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Identification of Regional Fundamental Economic Structure (FES) of India

An Input-Output and Field of Influence Approach

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Abstract

This study provides an understanding of the Indian regional economy utilizing the fundamental economic structure (FES) approach. The FES construct implies that selected characteristics of an economy will vary predictably with region size, as measured by net state domestic product, population, and total gross output. The big question addressed in this study is if identifiable patterns of relations between various macro aggregates and economic transactions can be revealed via regional input-output tables. Jensen et al. (1988) discuss the tiered, partitioned, and temporal approaches to the identification of FES using input-output tables. This research addresses the following four questions: (1) Does a regional FES exist for the Indian economy during the period 1965? (2) What proportions of the cells are predictable? (3) Can the 1965 regional FES predict 1983-84 table for Punjab economy? (4) Does regional FES manifest an enhanced understanding of the Indian regional structure? Regression analyses are used to identify the FES and non-FES cells for the Indian regional economy. The regional input-output tables for 21 States and Union Territories provide data for the analysis. Analysis reveals regional FES includes primary and secondary sectors as components of FES. This research has extended the notion of FES to include: weak, moderate and strong FES cells.

Keywords: regions, economic structure, input-output, India

JEL classification: O21

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Figures appear at the end of the paper.

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1 Introduction

The Indian economy is large with over a billion population in 2001 (Census of India 2001) and the various regional divisions are characterized by a high degree of heterogeneity. There has been a growing concern over the rising regional imbalances in the Indian economy. The study of regional disparity is important to policy makers since with an increase of regional disparity other things being equal imbalances at the national level increases along with economic and social imbalances. This has drawn attention of policy makers since such disparities often intertwines with political and ethnic tensions and thus leads to political instability (Kanbur and Venables 2005). Thus policy makers need to understand the structure of the regional economic system and analytical tools for evaluating and formulating balanced regional development strategies.

Berry (1966, 1972) studied the Indian regional structure with respect to commodity flows and regional interdependence using economic transactions. His analysis confirmed the general theory of polarized development in India. Reed (1967) in a micro-analytic study of commodity flows in the Bengal-Bihar region concluded that commodity trades in the area were inversely related with the distance shipped and directly with the demand and supply conditions in the Indian economy (Chattopadhyaya and Raza 1975; Berry 1966; Reed 1967). Raza and Aggarwal (1986) conducted a substantive study of the Indian regional structure and concluded that: (1) the Indian economy was dominated by the distorted role of metropolitan cities, (2) the urban system was less integrated with the regional system due to lack of transport infrastructure, and (3) urban system was characterized by a significant primary, weak secondary and bloated tertiary sector.

Chakravorty (2000, 2003) examined the impact of structural reforms policies on the regional dimension of the Indian economy. He concluded the pattern of industrial location has changed between the pre-reform and post-reform period to that of promoting ‘interregional polarization’ followed by ‘intraregional dispersal’ in the leading regions of growth. Further Lall and Chakraorty (2005) examined the causes of spatial inequality at the firm level in India. They observed that industrial diversity leads to cost savings at the firm level in regional economies. They also observed that private sector tended to locate away from ‘inland towns’ and ‘lagging regions’. The reason for this was lack of social infrastructure which distanced firms from the ‘coastal towns’ and ‘urban clusters’. Thakur (2007) examined the impact of development policies on regional growth patterns in India. He observed that the Northwestern states performed better than eastern states in the agriculture sector and in the industrial sector Western states performed better than Eastern states.

The Indian policy-makers implemented the tenth Five-Year Plan (2002-07) (Government of India 2002) which focuses upon ‘*growth, equity and sustainability*’. This poses the question if the Indian regional economic structure lends itself to a sustainable economic development in the long run? The growing regional differences raise several policy questions. Will the economic reform process make the prosperous regions more successful and lagging regions more impoverished? Will economic reforms boost the growth rates of lagging regions and lead to economic convergence across regions? Are the geographical differences large in India and would that prevent regional equality? Which economic activities shape the Indian regional structure? Which economic activity is the engine of growth? Is it agriculture-led activities, manufacturing activities, urban-type service activities, business intensive, finance, insurance and real estate intensive activities, information-intensive activities or a combination of these activities? Is there a core set of economic activities that is minimally required for the sustenance of Indian regional economies? To provide answers to such questions economic analysts require an understanding of the composition, magnitude and interrelationships among economic sectors for evaluating and formulating balanced regional development strategies. The current study in response to previous studies addresses the problem whether there are identifiable patterns of relations between various macro aggregates and the regional economic structure as revealed via regional input-output tables. Would identification of such patterns allow regional analysts to predict regional development and change?

To elucidate this issue further this research paper is divided into six sections. The first section provided the motivation for this research, and the second section provides a descriptive overview of the Indian regional economy. The third and fourth sections discusses the types of fundamental economic structure and methodology used in implementing this research, followed by the fifth section which discusses the identification of regional fundamental economic structure (FES) in India. The last section provides concluding remarks.

2 Regional economies of India

The Indian economy is characterized by unequal distribution of natural resource endowments, and misallocation of resources across sectors and states (Lefeber 1964; Mathur 1983; Prasad 1988; Shaw 1999; Kumar 2000), imperfect mobility and indivisibility in production factors, imbalance in infrastructure supply (Ghosh and De 1998; Lall 1999) and an unequal growth profile of regions (Saha 1993, 1988; Dhalokia 1994; Das and Barua 1996; Shand and Bhinde 2000) leading to an uneven regional growth in India. Sachs et al. (2002) have shown a partial economic convergence for the regional economies in India between the periods 1980-98. The rich states experienced a higher degree of convergence and the poor states showed divergence. This observation prompts the questions whether geographical differences are large and whether this difference would be a hindrance to economic convergence in India. Indian planners until the 1990s had adopted the policy of economizing the use of scarce resources and have located economic activities in selected points in space inducing regional concentration. The economic reforms measures implemented in 1991 have alleviated this inclination. Kant (1999) argued that ‘spatial efficiency’ has increased at the cost of ‘spatial equity’ thereby increasing inter-regional inequality in India (Chakravorty 2000; Jha 2000).

A cursory glance of the map of India reveals the spatial pattern of development for the Indian economy. The Western region is industrialized and prosperous; the Northwest is agriculturally prosperous and East moderately prosperous; the South and Southeast are high-tech regions, the Southwest is characterized by high human and social development, and Central states such as the *BIMARU* states (Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh) are known as the sick states and are a drag on development (Figure 1).

There are strong physical contrasts in the distribution of population in India. The highest densities occur along the river Ganges in the Northern Indian plains, and around the coastal plains of the peninsula. These areas of high density contrast markedly with the low population densities of the dry and mountainous regions. Economic and social-well being in India is increasingly a matter of east-west and north-south contrasts. The states of Punjab, Haryana (Northwest) and Gujarat, and Maharashtra (West) experienced faster economic development than the Eastern states of Bihar and Orissa. Similarly, Karnataka, Tamil Nadu and Andhra Pradesh in the South have experienced higher growth as compared to Madhya Pradesh, Uttar Pradesh in the North.

Figure 2 shows the changing mix of Indian industries at the regional levels for four different times periods (1965, 1975, 1985 and 1995). The list of industries and states depicted in Figure 2 are shown in Appendix 1. The economy was highly agricultural in the mid 1960s and most of the states showed high shares of primary sector, and relatively low shares of secondary and tertiary sectors. This trend changed and the shares for secondary and tertiary sectors increased during the periods 1975, 1985 and 1995. The share of agriculture as a proportion of total gross state domestic product was more than half till the mid 1980s for Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan, Orissa, Punjab, Haryana, and Himachal Pradesh. During the post 1980s the share of secondary sector especially in the areas of mining, manufacturing, electricity and construction increased. Similarly in the tertiary sector industries such as trade, hotels and restaurants, banking and insurance, real estate and public administration increased significantly across states in India.

3 Types of fundamental economic structure (FES)

The economic structure of a region is defined as the composition and patterns of various components of the regional economy such as: production, employment, consumption, trade, savings, investment, taxes, subsidies, regional product and expenditure and regional domestic product. The regional economic structure can be examined over a given period of time for sub national economies and at a given period of time. Broadly two approaches have been used to study structural change. The first seeks to identify statistically certain universal relationships between economic growth and change in economic structure using international cross section data or time series data for national economies.

Syrquin and Chenery (1989) in their study identified similarities in structural change during the process of economic growth for a 100 nation sample in an attempt to provide a ‘general theory of structural change’. A few of the similar characteristics are shift from agricultural to industrial production, steady accumulation of human and physical capital, changes in consumer demand and shift from food and basic necessities to manufactured goods and services, growth of cities and urban industries due to migration of people from rural to urban areas, increase in the demand of information intensive goods and services and products produced in foreign countries (Smith and Todaro 2003). The second approach focuses on historical change and experience as economies with similar initial conditions develop over time. The understanding provided by Lewis’s dual sector theory (1954), Myint’s vent for surplus theory (1958) and Todaro’s rural–urban migration theory (1969) provide insights to the process of structural change during economic development. Syrquin (1988) identified three stages of structural transformation in the regional economic evolution process: during stage one the focus remains on primary production; in the second stage focus shifts to manufacturing sector, and during the third stage the shift focuses to services and exports. Further Malecki

(1997) includes the quaternary and quinary as the new tertiary sector activities upon which policy-makers focus their growth.

An important variant and advance in structural change studies is the taxonomic approach to classifying economic activities (Jensen et al. 1987). Simpson and Tsukui (1965) discovered the concept of fundamental structure of production. This concept was reformulated and extended to form the notion of fundamental economic structure (FES) (Jensen et al. 1987). The concept of FES includes various other economic activities beyond the production such as households, imports, exports, government expenditure (Jensen et al. 1987). The concept of FES embraces people-related activities as these were assumed to be the common denominator for all economies. This belief led to the contemplation of a 'partitioned approach' to the identification of FES. The approach classified each cell in an input-output table as either fundamental or non-fundamental. The second type of FES, the tiered approach, is based on the concept that the input-output tables could be separated into two layers, one is fundamental and the other non-fundamental (Jensen et al. 1991). The partitioned and tiered FES approaches were inherently an expression of a spatial FES. The third type of FES is the 'temporal FES'. It is that component of economy which is predictable over time. This concept is broader because it includes a wider array of economic activities. It is possible for a temporal FES to uncover the economic structure over time or for spatial FES to extract the regional economic structure from a substantially large sample of regional tables within a nation. The temporal non-FES is the unpredictable component and spatial non-FES is the unpredictable component at the spatial scale due to geographic differences in natural resource endowments.

Jensen et al. (1988) studied the regional economic structure of Queensland economy in Australia. The analysis identified regularities and patterns in cell behaviour for the Queensland economy. The term cell behaviour implies change in value, rather than regularity in value relationships. Further, empirical regularities in certain cell values pertain to the relationships of economic size and cell values. Similarly, Van der Westhuizen (1992), Imansyah (2000), and West (2000, 2001) identified FES for the South African, Indonesian, and Australian economies, respectively. These studies are an exercise in positive economics as they provide empirical evidence of the existence of spatial and temporal FES.

The above studies claim that structures of regional economies are more similar than different at various levels of aggregation. If the core economic structures are similar, then, this information can be utilized to predict economic structure at similar levels of development. Although, structure of economies varies across regions, some economic activities are common to all regions and this common part is called regional FES. Thus, regional FES is conceptualized as those economic activities that are consistently present or inevitably required in economies at statistically predictable levels. These 'core' sets of economic activities are represented by transactions in input-output tables and are a function of the size of economies measured by aggregate economic indicators of the region. It is postulated that economic transactions and the region size are related and this functional relationship can be estimated using suitable indicators of size as independent variables and transactions as dependent variables.

A regional economic structure can be classified into FES and non-FES (NFES) cells in the input-output tables. The FES cells are the core and remain the same while the non-FES cells are the unpredictable component. The FES component is predictable since it comprises those sets of economic activities that are similar in all sample tables over time or across space and is extracted from the common characteristics of the economic systems. In the process of identifying regularities and FES patterns, a tentative natural order of sectors has been suggested based on the economic logic of the 'primary-secondary-tertiary' continuum (Jensen et al. 1988).

Can a regional FES be identified from a set of sub-national economies within a nation to extend the applicability of the theory of structural change? This research is novel and is the first attempt to identify and interpret the regional economic structure of the Indian economy using the FES approach. The author in an earlier study identified a temporal FES for Indian economy for the period 1968-90 (Thakur 2008). This research addresses the following questions: (1) Does the regional FES exist at predictable levels and can it be identified for the period 1965? (2) What proportions of the cells are predictable in a statistical sense? (3) Can the regional FES be used to predict the 1983-84 Punjab regional input-output table? (4) Does the regional FES manifest an improved understanding of the Indian regional structure?

4 Research methodology

To identify the fundamental economic structure at the regional level, 21 regional input-output tables were assembled from the *Artha Vijnana* (Economic Science) journal published from the Gokhale Institute of Politics and Economics in their special edition titled *Regional Input-Output Matrices*, *India* (Venkatramaiah et al. 1979) (Appendix 2). These regional tables represent the regional economic structure of both State and Union Territories in India. These tables are consistent and comparable and pertain to the same base year 1965. These tables are the only set of consistent matrices available at the regional level for the Indian economy. An assumption is made in the identification of regional FES. Although the table is dated it still reflects the regional structure during late 1980s since the Indian regional structure did not change due to the adoption of a command economy approach during 1965-85. In other words the regional economic structure did not change much during the period 1965 through the late 1980s.

The regional tables are of varying dimensions and have been made comparable after sector aggregation. Table 1 shows the sector classification. The sectors have been aggregated to 24 and, hence, the regional input-output tables are comparable with the dimension of 24x24 intermediate transaction cells. Three economic variables characterizing the region sizes have been selected: population, net state domestic product (NSDP), and total sector output for 1965 for the sample regions. These economic variables were obtained from the report titled *Domestic Product of States in India* (Economic and Political Weekly Research Foundation 2003) and the total sector output from the regional tables (Venkatramaiah et al. 1979). Two regression models, linear and logarithmic, are run in statistical package for social sciences (SPSS) with one independent variable (that is, economic size) and another dependent variable (that is, transaction size).

Table 1: Sector classification for regional economies in India: 1965

Number	Sector name
1	Food crops
2	Oilseeds, fibers and sugarcane
3	Plantation and other crops
4	Livestock
5	Fisheries and forestry
6	Coal, ferrous and crude petroleum
7	Stone, clay and bauxite
8	Fertilizer, chemicals, metal and non metal mining
9	Food manufacturing and beverages
10	Textiles, apparel and footwear
11	Sawmills, wood and furniture
12	Paper, printing and publishing
13	Rubber and leather products
14	Fertilizers, chemicals, oils and paints
15	Misc. chemicals, petroleum and coal
16	Clay, cement, glass and chinaware
17	Metals, non-metals and iron steel
18	Machinery
19	Transport equipment
20	Scientific, unspecified and other industries
21	Construction
22	Electricity and gas
23	Rail, road transport and repair services
24	Trade and excise

5 Identification of regional FES in India

5.1 Pattern analysis

This section identifies the fundamental economic structure using the tiered approach (West 2000, 2001). The fundamental and non-fundamental components are determined by implementing the regression analysis and analyzing the pattern of regression estimates. This is done by examining the significance tests of the beta parameters at five per cent significance level and examining the adjusted R^2 results. Similarly, stability pattern and importance are examined by applying coefficient of variation and field of influences tests. The three patterns together characterize the fundamental economic structure. The intersection and union of the three sets establish a weak, moderate and strong fundamental and non-fundamental economic structure at the regional level.

5.2 Predictability

The fundamental economic structure is characterized by a predictability element which can be measured by regression analysis. It is hypothesized that a systematic pattern in transactions can be recognized by applying the FES notion that selected characteristics of an economy will vary predictably with region size, as measured by net state domestic product, population and total gross output or other measures of region size. It is well understood that as regions develop the transaction size changes or becomes complex such that economic transaction represented by the intermediate transaction table becomes intricate and also tends to be more secondary and tertiary-oriented (Leontief 1963; Jensen et al. 1988). The economic activities are urban-oriented or people-oriented activities. To test the statistical relationship, two regression models are run to establish the relationship between the variables – economic transactions and region size. The dependent variable is intermediate transaction and independent variables are – net state domestic product, population and total sector output representing the region size. The two models are linear and logarithmic regression models and can be written as:

$$X_{ij}(\mathrm{r}) = \alpha + \beta X(r) \tag{1}$$

$$\mathrm{Log}\ \mathrm{X}_{ij}(\mathrm{r}) = \alpha + \beta \log X(r) \tag{2}$$

Where

$X_{ij}(r)$ = is the economic transaction from industry i to industry j for the rth region ($i, j = 1 \ldots k$)

$X(r)$ = is the independent variable for the rth region (population, net state domestic product, total sector output)

α = is the constant term

β = are the coefficients of regression

r = is the number of regions (1 ... n)

k = is the number of sectors after aggregation

Subsequent to sector aggregation the regional input-output tables are consistent and comparable with 24 sectors and 576 cells. Of these 576 cells, 183 cells have zero values and 393 cells have positive transaction values. Thus, the statistical analysis is based upon 393 cells as the dependent variables and the three independent variables used one at a time independently as a single predictor. This precludes any multicolinearity amongst the independent variables. Of the six regression models, three are linear and three logarithmic with three independent variables. The highest proportion of significant cells are predicted by the variable log total sector output that is, 243 cells out of 393 were significant at the 5 per cent significance level. This amounts to 61.7 per cent of the cells being statistically predictable (Table 2).

Table 2: Summary of percentage of statistically significant cells at 95% confidence levels for regression models with 24 sectors: Indian regional economy

Model/ variable/cells	Independent variables					
	Net state domestic product %	No significant cells	Population %	No. of significant cells	Total sector output %	No significant cells
Linear	20.80	82	16.20	64	33	190
Logarithmic	61.20	241	28.40	112	61.70	243
Total cells predicted		393		393		393

The second best predictor is log net state domestic product with 241 cells predictable at the 5 per cent significance level. This makes 61.2 per cent of the dependent variables predictable. The linear regression models (that is, net state domestic product and population) do not perform well as a predictor. The pattern of predictable cells with total sector output and log total sector output perform better than the linear regression models with population and NSDP as independent variables. The predictable pattern of cells with log total sector output is shown in Figure 3. It can be observed that predictable cells are located in the secondary-secondary, primary-secondary, primary-primary and secondary-primary partitions of the intermediate transactions table. This pattern is unlike the Australian regional economies in which the fundamental cells were located predominantly in the secondary, tertiary and trade sectors (Jensen et al. 1988; Jensen et al. 1991; West 2000).

Table 3: Distribution of FES cells across the Primary (P), Secondary (S) and Tertiary (T) sectors, partitions in the Indian regional economy: 1965

Partition	Zeros	Unpredictable cells	Predictable cells	Total	% share in partition
P-P	40	7	17	64	70.8
P-S	42	17	53	112	75.7
P-T	11	4	1	16	20.0
S-P	51	28	33	112	54.1
S-S	35	34	127	196	78.9
S-T	2	17	9	28	34.6
T-P	0	15	1	16	6.3
T-S	1	25	2	28	7.4
T-T	1	3	0	4	0.0
Total	183	150	243		

The predictable cells in the Indian regional economy are located in the secondary and primary sectors predominantly (Table 3). The Indonesian study established that predictable cells were located in secondary, tertiary and primary sectors as well, thus expanding the domain of FES cells (Imansyah 2000). The cell pattern observed in the Indonesian study is closer to the Indian case in which the primary sector constitutes a part of the fundamental economic structure, unlike the Australian regional FES. These economic activities are urban and people-oriented activities (West 2001; Jensen et al. 1988) and also include primary activities located in rural regions.

Stoner (1968) observed that Indian cities during the periods 1951 and 1961 required greater than expected non-basic employment representing city-serving employment or the minimum required services for population in Indian cities. This observation lends support to the notion of fundamental activities as the basic and driving force regulating the regional distribution of economic activities.

Several reasons explain why the primary sector in the Indian regional economy is a component of the regional FES. First, during 1965, regional economies in India had over one-third to two-thirds of the industrial origin from the primary sector, especially agriculture. Second, in the period prior to 1965 the five-year plans (FYP) expressed emphatically an importance for assigning highest priority to overcome the food crisis in India (Misra and Puri 1996). This policy was later translated to the adoption of the high yielding variety (HYV) programme also known as new agriculture technology for enhancing agricultural productivity in the various regions. Third, agriculture in the rural sector is a subsistence farming activity and the output is meant for self-consumption – a hedge against monsoon failure in a future season, thus, making it a basic activity. The rural sector is heavily dependent upon farming activities which are also the main source of employment for the majority of the population.

Fourth, several regions endowed with mineral resources were heavily dependent upon such resources for revenues through mining, forestry and logging activities. Therefore, substantial investments were made in the exploitation and mining of these resources. This was especially true in eastern India establishing the dominant role of the primary sector as an important component of basic activity. These explanations provide the plausible suggestions for the primary sector in India’s regional economy as a component of the regional FES.

In order to choose the best independent variable that explains the highest proportion of unexplained variation in the dependent variable, one uses the adjusted R^2 statistic in addition to the R^2 statistic. The highest R^2 value will suggest that the variable is a good predictor. However, one encounters a problem with such a conclusion. An addition of a predictor increases the R^2 values but also changes the degrees of freedom associated with the measure that makes up the R^2 statistic. If the addition of an independent variable contributes to the unexplained variation in the dependent variable, then, it increases only the adjusted R^2; otherwise, it diminishes (Maddala 2002; Kennedy 1998; Dillon and Goldstein 1984).

Thus, it is important to examine the pattern of adjusted R^2 for additional independent variables. It is also true that the adjusted R^2 may be relatively low but the *t* statistic might be significant and the vice versa situation where the value of the adjusted R^2 is relatively high but the *t* tests are not significant. A plausible reason for the latter case might be incorrect model specification. Thus, it is appropriate to evaluate the predictable pattern of transactions by ascertaining the adjusted R^2 values for the six regression models and also examine the significance test results.

In comparing the three linear regression models with the three logarithmic regression models, one encounters a comparison problem. In comparing the models, the dependent variables ought to be in the same measuring unit since three models are in logarithmic form and other three in non-logarithmic form.

The following steps will resolve the problem and make it comparable. First, if the dependent variable is in logarithmic form, then, after estimating the model the next step is to reckon the dependent variables in logarithmic form using the regression estimates; second, transform the estimated values of the dependent variable in antilog form; third, recalculate the adjusted R^2 based on these transformed values. These three steps of transformations will make the models comparable with dependent variables with same measuring units.

Table 4 shows the comparison of adjusted R^2 for the various regression models. The logarithmic regression model with log population as independent variable shows more than half (52.25 per cent) the cells have an adjusted R^2 value of 0.7.

Table 4: Summary of adjusted R^2 values for the Indian regional economies with cell sizes as dependent variable

		Zeros	Less than 0.7	More than 0.7	Non-zero cells	Total cells
Total sector output	Number of cells	183	329	64	393	576
	Percentage	31.8	57.6	11.1		
NSDP	Number of cells	183	289	104	393	576
	Percentage	31.8	50.2	18.1		
Population	Number of cells	183	321	72	393	576
	Percentage	31.8	55.7	12.5		
Log sector output	Number of cells	183	278	115	393	576
	Percentage	31.8	48.3	20		
Log NSDP	Number of cells	183	265	128	393	576
	Percentage	31.8	46.0	22.2		
Log population	Number of cells	183	92	301	393	576
	Percentage	31.8	15.97	52.25		

The second best predictor is log total sector output with 20 per cent cells with more than 0.7 adjusted R^2 values.

5.3 Stability

The term *stability* in input-output literature implies consistent economic interaction among industries over a period of time or across a range of regions. In other words, it implies no change in the coefficients over time or across regions. The concept of stability deals with structural or technical change in inter-industry analysis (Miller and Blair 1985). Thus, if a sample of regional input-output tables are examined, then, the variation of coefficients across the regions will be expected to be minimal, and thus, can be used to ascertain the stability or minimal change in the technological coefficients. Gaiha (1980) showed that changes in the input-output coefficients were nominal for the Indian economy for a limited number of tables he examined for India. He also stated the assumption of stability of input-output relationships is rationalized although the accuracy of intermediate demand projections can be enhanced if changes in crucial relationships are incorporated from time to time.

The coefficient of variation (CV) measure is utilized to ascertain the degree of stability in the regional economies of India. The calculation of CV can be expressed as standard deviation divided by mean of the technological coefficients for the sample regions in India:

$$CVa_{ij} = \frac{\sqrt{\frac{(a_{ij} - \overline{a}_{ij})^2}{N}}}{\overline{a}_{ij}} \tag{3}$$

a_{ij} = coefficient of regional input-output tables

$\overline{a}_{ij}$ = mean of coefficients of regional input-output tables

N = number of regions (21)

Of the 576 cells in the regional table, 183 cells, or 31.6 per cent of all cells, have a coefficient of variation of zero. The mean of the cell values with coefficient of variation distribution is 1.74 which is also assumed to be the threshold. There are 119 cells with coefficient of variation values less than 1.74 but more than zero; 274 cells have coefficient of variation values more than 1.74 (Table 5). Most of the stable cells with less than the threshold value of 1.74 are located in the primary-primary, primary-secondary, secondary-secondary, tertiary-secondary partitions of the intermediate transactions table (Figure 4).

Table 5: Input stability in the Indian regional economy: 1965

Coefficient of variation (CV)	Number of cells	Per cent
Zero	183	31.60
<1.74	119	20.66
>1.74	274	47.74
Total	576	100.0

Figure 5 shows 24 of the most stable cells are those with coefficient of variation values between 0.8 and 1.1. These cells are located in the following industries: tobacco, tea and coffee, livestock, construction, rail road transport and repair services. The cells with minimum variance imply that these cells across all regions are part of the core activities and are the foundation of the regional economies.

The cells representing these economic activities are basic activities necessary for the sustenance of the economy and also necessary for the average household consumption. These cells represent a constituent of the fundamental economic activities of a region and would remain situated even if the economy undergoes a downswing or an upswing. The non-fundamental economic activities would envisage the more variable type economic activities that rise or fall due to change in economic environment, taste, technology and consumer preferences. This will also imply that if the economy was undergoing a business downturn, the non-fundamental economic activities will be affected more and the fundamental activities will be the least affected.

5.4 Importance

The notion of technological change can be analyzed by measuring the extent and magnitude of coefficient change by a method called the field of influence. In a series of research papers: Hewings et al. (1988); Sonis and Hewings (1989); Hewings et al. (1989); Sonis and Hewings (1992); Sonis et al. (1996); Okuyama et al. (2002) have developed the mathematical formulation and application of the concept of field of influence. The approach proposes a methodology of measuring the largest field of influence due to a small change in the input-output coefficients. Suppose there is a small change (ε or epsilon) in the direct input coefficients, then, the concomitant change in the components of Leontief inverse can be ascertained by the following mathematical formulation (Hewings et al. 1988):

$$a_{ij} = a_{ij}(t+1) - a_{ij}(t) \tag{4}$$

The term a_{ij} is the direct input coefficients and the change in the coefficients can be represented by the equation (4). The parameter that generates the transformation from $a_{ij}(t)$ to $a_{ij}(t+1)$ can be expressed as the equation (5):

$$a_{ij}(\varepsilon) = a_{ij}(t) + \varepsilon a_{ij} \tag{5}$$

where ε is the transfer parameter and the value remains between $0 \leq \varepsilon \leq 1$. Further the matrix A ($\varepsilon$) = $a_{ij}(\varepsilon)$ and the associated Leontief inverse can be written as C (ε) = [I-A (ε)]$^{-1}$. If ε = 0 then, the matrix:

A (0) = $a_{ij}(t)$

this is the matrix of direct input coefficients at time t with Leontief inverse expressed as:

C (0) = [I-A (*t*)]$^{-1}$

Also, when $\varepsilon = 1$ then, A (*t*+1) = a_{ij} (*t*+1) is the matrix of the direct input coefficients at time (*t*+1). The associated Leontief Inverse can be expressed as C (*t*+1) = [I-A (*t*+1)]$^{-1}$.

Table 6: Top 15 most important cells in the Indian regional economy: 1965

Most important cells	Largest field of influence
Water and electricity - rail road transport and repair services	2.488
Trade and excise - rail, road transport and repair services	1.589
Metals, non-metals and iron steel - rail road transport and repair services	1.077
Trade and excise - transport equipment	1.017
Textile, apparel and footwear - textile, apparel and footwear	1.015
Metals, non-metals and iron steel - transport equipment	0.954
Scientific unspecified and other industries - transport equipment	0.907
Trade and excise - construction	0.804
Trade and excise - textile, apparel and footwear	0.792
Scientific unspecified and other industries - construction	0.649
Scientific, unspecified and other industries - textile, apparel and footwear	0.629
Metals, non-metals and iron steel - machinery	0.580
Trade and excise - machinery	0.550
Metals, non-metals and iron steel - metals, non metals and iron steel	0.543
Trade and excise - sawmills, wood and furniture	0.538

If the direct input coefficient is changed by perturbing the matrix with a small ε then the field of influence can be measured by the following equation:

$$G(t+1, t) = [C(\varepsilon) - C(0)] / \varepsilon \qquad (6)$$

The outlined approach can be applied to ascertain the most important cells in the input-output tables. First, the average of the sample regions is calculated from the regional input-output coefficient tables for 1965. This is called the average reference table. Second, all the cells in the average reference table are perturbed by a ε=10 per cent increase in cell values.

The product of this approach is shown below as the top 25 per cent of the cells which experience the maximum field of influence and hence are most important. Of the 576 cells in the average regional economy, 144 (25%) cells are critical with respect to maximum connectivity and importance to the rest of the regional economic system (Figure 6). Of these critical cells, the top fifteen most important cells for the year 1965 are shown in Table 6 and Figure 7. The value in the column shows the largest field of influence and denotes the difference in the Leontief Inverse before and after a 10 per cent increase in each of the cells. These cells were identified to have maximum change, hence, signify maximum importance in the regional economic system.

A unit change in the multiplier value of these cells will have the maximum ripple effect within the regional economies. The three cells associated with transport sector are: rail, road and repair services in transport. The transport sector plays an important role in the regional economic development process. This sector is a social overhead capital (SOC) which is needed in the production of other directly productive assets (DPA).

This type of economic infrastructure is immobile, labour intensive, indivisible, open of access and has economy-wide impacts. Also, transport infrastructure plays three important roles in the process of regional development (Rietveld 1989). First, it is utilized as a production factor as land, labour, capital or entrepreneurship; second, as a location factor influencing the spatial decision-making of private and public investment and employment generation; and third, has an impact on enhancing interregional trade flows.

Regional development analysts argue that economic infrastructure investment, such as transport, telecommunication, public utilities, social community facilities are some of the most essential social facilities for economic development of a region. The argument is that infrastructure is a precondition for economic development and, hence, should be provided before development in the form of excess capacity or in the form of directly productive assets. The second option will lead to bottlenecks due to lack of social overhead capital and, hence, delay development. The First and Second five-year plans (FYP) encompassing the periods 1951 through 1961 placed a strong emphasis upon overcoming the transport infrastructure bottleneck.

The goal was to attain heavy industrialization and so provision of transport infrastructure was thus a necessity. The transport sector has a gestation period between investment and returns and, thus, the impacts are realized over a substantially long period of time. This sector is important and has been used as an input in every industry in the regional economies in India.

D'Souza (1986) has econometrically estimated the extent of infrastructural linkages for railway, power and coal and has shown that changes in the quantity of coal produced brings about most significant changes in the output of freight services, via, the demand side. Similarly, other important sectors such as: construction, transport equipment, metals, non-metals and iron and steel, and textile, apparel and footwear are important industries where the linkages with other industries are important and so a change in the magnitude of these industries will produce a sizeable impact on others, via, inter-industry relationships.

A significant observation is that most of the critical cells are located in the primary-primary, primary-tertiary, secondary-secondary, and secondary-tertiary sectors. This pattern is different from the one observed for the Australian and South African economies. The FES in Australia and South Africa and to some extent Indonesia constituted secondary, tertiary and trade sectors which are essentially urban-oriented and people type economic activities.

5.5 Union and intersection of FES characteristics

After examining the FES characteristics (predictability, stability and importance) a union and intersection of the sets of predictable, stable and important cells can give an estimate of the number of cells that can be ascertained to be *weak, moderate or strongly fundamental* (Table 7). A *weak fundamental structure* implies that the transactions are predictable, or stable or important. A *moderate fundamental structure* implies that the cells are characterized by predictability and stability, or predictability and importance, or stability and importance. A *strong fundamental structure* implies that the transactions have all three properties of predictability, stability and importance. A *fundamental cell* is one which is weak, moderate or strong, that is, predictable (P), stable (S), important (I), predictable and stable (PS), predictable and important (PI), stable and important (SI), and or predictable, stable and important (PSI).

Table 7: Weak, moderate and strong fundamental economic structure (FES) cells in India

	Weak FES	%	Moderate FES	%	Strong FES	%	Fundamental cells	%
Predictable (P)	243	61.8						
Stable (S)	119	20.6						
Important (I)	144	25.0						
Predictable and stable (PS)			54	13.7				
Predictable and important (PI)			38	9.7				
Stable and important (SI)			14	3.6				
Total (PS, PI and SI)			106	27.0				
Predictable, stable and important (intersection)					44	11.2		
Predictable, or stable or important (union)							302	76.8

The regional tables of India have almost 30-35 per cent of the cells with zero values at the 24 sector aggregation. A third of the cells have zero values and thus the estimation of the economic interaction utilizing the fundamental economic structure approach becomes less expensive since only the other two-thirds of the cells need to be estimated. Using the predictability criterion, 243 cells (61.8 per cent) can be estimated using regression analysis; 119 cells (30 per cent) can be estimated using the stability property of the fundamental economic structure and 144 cells (25 per cent) can be ascertained to be important with critical links with the rest of the regional economic system (Table 7). There are 54 cells which are predictable and stable, 38 cells which are predictable and important, and 14 cells which are stable and important and 106 cells share the properties of predictability and stability, predictability and importance and stability and importance.

A total of 44 cells are strongly fundamental of the 576 cells. There are 302 cells which are fundamental since these cells are either predictable (P), stable (S), important (I), predictable and stable (PS), predictable and important (PI), stable and important (SI) and or predictable, stable and important (PSI). Thus, 52.6 per cent cells are fundamental, 15.1 per cent are non-fundamental and 31.8 have zero values. Of the total cells 90 are non-fundamental.

5.6 Regional FES table for Punjab, 1983-84

So far utilizing the characteristics of FES and the methodology outlined in the research methodology section, the predictable, stable and important cells for the average regional economy have been determined. If it is conceivable to demonstrate the existence of regional FES based on the 21 regional input-output tables, then, it is possible to use the information extracted to predict the regional input-output table for the Punjab economy for 1983-84 using the total sector output as a predictor.

A total of 243 cells are statistically predictable out of 576 cells using the logarithmic regression model with log total sector output as the predictor. In addition, the stability property determined 119 cells to be stable with values less than 1.74 which is the threshold. Applying the field of influence method, 144 cells were ascertained to be important and critical. A common feature of all the three characteristics is that the pattern of the predictable cells corresponds to the pattern of stable and important cells. All the cells that are predictable, stable and important are located in the primary-primary, secondary-secondary, and secondary-tertiary partitions. This implies that fundamental economic structure is not only predictable, but stable and important. Three different methods (regression, coefficient of variation, and field of influence) have been utilized to examine the fundamental economic structure and the results show similar patterns of fundamental economic structure. The three results can be combined to ascertain and construct the regional FES table which can be used to construct the Punjab regional table.

The State of Punjab is the most developed agricultural economy in India. The rationale for the success of Punjab's economy is the risk-taking entrepreneurs and the successful implementation of the seed-fertilizer technology during the 1960s in the cultivation of wheat and rice. The Punjab development model suggests that rapid agricultural growth stimulated growth in other sectors, via, input, output and consumption linkages and, thus, made it possible to transform the economy into a modern and developed region (Bhalla 1995). The Punjab input-output table for 1983-84 has 78 sectors and has a 79x86 dimensions (Saluja 1990). The regional table has been aggregated to 24x24 for the intermediate transactions component. To predict the Punjab regional table using the regional FES properties, the following steps are followed. First, the logarithmic value of the total sector output for the Punjab regional table is used along with the regression coefficients from the predictability analysis for estimating 393 cell values which include both fundamental and non-fundamental cells; second, the location of the stable and important cells are known *a priori*; third, the estimated values are substituted in 243 of the predictable cells. The remaining 150 cells are stable, important or non-fundamental cells. The cell locations of the stable and important cells are already known.

Thus, if the cells are stable the average coefficient size of regional tables are taken and, then, multiplied by the average of the column totals of transactions to ascertain the cell size. Also, if the cell is not predictable and unstable, then, it is checked for importance. If the cell is important then the regression estimate is used to ascertain the value of the cell. For any cell that is not predictable, stable or important but is non-fundamental the regression estimates are still used to determine the cell size; and further, if the cell had a zero value in the original table, that value is kept in the predicted table. The actual regional table for Punjab for 1983-84 is shown in Figure 8. Following the above steps the regional table for Punjab's economy is compiled and shown in Figure 9. The bi-proportional technique has been used to reconcile the predicted and original Punjab table.

5.7 Verification and validation

A model is an idealized and structured representation of the real world. The degree of accuracy in formulating a problem into a model is known as verification. Validation is the process of substantiating and accepting the model for the intended use provided it meets a specified performance requirement (Rykiel 1996). In other words the term validation of a model implies if it behaves as expected or not. Thus validation is not a test that is reported but a practice where researchers examine and state the degree of validity of the model in question (Jensen 1991). In the process of compiling input-output tables errors may be introduced due to factors such as interregional variations in prices, consumption patterns, inter-regional trade relationships, and spatial variations in technology among others (Jackson 2001). Modelers often report validity by examining error patterns.

After compiling intermediate transactions tables based upon ordinary least square estimates and the associated FES characteristics (predictability, stability and importance) the next step involves model verification and validation. In the current study validity can be determined by comparing the predicted regional intermediate transaction tables with the actual intermediate transaction tables. In the quest for maximizing accuracy in compiling intermediate transactions table it is important to bear in mind the distinction between *partitive and holistic* accuracy. Jensen (1980) distinguishes between these two terms in the context of deriving synthetic tables. A partitive accuracy focuses on cell by cell precision in a statistical sense within input-output tables, while holistic accuracy centers on identifying the main features of the economy in a descriptive sense and preserves the importance of these features in an analytical sense. Also, partitive accuracy maintains that the table will be holistically accurate; but holistic accuracy does not guarantee a high degree of partitive accuracy (Jensen 1980).

The identification of FES can provide a holistic as opposed to partitive accuracy in the process of updating and compiling regional input-output tables. This accuracy can be measured by examining the degree of deviation between actual and predicted matrices and analyzing the error patterns. To implement the error analysis five measures of deviation are utilized and results reported to compare the actual and predicted intermediate transactions table based upon the FES methodology. These measures of deviations are: mean deviation (MD), mean absolute deviation (MAD), mean percentage error (MPE) means absolute percentage error (MAPE) and root mean squared error (RMSE).

Table 8: Deviation among actual and predicted (RAS) tables for Punjab economy: 1983-84

Variable	ATV (RAS)	MD	MAD	MPE	MAPE	RMSE
Intermediate transactions matrix	69323.15	0.0364	0.0129	(-)241.5	240.6	0.0259
FES component	69323.15	0.0426	0.0139	(-)239	238.6	0.032
NFES component	69323.15	0.0085	0.0097	(-)249.2	250.2	0.0289

The predicted intermediate transaction table is assembled utilizing the marginal totals for the regional table from 1983-84. A bi-proportional adjustment technique has been used to reconcile the predicted table with the actual table for the Punjab (1983-84) economy. The error patterns for the Punjab table are reported in Table 8. The results are based upon implementing the tiered approach for identifying the fundamental economic structure and the associated fundamental economic structure characteristics.

The error patterns for fundamental and non-fundamental economic structure components are reported separately to contrast how well the two components are predicted for the Punjab economy and Indian economy respectively. In the case of Punjab economy the three deviation measures (mean deviation, mean absolute deviation and root mean square error) show the non-fundamental component to depict relatively lower errors as compared to fundamental component. The mean absolute percentage error and root mean square error shows that fundamental component has relatively lower error as compared to non-fundamental component (Table 8). This implies that although the non-fundamental cells are unpredictable in a statistical sense, these cells are fundamental since they might be characterized by stability and importance properties. The OLS estimates can still be used to predict the non-fundamental cells. The overall matrix error is a weighted sum of the FES and non-FES components. However compared to the other measures of error the mean percentage error is high for the Punjab economy.

6 Conclusions

This research is a significant departure from Berry's (1966, 1972) analysis of the spatial structure of the Indian economy. The FES is defined as that component of the regional economic system which consists of transaction cells in input-output tables consistently present at statistically predictable level across a range of regional economies. A regional FES for the Indian economy exists and has been identified for the period 1965 using the 21 regional input-output tables for 21 representative states of India. The highest proportion of predictable cells has been identified using log total sector output as the predictor resulting in 61.7 per cent of the cells being statistically predictable at 5 per cent significance level. These cells are located in secondary-secondary, primary-secondary, and secondary-primary partitions of the intermediate transactions table. The logarithmic regression models have out performed the linear regression models. Using the FES characteristics of predictability, stability and importance, 20.6 per cent of the cells were found to be stable with coefficient of variation values less than average; 25 per cent of the cells were found to be important. The stable cells with values less than the threshold of 1.74 are located in the primary-primary, primary-secondary, secondary-

secondary, and tertiary-secondary partitions of the intermediate transactions table. Further, the important cells are located in the primary-primary, primary-tertiary, secondary-secondary, and secondary-tertiary partitions of the intermediate transactions table. These patterns are unlike the Australian regional economic structure since the fundamental component are located in the secondary, tertiary and trade sectors of the intermediate transactions table.

This study has extended and modified the notion of FES. Utilizing the characteristics of FES, fundamental cells have been classified to be weak, moderate and strong. A *weak fundamental structure* implies that transactions are predictable, stable or important. A *moderate fundamental structure* implies that cells are characterized by predictability and stability (13.7 per cent), predictability and importance (9.7 per cent), or stability and importance (3.6 per cent). A *strong fundamental structure* implies that transactions are characterized by predictability, stability and importance (11.2 per cent). A fundamental cell is one which is weak, moderate or strong (76.8 per cent).

Utilizing the regional FES properties, the regional input-output table for Punjab economy (1983-84) has been compiled for a 24 sector classification. The predicted table show a similarity in the regional economic structure as compared to the actual table. This research is a significant contribution to the FES literature since the only other study identifying regional FES is that for the Australian regional economies (Jensen et al. 1988, 1991).

Compiling a regional input-output table is expensive, manpower intensive and time consuming. The FES methodology provides an alternative approach in constructing the regional tables using a hybrid approach. The FES characteristics of predictability, stability and importance could be utilized to ascertain intermediate transaction matrix. The cells which are not fundamental can be ascertained using superior data such as published and survey data from government departments. The application of such an approach will make the tables more accurate and realistic.

The FES is a conceptual notion which provides an improved understanding of the regional economic structure. The FES methodology can be utilized to measure, interpret understand and predict economic structure at various geographical scales. This methodology is a challenge to regional analysts to test, modify, refute, provide alternative hypotheses and explanations of the study of regional economies and strengthen the notion of a proposed general theory of FES.

Appendix 1

List of industries and states for 1965, 1975, 1985 and 1995

S. No.	Industries	States
1	Agriculture	Andhra Pradesh
2	Forestry	Assam
3	Fishing	Bihar
4	Mining	Delhi
5	Manufacturing	Gujarat
6	Construction	Jammu and Kashmir
7	Electricity, gas and water supply	Kerala
8	Transport, storage and communication	Karnataka
9	Railways	Maharashtra
10	Other commerce and transport	Madhya Pradesh
11	Storage	Orissa
12	Communication	Punjab
13	Trade, hotels and restaurants	Rajasthan
14	Banking and insurance	Tamil Nadu
15	Real estate, ownership of dwellings and business services	Uttar Pradesh
16	Public administration	West Bengal
17	Other services	Himachal Pradesh
18		Goa Daman Diu
19		Tripura
20		Pondicherry
21		Andaman Nicobar Is

Appendix 2

Regional technical coefficient matrices of states and union territories in India, 1965

States	Union territories
Andhra Pradesh	Andaman and Nicobar Islands
Assam	Delhi
Bihar	Goa, Daman and Diu
Gujarat	Himachal Pradesh
Jammu and Kashmir	Pondicherry
Kerala	Tripura
Madhya Pradesh	
Madras/Tamil Nadu	
Maharashtra	
Mysore/ Karnataka	
Orissa	
Punjab	
Rajasthan	
Uttar Pradesh	
West Bengal	

Source: Venkatramaiah et al. (1979).

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Figure 1: Regionalization in India

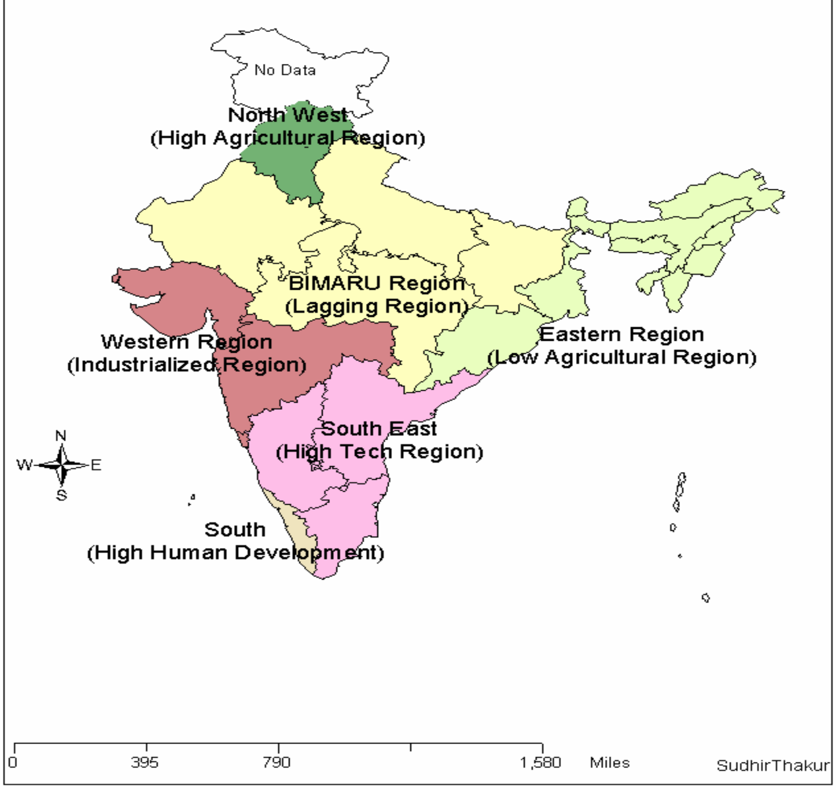
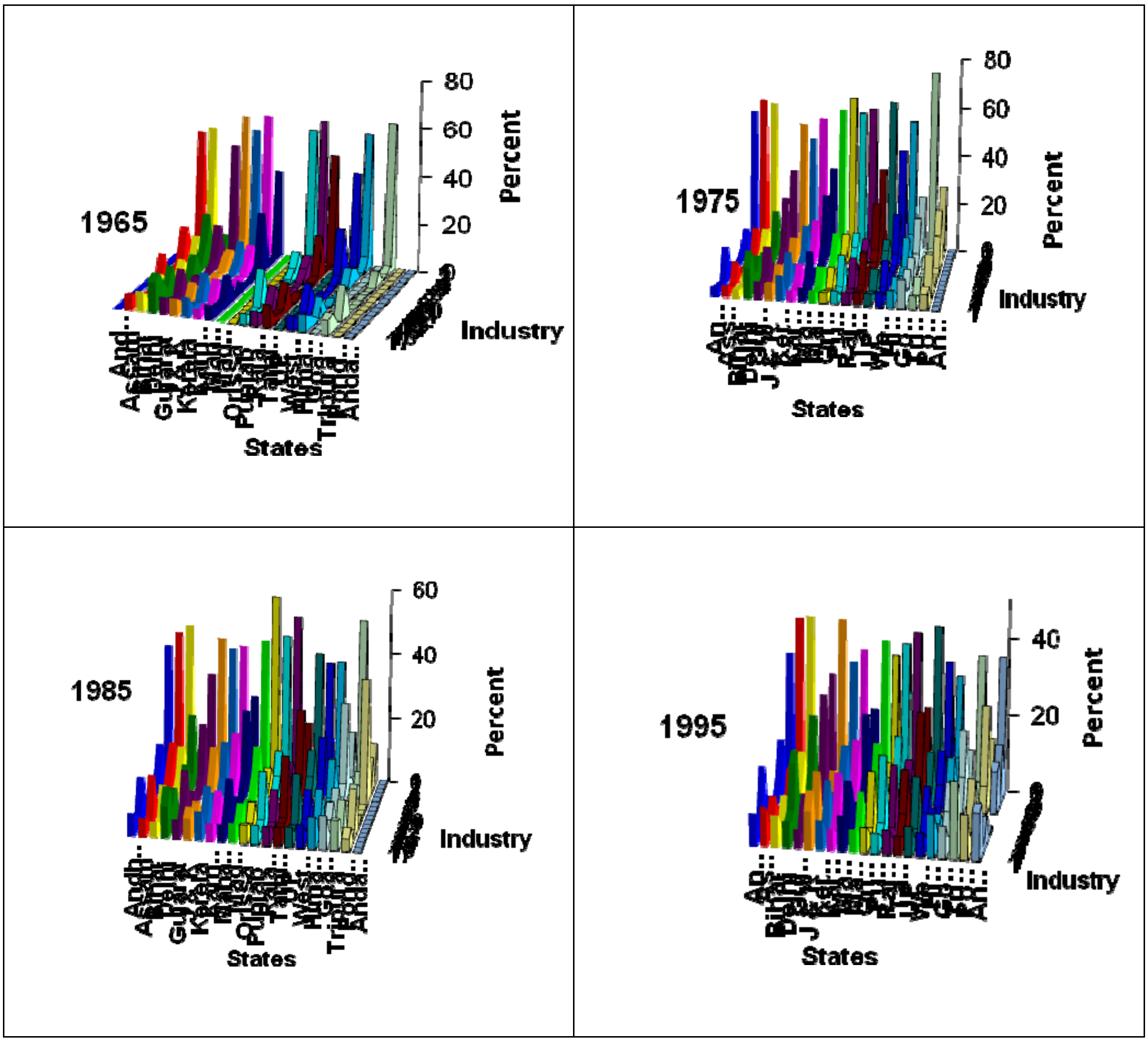
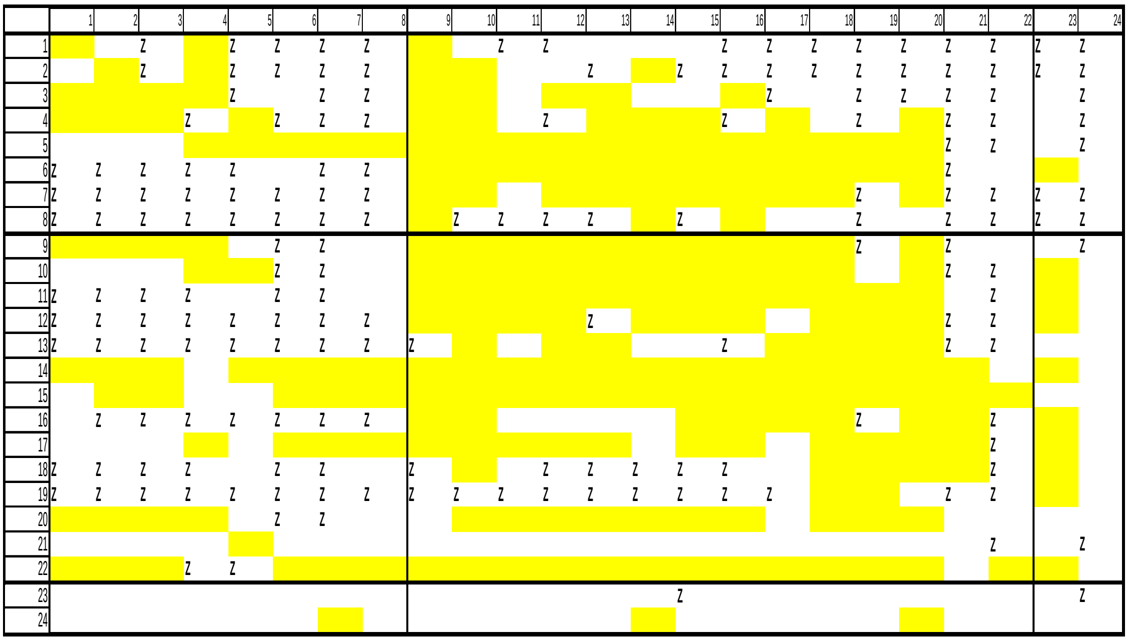


Figure 2: Regional mix of industries in India: 1965, 1975, 1985 and 1995



Source: Domestic Product of States in India, 1960-61 to 2000-01, EPW Research Foundation.

Figure 3: Pattern of predictability of cells with log total sector as independent variable and transaction as dependent variable



Primary sector   Secondary sector   Tertiary sector

Notes: Unpredictable (blank cells), predictable (shaded cells), zero (Z).

Figure 4: Regional stability of input variability in India, 1965

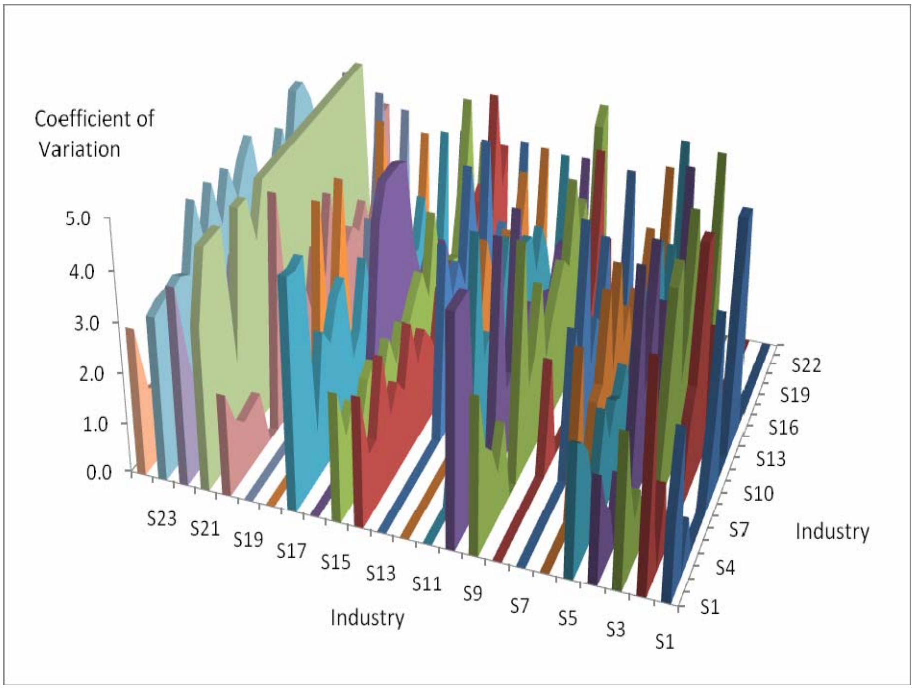


Figure 5: Most stable cells for the Indian regional economy: 1965

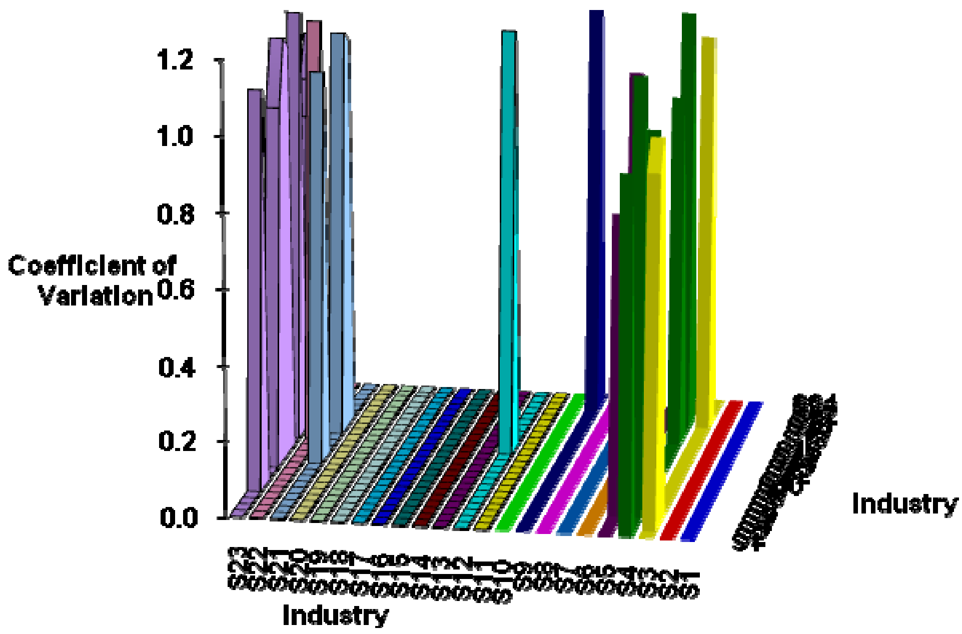


Figure 6: Top 25% of the largest field of influence for the average reference table for India: 1965

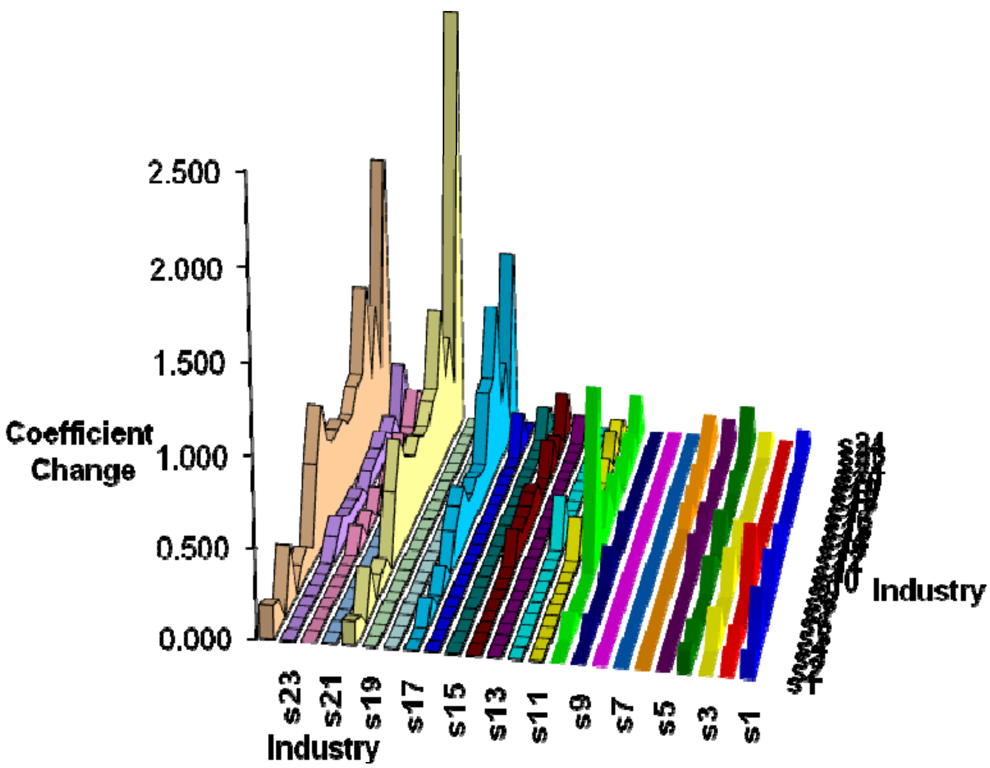


Figure 7: Top 15 of the most important cells in the Indian regional economy: 1965

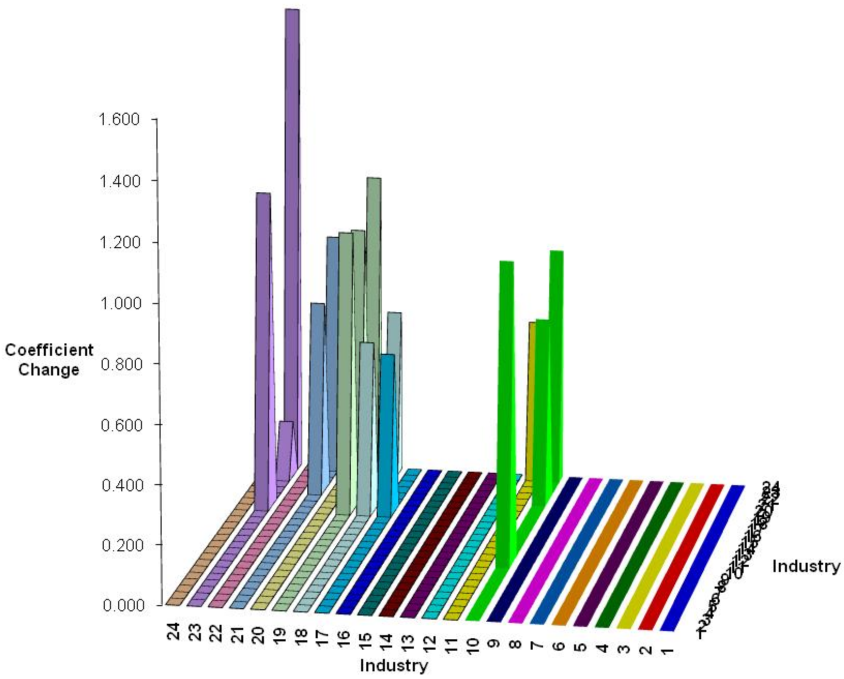


Figure 8: Actual regional table for Punjab: 1983-84

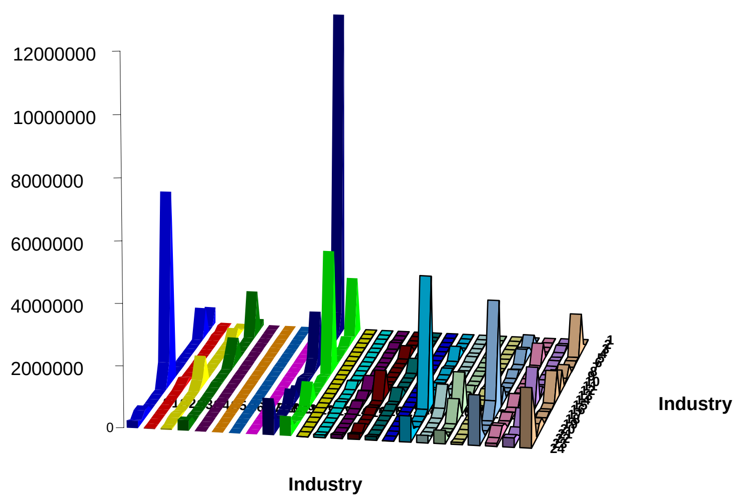


Figure 9: Predicted regional table for Punjab using FES: 1983-84