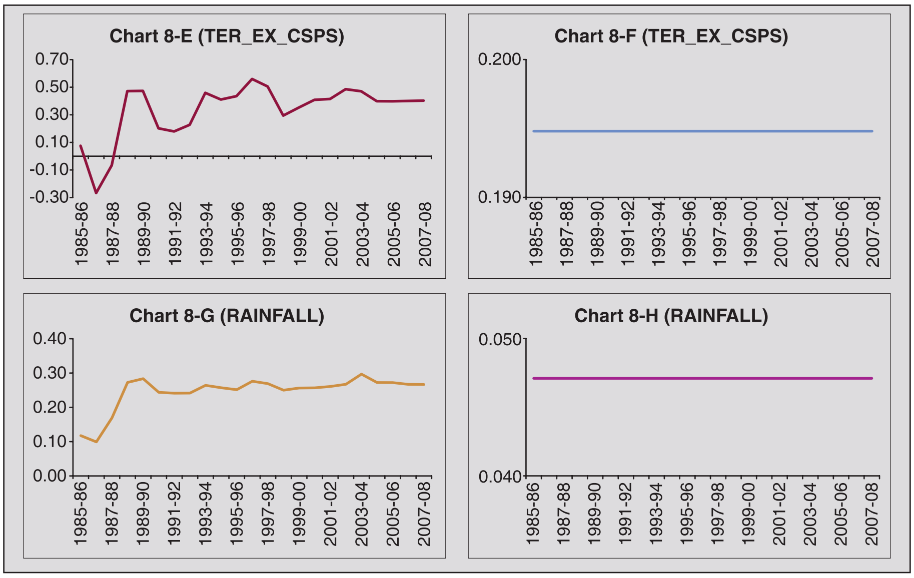
1 The empirical estimates using the secondary sector was not found to be consistent.

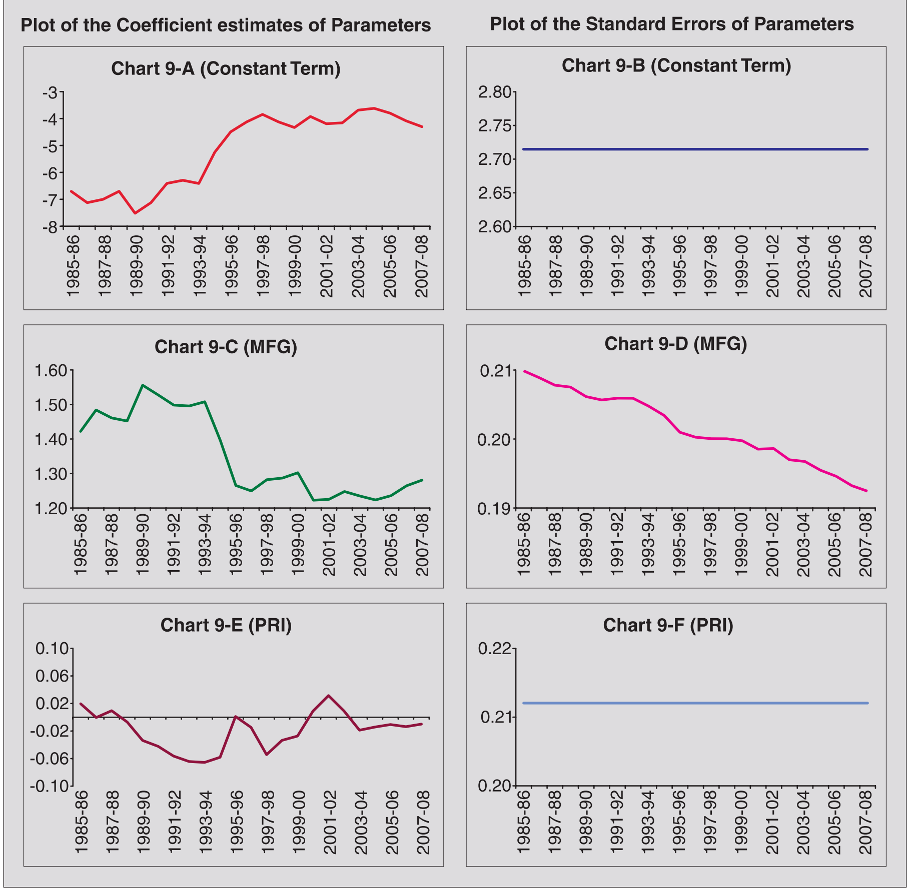


the primary sector (Chart 9). The standard errors for the constant term, and the coefficients of the manufacturing sector and primary sector indicate the stability in the estimate of the parameters. The coefficient of the manufacturing sector shows a declining trend from 1989-90 to 2004-05, and thereafter an increasing trend. The increase in the coefficient of the manufacturing sector on BNKI may be attributed to the rise in the banking and insurance activities corresponding to the rise in the manufacturing sector activities during the expansionary phase observed in the Indian economy from 2005-06 onwards. The coefficient of the primary sector output also shows a slowly increasing trend since 1992-93.

VI.7. Trade, Hotels, Transport & Communication Sector and Manufacturing Sector

In the ultimate analysis, THTC sector output is considered to be a function of manufacturing sector and the USGDP. Time plot of the estimated standard errors indicates the stability in the estimate of all the parameters. The coefficient of the manufacturing sector shows a rising trend since 2000-01, suggesting that manufacturing sector plays

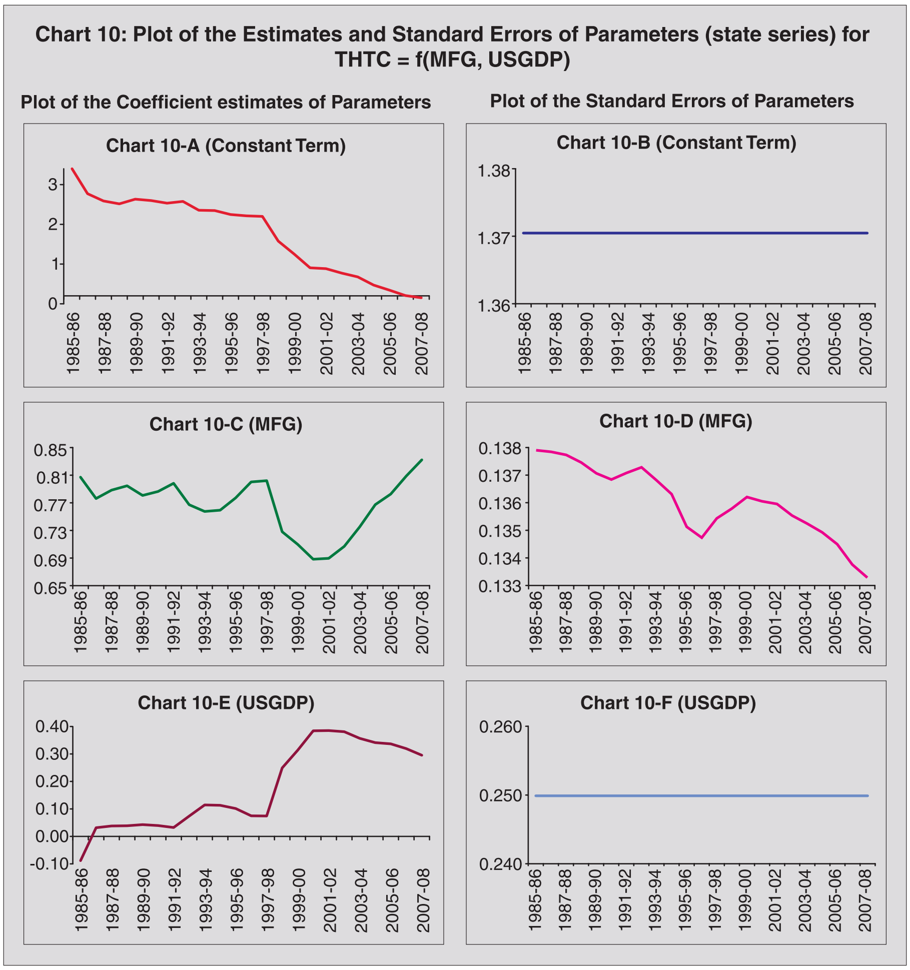
Chart 9: Plot of the Estimates and Standard Errors of Parameters (state series) for BNKI = f(MFG, PRI)



a vital role in influencing THTC (Chart 10). Similarly, coefficient of the USGDP shows a declining trend since 2000-01, possibly indicating trade diversification of India's external sector to the non-US countries.

Section VII
Policy Implications emanating from the Study

Though services sector has emerged as the growth driver of the economy over the period of the analysis, possible negative implications of the same are agenda for active debate in the growth literature. It is argued that to the extent to which the services sector is not commodity producing in nature, a wide disparity between



sectoral incomes would widen the demand-supply gap of the commodities, which would result in inflation, high import demand and balance of payment (BoP) problems in a closed economy (Bhattacharya and Mitra, 1990). The decade of the 1990s marked the opening up of the Indian economy. Contrary to a section of the literature, which vouches for the aforementioned conclusions, India's experience in the post-reform period suggests that despite higher growth of services sector in relation to other commodity producing sectors, the country has not confronted any significant inflationary pressures and BoP problems. In fact, rising flow of services invisibles have aided in keeping the current account deficit of the country at a manageable level. Nevertheless, this pattern of India's growth needs a more careful re-examination for its sustainability and other macroeconomic and distributive implications. *Prima facie*, it appears reasonable to argue for a more synchronised sectoral growth of the Indian economy since this would create/expand the market of commodities and services produced by each sector. Growth of agriculture is critical for raising the income levels of the people engaged therein, while manufacturing sector needs to grow faster for ensuring macroeconomic balance and overcome supply constraints, and thereby ensure price stability and trade balance. Above all, it needs to grow faster to generate employment opportunities, as among the three sectors, manufacturing has a reasonably high and growing employment intensity.

The foregoing co-integration analysis highlights that services sector maintained long-term equilibrium relationship both with agricultural and industrial sectors. As per I-O relationship, however, services activity was found to have strong linkages with the industrial sector, while a great degree of association was evident between the agriculture and the industrial sector. Over the years, the services sector has remained in the forefront of the economic progress, while the growth of agriculture sector has not only remained significantly lower, but also volatile. This seems to indicate that the growth synergy between agriculture and services sectors has remained weak. This may be attributable to the fact that reforms in the agricultural sector have lagged significantly behind reforms in the industry and services sectors. This indisputably is a concern area since it is desirable that the leading sector (*i.e.* services sector) in the economy should share its positive growth impulses with rest all sectors, if an economy were to realize its true growth potential. Bathla (2003) argues that if liberalised measures were directed simultaneously at all the three sectors, it would go a long way in expanding the markets for goods and services produced in the economy. In view of this, policy measures need to foster agricultural growth by unleashing the export potential of agro-products. Consequently, this would stimulate demand for specialised infrastructure services such as warehouses, cold storage, refrigerated vans, ports, transportation, communication, finance, insurance and the like, thereby reinvigorating the inter-sectoral synergy, especially between agriculture and the services sectors. Further, promotion of export of agri-products by attending to agro-processing industries would further reinforce the growth linkages between agriculture and industry.

In India, the share of 'banking and insurance' in GDP has increased from about one per cent in 1950-51 to about seven per cent in recent years, reflecting growing financial sector activity. In our empirical analysis, 'banking and insurance' sector was found to be cointegrated with both the manufacturing and agricultural sectors. This is in sync with experiences of a number of countries, where finance and growth have been found to move in tandem. There is a need to foster this association further by extending the reach of financial sector to the unorganised sector, thereby facilitating better financial inclusion. Ironically, though the size of unorganised sector in India continues to remain enormously large, the missing links deprive this segment of the potential benefits from the 'banking and insurance' sector. In this regard, public policy needs to focus on encasing the unorganised sector within the financial sphere so that its latent growth potential could be fully unleashed. The motivation behind public policy interventions here emanate from the fact that the financial sector initiatives in India in terms of their outreach have, by and large, been State led.

Section VIII
Concluding Observations

The present study has endeavored to examine and analyse inter-sectoral linkages in the Indian economy following both the I-O approach and the econometric exercises using co-integration and state-space models. The analysis of I-O tables from the production side reveals that input demand of the services sector is industry intensive rather than being farm (denoting agriculture) intensive. Further, that the farm sector is significantly reliant on industry for inputs. The demand linkage examination amply demonstrates that the agricultural sector exhibits strong association with the industrial sector, while the converse connection in terms of demand linkages of industry with the agricultural sector have weakened in the last two decades or so. Demand linkages of the services sector were observed to have strengthened *vis-à-vis* the industrial sector overtime.

The cointegration analysis (covering the period since mid-1980s) at the broad sectoral level supports the assessment that the three broad sectors *viz.*, primary, secondary and tertiary (excluding CSPS) demonstrate strong long-run equilibrium amongst themselves. In bivariate framework also, these sectors confirm robust long-term equilibrium relationship with one another. At the sub-sectoral level, existence of long-term equilibrium was observed between 'trade, hotels, transport & communication' and the 'manufacturing' sectors. Further, the financial sector activity in the 'banking & insurance' sector was noticed to be cointegrated with the 'manufacturing' and 'primary' sectors. Our analysis based on state space model using Kalman filter also corroborates the outcome of the cointegration analysis, as the results capture variations in one sector influencing the other sector's performance over time.

As per the policy implications of the study, it is found that relatively stronger growth of the services sector in India *vis-a-vis* other sectors does not appear to be desirable and calls for a correction in terms of enhancing the growth synergies among sectors. This is likely to give a stimulus to the dormant growth potential. Towards this end, reforms in the agriculture sector which lagged behind that of the industrial and services sectors deserve policy consideration to be able to harness the export potential of agro-products. Creation of specialised infrastructure services for promoting agri-exports would strengthen the agriculture-services relationship. Finally, the public policy needs to be geared towards encasing the unorganised sector in the ambit of banking and insurance so that the latent growth potential of the sector could be fully realised.

Annex-I

Table : Empirical Results of the Co-integration Tests based on Johansen-Juselius method

Variables in the system		Eigenvalue	Trace Statistic	Maximal Eigenvalue Statistic	Conclusion
1	2	3	4	5	6
PRI, SEC	None	0.775	36.636 (0.000)	35.820 (0.000)	One co-integrating relationship exists.
	At Most 1	0.033	0.816 (0.972)	0.816 (0.972)	
PRI, MFG	None	0.783	37.199 (0.000)	36.699 (0.000)	One co-integrating relationship exists.
	At Most 1	0.021	0.500 (0.995)	0.500 (0.995)	
PRI, TER	None	0.797	42.298 (0.000)	38.280 (0.000)	One co-integrating relationship exists.
	At Most 1	0.154	4.018 (0.409)	4.018 (0.409)	
PRI, TER_EX_CSPS	None	0.818	45.853 (0.000)	40.870 (0.000)	One co-integrating relationship exists.
	At Most 1	0.188	4.984 (0.285)	4.984 (0.285)	
SEC, TER	None	0.488	21.491 (0.006)	16.059 (0.026)	One co-integrating relationship exists.
	At Most 1	0.203	5.432 (0.020)	5.432 (0.020)	
SEC, TER_EX_CSPS	None	0.497	21.375 (0.035)	16.508 (0.040)	One co-integrating relationship exists.
	At Most 1	0.184	4.867 (0.298)	4.867 (0.298)	
PRI, TER_EX_CSPS	None	0.818	45.853 (0.000)	40.870 (0.000)	One co-integrating relationship exists.
	At Most 1	0.188	4.984 (0.285)	4.984 (0.285)	
PRI, SEC, TER	None	0.684	44.894 (0.001)	27.648 (0.005)	At most Two co-integrating relationship exist.
	At Most 1	0.453	17.246 (0.027)	14.499 (0.046)	
	At Most 2	0.108	2.747 (0.098)	2.747 (0.098)	
PRI, SEC, TER_EX_CSPS	None	0.714	46.417 (0.000)	30.017 (0.002)	At most one co-integrating relationship exists.
	At Most 1	0.421	16.400 (0.037)	13.131 (0.075)	
	At Most 2	0.127	3.269 (0.071)	3.269 (0.071)	
BNKI, MFG, PRI	None	0.579	31.607 (0.031)	19.917 (0.073)	One co-integrating relationship exists (by Trace Statistic).
	At Most 1	0.398	11.691 (0.172)	11.688 (0.123)	
	At Most 2	0.0001	0.002 (0.959)	0.002 (0.959)	
TRADE, MFG	None	0.483	18.753 (0.016)	15.826 (0.028)	One co-integrating relationship exists.
	At Most 1	0.115	2.927 (0.087)	2.927 (0.087)	

Annex - II

Methodology of Time Varying Parameter approach using Kalman filter algorithm

The time varying parameter approach is based on the assumption that parameters are assumed to follow some underlying processes over time. These time varying parameters are modeled and estimated using the Kalman filter algorithm (Kalman, 1960). Kalman filter is an estimation method, which is used to estimate state-space models. The general form of the Kalman filter model comprises of two equations – the measurement and transition equations.

The measurement equation is given by –

$$A_t = B\alpha_t + e_t, \qquad \text{var}(e_t) = R \qquad \text{(II.I)}$$

and the transition equation is given by –

$$\alpha_t = T\alpha_{t-1} + v_t, \qquad \text{var}(v_t) = Q \qquad \text{(II.2)}$$

The measurement equation (7.1) is an ordinary regression equation with time-varying parameters, α_t, while the transition equation (7.2), defines the evolution of the parameters over time. Here A_t represents the *(n*x*1)* vector of n- observable variables and α_t is a *(r*x*1)* vector of r unobservable components. B and T represent matrices of order *(n*x*r)* and *(r*x*r)* respectively. e_t and v_t are Gaussian error vectors of order *(n*x*1)* and *(r*x*1)* respectively.

If one has an estimate of α_{t-1} and its mean square error p_{t-1}, then the updated estimate of α_t, given A_t and B_t, is estimated by the following Kalman-filter algorithm:

$$\left.\begin{aligned} S_t &= TP_{t-1}T' + Q \\ P_t &= S_t - K_t BS_t \\ \alpha_t &= T\alpha_{t-1} - K_t(A - B\alpha_{t-1}) \end{aligned}\right\} \qquad \text{(II.3)}$$

The matrix K_t, referred as the Kalman gain matrix, is defined as,

$$K_t = S_t B'(BS_t B' + R)^{-1} \qquad \text{(II.4)}$$

The problem is to develop appropriate estimates for the four unknown parameters of the model $\beta = \{B,T,R,Q\}$ and make inference about the state vector α_t .

For implementation of the Kalman filter, one has to specify initial values for the state vector α_0, its mean squared error P_0, and the parameters $\beta^{(0)} = \{B_0,T_0,R_0,Q_0\}$. Given these initial values, the sequence of state vector α and the mean square error P is computed using Kalman filter. These are then used to evaluate the Gaussian log-likelihood function,

$$\log L(\beta) = -\frac{nm}{2}\log(2\pi) - \frac{1}{2}\sum_t \log |BP_tB' + R| - \frac{1}{2}\sum_t e_t'(BP_tB' + R)^{-1}e_t \qquad \text{(II.5)}$$

and find the next set of parameters $\beta^{(1)}$ and this completes one iteration. The next iteration starts with initial values α_0, P_0 and $\beta^{(1)}$ to obtain $\beta^{(2)}$ and so on, until convergence is achieved. In equation (II.5), 'm' represents the number of observations.

Annex – III

Formulation of the State Space Model

Let's consider a three-sector framework consisting of sectors X, Y and Z, wherein sector X depends on the other two sectors. The specification of the model under the state-space form can be formulated as:

$$\log(X_t) = b_{0t}+b_{1t}\log(Y_t)+b_{2t}\log(Z_t)+e_t \qquad (III.1)$$

$$b_{0t}+b_{0t-1}+u_{0t} \qquad (III.2)$$

$$b_{1t}+b_{1t-1}+u_{1t} \qquad (III.3)$$

$$b_{2t}+b_{2t-1}+u_{2t} \qquad (III.4)$$

In the above specification, equation (III.1) is known as the measurement equation, which states that the output of the sector X depends on the output on the other two sectors Y and Z. Equations (III.2) through (III.3) are known as transition equation.

The measurement equation (III.1) can be written in the matrix form as,

$$\log(X_t) = \begin{pmatrix} 1 & \log(Y_t) & \log(Z_t) \end{pmatrix} \begin{pmatrix} b_{0t} \\ b_{1t} \\ b_{2t} \end{pmatrix} + e_t \qquad (III.5)$$

and the corresponding *transition* equation, takes the form,

$$\begin{pmatrix} b_{0t} \\ b_{1t} \\ b_{2t} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} b_{0,t-1} \\ b_{1,t-1} \\ b_{2,t-1} \end{pmatrix} + \begin{pmatrix} u_{0t} \\ u_{1t} \\ u_{2t} \end{pmatrix} \qquad (III.6)$$

The matrices, as defined in (III.5) and (III.6) may be represented as,

$$\left.\begin{aligned} A_t &= B\alpha_t + e_t \\ \alpha_t &= T\alpha_{t-1} + v_t \end{aligned}\right\} \qquad (III.7)$$

where

$$A_t = \log(X_t),\quad B = \begin{pmatrix}1 & \log(\mathrm{Y_t}) & \log(\mathrm{Z_t})\end{pmatrix},\quad \alpha_t = \begin{pmatrix}\mathrm{b_{0t}} \\ b_{1t} \\ b_{2t}\end{pmatrix}, T = \begin{pmatrix}1 & 1 & 1\end{pmatrix},\quad v_\mathrm{t} = \begin{pmatrix}\mathrm{u}_{0t} \\ u_{1t} \\ u_{2t}\end{pmatrix}$$

The model, as presented in (III.7), can be estimated by using the Kalman filter and maximum likelihood, as described in Appendix-II.

References

Ahluwalia, U.J.; Rangarajan, C. (1989), 'A Study of Linkages between Agriculture and Industry: The Indian Experience', in Williamson, J .G and Panchamukhi, V.R. (Edt.). *The Balance Between Industry and Agriculture in Economic Development*. Vol. 2 (Sector Proportions), MacMillan Press, London, 305-319.

Banga, R. and Goldar, B.N. (2004), 'Contribution of Services to Output Growth and Productivity in Indian Manufacturing: Pre and Post Reform', *ICRIER Working Papers*, No.139, Indian Council for Research on International Economic Relations, New Delhi, India.

Bathla, S. (2003), 'Inter-Sectoral Growth Linkages in India: Implications for Policy and Liberalized Reforms', *Institute of Economic Growth Discussion Papers*, No.77, Institute of Economic Growth, Delhi, India.

Bhattacharya, B.B. and Mitra, A. (1989), 'Industry-Agriculture Growth Rates: Widening Disparity: An Explanation', *Economic and Political Weekly*, August 26, Vol. XXIV, 1963-70.

______. (1990), 'Excess growth of Tertiary Sector in Indian Economy: Issues and implications', *Economic and Political Weekly*, November 3, Vol. XXV, 2445-50.

_____. (1997), 'Changing Composition of Employment in Tertiary Sector: A Cross-Country analysis', *Economic and Political Weekly*, March 15-21, Vol. XXXII, 529-34.

Central Statistical Organisation (2007), 'National Accounts Statistics: Back Series 1950-51 to 1999-00'.

Chowdhury, K. and Chowdhury, M.B. (1995), 'Sectoral Linkages and Economic Growth in Asia: Evidence from Granger Causality Test', *The Indian Economic Journal*, Vol. 42(4), 59-75.

Clark, C. (1940), 'The Conditions of Economic Progress', Macmillan Publishing Co., London.

Dhawan, S. and Saxena, K.K. (1992), 'Sectoral Linkages and Key Sectors of the Indian Economy', *Indian Economic Review*, Vol. XXVII (2), 195-210.

Dickey D.A. and Fuller W.A. (1979), 'Distribution of the Estimators for Autoregressive Time Series with a Unit Root', *Journal of the American Statistical Association*, Vol. 74, 427-31.

Dickey D.A. and Fuller W.A. (1981), 'Likelihood Ratio Statistics for Auto-regressive Time Series with Unit Root', *Econometrica*, Vol. 89(4), 1052-72.

Engle, R.F. and Granger, C.W.J. (1987), 'Co-integration and Error-Correction: Representation, Estimation and Testing', *Econometrica*, Vol.55, 251-76.

Fisher, A. (1939), 'Production: Primary, Secondary and Tertiary', *Economic Record*, Vol. 15, (June), 24-38.

Hansda S. (2001), 'Sustainability of Services-Led Growth: An Input-Output Analysis of the Indian Economy', *Reserve Bank of India Occasional Papers*, Vol. 22(1, 2 & 3), 73-118.

Johansen, S. (1988), 'Statistical Analysis of Cointegration Vectors', *Journal of Economic Dynamics and Control*, Vol. 12, 231-254.

Johansen, S. and Juselius, K. (1990), 'Maximum Likelihood Estimation and Inference on Co-integration with Application to Demand for Money', *Oxford Bulletin of Economics and Statistics*, Vol.52, 169-210.

Kalman, R.E. (1960), 'A New Approach to Linear Filtering and Prediction Problem', *Journal of Basic Engineering*, Vol. 82(D), 35-45.

Pani, P.K. (1984), 'A Macro Model of Indian economy with Special Reference to Output, Demand and Prices', *Reserve Bank of India Occasional Papers*, Vol. 5(2), 113- 239.

Palanivel T. and Klein, L. (1999), 'An Econometric Model for India with Emphasis on the Monetary Sector', *The Developing Economies*, Vol. XXXVII-3, September, 275–336.

Rangarajan, C. (1982), 'Agricultural Growth and Industrial Performance in India', Research Report No. 33, International Food Policy Research Institute, Washington D.C.

Rath, D. P. and Raj Rajesh (2006), 'Analytics and Implications of Services Sector Growth in Indian Economy', *The Journal of Income and Wealth*, Vol.28 (1)**,** 47-62.

Sastry, D.V.S.; Singh, B.; Bhattacharya, K. and Unnikrishnan, N.K. (2003), 'Sectoral Linkages and Growth: Prospects Reflection on the Indian Economy', *Economic and Political Weekly, June 14*, Vol. XXXVIII (24), 2390-97.