Globalization and Structural Changes in the Indian Industrial Sector: An Analysis of Production Functions

SK Mishra
Department of Economics
North-Eastern Hill University
Shillong (India)

I. Introduction: In 1991 India chose to open her economy to global economic forces and formulated the New Economic Policy (NEP). Under the structural adjustment and reform programmes, the NEP aimed at promoting growth by eliminating supply bottlenecks that hinder competitiveness, efficiency and dynamism in the economic system.

As it is well known, the Indian industrial policies in the pre-liberalization era had imposed several restrictions on the manufacturing sector with regard to the scale of operation, procurement and use of raw materials and capital, nature and type of industry where private sector could enter, markets that they could supply to, etc. The policies had also favoured labour-intensive, small-size firms. They also protected inefficiency in production in some sense by restricting competition. All these restrictions did not allow an optimal allocation of resources in response to the ever-changing economic environment in the domestic as well as foreign domain.

Long back, Sankar (1970) estimated the elasticity of substitution and returns to scale in 15 manufacturing sectors of India using CES production function modified to allow for the possible non-constant returns to scale. He found increasing returns to scale in most of the sectors. On the basis of his findings, Sankar opined that the (then) government's policy of encouraging the establishment of small firms had little economic justification.

Williams and Laumas (1984) found that there were considerable economies of scale in India's manufacturing sector although they were more predominant in some industrial groups than in others. They found that shortage of capital and skilled labour was not a serious constraint on the rate of growth in output. Increase in the supply of raw materials could help stimulate further growth of manufacturing sector. They also found that the Cobb-Douglas production function was largely unsuitable to understand the working of Indian manufacturing sector.

Nath (1996) studied the efficiency of small-scale industries in different states of India. His relative efficiency measures indicated that in Maharashtra and Madhya Pradesh, most of the SSIs were more efficient than in other states. On the other hand, in Andhra Pradesh, Bihar, Kerala, Tamilnadu and West Bengal they were less efficient. A use-based classification of industries revealed that consumer durable industries had some of the highest average efficiency indexes and relatively smaller coefficient of variations. It could be due to greater diffusion of technical knowledge and more uniform demand for the products across the states. On the other hand, the intermediate product industries and the consumer non-durables industries had wider variations in their relative efficiency indexes across states. Nath found that relative efficiency was positively correlated with relative size in some industries. The efficiency index had positive correlation with the level of capacity utilization in most of the industry groups studied by him.

Nikaido (2004) observed that the industrial policies in the past discriminated in favour of SSI through regulating and restricting economic activities of all firms including not only domestic large firms and foreign firms, but also small-scale firms, which might have invoked invisible cost and disadvantage.

These representative studies indicate that the manufacturing sector in the pre-liberalization era often exhibited increasing returns to scale (primarily due to restrictions on size of the factory, input procurement and limited market) and a sub-optimal input mix in favour of excessive employment of manpower.

The New Economic Policy of 1991 removed many of those restrictions and regulations. Consequently, one may expect, therefore, capital to be substituted for labour, firm sizes to grow, small scale industries to be pushed behind, increasing returns to scale to vanish and, in turn, production to grow in size and variety.

A number of researchers have found these changes occurring. Some have found globalization discriminating against the unorganized sector, pushing them farther to the margin (Hensman, 2001; Saptari, 2001). The percentage of workers in manufacturing in urban areas started decreasing since 1977, and continued apace between 1987-88 and 1993-94, while two sectors that have experienced systematic increases in employment share have been the “wholesale and retail trade” and “community and other services”. Kundu (1997) explains the loss of manufacturing employment in terms of jobs being subcontracted out by large manufacturing units to smaller ones which are often household units that classify themselves as service units (Dutt and Rao, 2000).

Chand and Sen (2002) found that post-reform trade liberalization in Indian manufacturing raised total factor productivity growth. Their results also support a key postulate of the new growth theories, that liberalization of the intermediate-good sectors has a larger favorable impact on total factor productivity growth than that of the final-good sectors.

Driffield and Kambhapati (2003) analyzed the determinants of firm-level efficiency in some manufacturing sectors (transport, textiles, metals, machines, foods and chemicals) in India and found that the overall efficiency in most of those sectors has increased. They also found that the output elasticity of labour is less than that of capital.

Kalirajan and Bhide (2004) observed that the economic reforms of the early 1990s did not lead to sustained growth of the manufacturing sector. After acceleration in the mid-1990s, growth slowed in the decade's second half. They found that manufacturing-sector growth in the post-globalization period has been "input driven" rather than "efficiency driven," with significant levels of technical inefficiency.

Balakrishnan et al. (2002) studies efficiency and returns to scale in 15 manufacturing sectors and found the hypothesis of constant returns-to-scale mostly untenable. They also found that a move to a more competitive market structure or an improvement in scale efficiency is not widespread across Indian manufacturing.

Nikaido (2004) used industry-state-wise data to study the technical efficiency of two-digit industry-groups belonging to small-scale category (SSI) and the relationship between technical efficiency and firm size and location. He found that on an average the industry groups operate at 80 per cent of the potential maximum production frontier, although diversification among industry groups is observed. Agglomeration of firms has a positive effect on technical efficiency, while 'firm size' has a negative effect on it.

II. Our Objectives: In this study we intend to investigate as to the structural changes in the manufacturing sector of India (possibly) brought about by liberalization and globalization of the economy. We assess structural changes in terms of employment of labour and capital, possibly indicated by replacement of the former by the latter. We also assess it in terms of returns to scale. It is well known that different states in India are at different levels of Industrialization. Some are industrially under-developed while some others are quite advance and enjoy the economies of agglomeration (Lall et al., 2001). We intend to assess the impacts of the new industrial policies on regional distribution of indicators of industrialization such as the labour-capital ratio, returns to scale and productivity.

III. The Data: In this study we use the data (see Table-I) on labour, capital, net value added and number of industrial establishments/factories provided by Report on Currency and Finance 1997-98, Govt. of India (reproduced in *Basic Statistics of North Eastern Region 2000, NEC, Govt. of India, Shillong*) and *Annual Survey of Industries*, Ministry of Statistics and Programme Implementation, Govt. of India (http:www.mospi.nic.in). The first source provides data for 1990-91 while the second source provides data for 2003-04. By *Labour* is meant the "total persons engaged" in the factories, by *Capital* is meant the "Fixed Capital" and *Net Value Added* (NVA) is "Gross value of output net of the value of total inputs and depreciation". The data are detailed state-wise, including the Union Territories. However, to make 2003-04 data comparable with 1990-91 data, aggregation is done for Bihar and Jharkhand, Madhya Pradesh (MP) and Chattisgarh, and Uttar Pradesh (UP) and Uttaranchal. In the category "others" we have the aggregate data for other states including the North-Eastern India (except Assam).

IV. Methods of Analysis: As it has been mentioned before, our current interest is a structural analysis of the industrial scenario that has been emerging in the post-globalization period in India. For this purpose we have used production functions as the apparatus of analysis. Production functions are technological relationships between the output and the inputs that are used by (efficient) industrial establishments. In response to changes in technological, economic and social environment, the industrial establishments determine the scale of operation and substitute the one factor of production (input) for the others so as to continuously move closer to the input mix that is most productive or rewarding.

To fit different models of production function we have used two approaches: the one that minimizes the sum of squared difference between the observed values and the expected values – the least squares, and the other that minimizes the sum of absolute difference between the said quantities – the least absolute deviations approach, to estimation of parameters of a production function. In certain cases where data contain outliers or input figures contain large sporadic errors, etc the least squares (LS) approach to estimation falters but the least absolute deviation (LAD) method yields good estimates of parameters (Taylor, 1974). In any case, LAD often gives estimated parameters that are comparable to or better than those given by the LS (Dasgupta and Mishra, 2004).

Whether the LS or the LAD, one has to minimize some type of norm of difference between the observed and the expected values of the explained variable. In the majority of cases the LS has a closed form and therefore it may be used in a routine manner. However, in certain specific cases an iterative method must be used. The Zellner-Revankar (1969) production function (used in this study) is an example where the LS estimates of parameters are not the Maximum Likelihood (ML) estimators. To obtain the ML estimators one must apply LS iteratively or use some advance method (Mishra, 2006-c). On the other hand, the LAD estimation has to be done iteratively. For linear models we may use the method of linear programming or the iterative method suggested by Fair (1974) or Schlossmacher (1973). However, these methods are not applicable to nonlinear models. In this study we have used nonlinear models so often. To estimate the parameters, therefore, we have opted to use the method of Differential Evolution (DE).

It would be useful to provide here an introduction to DE and related methods of minimization of extremely difficult nonlinear functions, particularly because these methods have scarcely been used in econometric analysis. In this category we have the methods such as the Genetic Algorithms (Holland, 1975), the Cluster method (Törn, 1978), the Simulated Annealing method (Kirkpatrick et al., 1983), the Tabu search method (Glover, 1986), the Particle Swarm method (Eberhart and Kennedy, 1995) and the Differential Evolution method (Storn and Price, 1995), to name some major ones. As the names suggest, these methods simulate the stochastic optimization processes observed in nature. The DE is an evolutionary, population-based, stochastic search method that simulates selection and mutation processes observed in the struggle of the living beings for survival. It is particularly suited to optimization of nonlinear functions continuous in variables (Mishra, 2006-a).

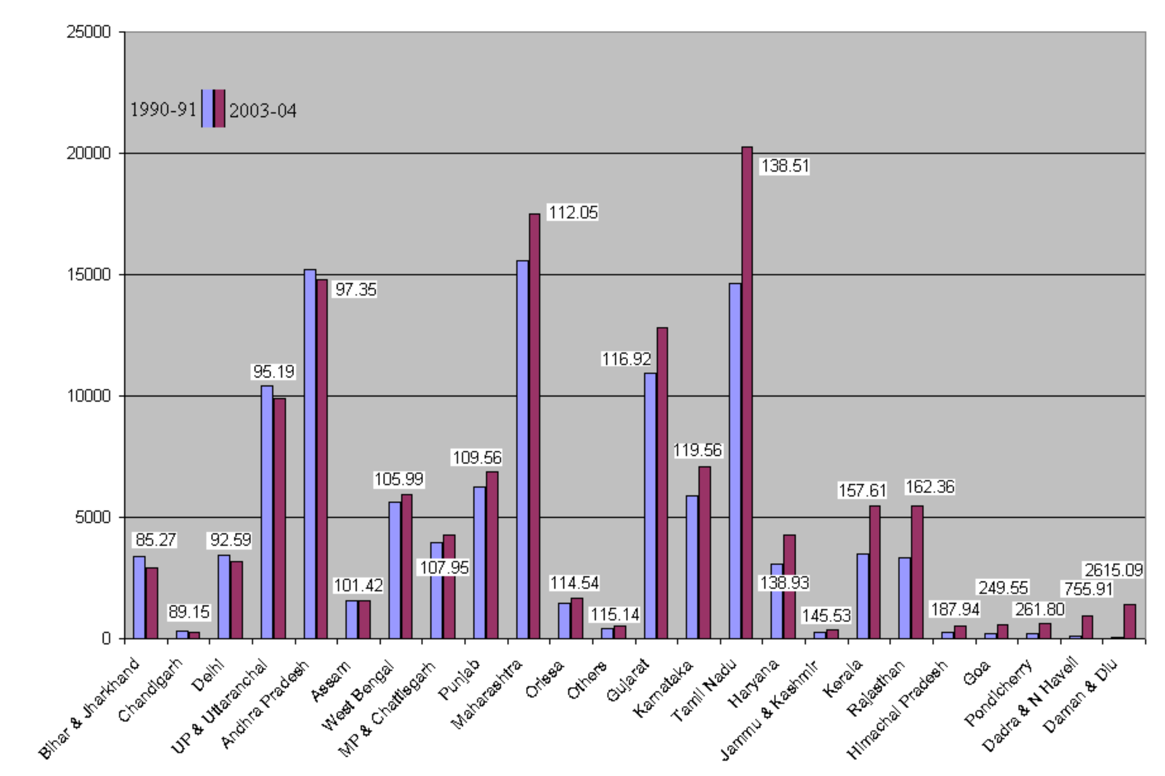
V. Observations on Growth in Number of Factories: A cursory perusal of Table-I indicates, first of all, that in the terminal year of our analysis (2003-04) the number of factories at the national level have increased (in comparison to 1990-91) by about 17 percent. In Goa, Pondicherry, Dadra & Nagar Haveli (DNH) and Daman & Diu (DD) the number of factories have more than doubled. On the other hand, the number of factories in Bihar & Jharkhand (BJ), Chandigarh, Delhi, UP & Uttaranchal (UPU) and Andhra Pradesh have reduced (Fig.-I). If we consider the growth rate of the number of factories relative to growth rate in population during 1991-2004, we may possibly get a better view of industrial development in different states. A perusal of Table-II reveals that the states in the eastern and central parts of India have experienced a setback or attracted lesser number of factories than those in other parts of India. If we disregard (population relative) number of factories in the smaller states (Goa, Pondicherry, Chandigarh, DNH, DD and Others – including non-Assam states in the North-Eastern Region, etc) we find that the coefficient of variation in the distribution of number of factories per lakh population in 2003-04 is lesser (0.6725) than that in 1990-91 (0.7222). However, inclusion of Goa, Pondicherry, Chandigarh and "others" (barring DNH and DD) raises the coefficient of variation from 0.7464 (1990-91) to 0.8446 (2003-04). Inclusion of DNH and DD (that amounts to taking all states and UT's in analysis) raises the coefficient of variation exponentially. A balanced view of this exercise suggests that as far as the distribution of number of factories in the post-globalization period is concerned, disparities among the states have not increased or decreased appreciably in any meaningful way. Nevertheless, the scale and size of investment, employment, value addition, etc (and not merely the number of factories) are appropriate measures to assess the significance of industrialization. Gini coefficients of population-deflated labour, capital and NVA (across the states) in 1990-91 were 0.88249, 0.87072 and 0.87498 respectively, which changed to 0.85268, 0.84822 and 0.83045 (respectively) in 2003-04. These figures may possibly suggest that inequalities over the states have decreased to some extent.

Table-I. Indicators of Industrial Sector of the Indian Economy

State/Union Territories	Year 1990-91*				Year 2003-04**			
	NFACT	LABOUR	CAPITAL	NVA	NFACT	LABOUR	CAPITAL	NVA
Andhra Pradesh	15205	832120	15779	2981	14802	864112	34216	13375
Assam	1548	108953	1032	734	1570	113993	6696	3741
Bihar & Jharkhand	3409	360362	6938	2598	2907	201933	19310	8773
Chandigarh	295	12185	45	70	263	8938	312	164
Dadra & N Haveli	127	5680	116	73	960	51861	4764	2801
Daman & Diu	53	2642	27	14	1386	59877	2422	2335
Delhi	3453	144554	879	1016	3197	115478	2105	2024
Goa	220	17309	241	158	549	34457	3739	2288
Gujarat	10943	675447	13099	4468	12795	729310	85789	28865
Haryana	3070	252974	3658	1636	4265	318266	15134	9143
Himachal Pradesh	282	53580	1118	378	530	36753	5714	1750
Jammu & Kashmir	235	13577	66	76	342	26952	382	188
Karnataka	5911	418955	4844	2769	7067	507410	35429	13844
Kerala	3484	271961	2661	1222	5491	316611	6930	4091
MP & Chattisgarh	3962	417099	10324	3007	4277	313904	22338	10633
Maharashtra	15595	1239152	22162	12004	17474	1114070	83472	41910
Orissa	1465	153220	4745	1153	1678	124983	16115	3215
Pondicherry	233	21661	204	97	610	39438	2301	1989
Punjab	6255	400960	5667	1857	6853	336397	9256	5314
Rajasthan	3358	241329	5099	1556	5452	245274	14012	5173
Tamil Nadu	14617	962589	11385	5793	20246	1162594	46421	19101
UP & Uttaranchal	10417	789011	14699	4625	9916	611164	32108	14163
West Bengal	5606	740980	8490	3198	5942	515267	24090	7903
Others	436	26204	380	34	502	21039	277	149
India	110179	8162504	133658	51517	129074	7870081	473331	202933

NFACT = No. of Factories; NVA = Net Value Added (Rs. Crore) ; Captal = Fixed Capital (Rs. Crore) ; Labour = No. of Employees; * Source : Report on Currency & Finance-1997-98; ** Source : MOSPI (asi_table3_2003_04.htm)

Fig-I. Percentage Growth in Number of Factories in Different States/UT 1991-2004



VI. The Average Size of Industrial Establishments: The size of a factory may be measured either in terms of the manpower it employs or the fixed capital that it applies to production. Each of these measures has its specific significance and limitations. While the size of the manpower employed by a factory may indicate its role in sharing the returns to industrialization among the people, it may be borne in mind that the issues of efficiency of labour, the quality of manpower employed, the nature of technology employed in production, the wage rate of labour, etc are the crucial considerations. On the other hand, fixed capital applied to production may indicate the nature of production technology and the share of capital in the returns to industrializations, but the issues regarding measurement of capital (Robinson, 1953; Felipe and Fisher, 2001) capacity under-utilization and X-efficiency, input and output specific rates of inflation, etc are very significant.

In Table-III we present the state-wise figures on labour and capital per establishment (factory) for 1990-91 and 2003-04. We also present the labour-capital ratios for those years. We observe that overall the manpower employed by the industrial establishments has reduced during the reference years. However, in some states such as Andhra Pradesh (AP), Assam, DNH, J&K and Karnataka, the measure has shown an increase. On the other hand, in some states such as Bihar & Jharkhand, Himachal Pradesh (HP), Madhya Pradesh & Chattisgarh (MPC), Orissa and West Bengal (WB), the manpower employed per factory has shown a sizeable decline. Different states have different reasons that have led to such changes.

Table-II: Population-weighted Growth of Number of Factories in the Post-Globalization Period						
States/Union Territories	No. of Factories		Population (million)			$\frac{\Delta(NFact)}{\Delta Popn}\times 100000$
	1990-91	2003-04	1991	2001	2004*	
Chandigarh	295	263	0.642	0.901	0.978	-9.518
Delhi	3453	3197	9.421	13.851	15.179	-4.445
Andhra Pradesh	15205	14802	66.508	76.210	79.121	-3.195
Bihar & Jharkhand	3409	2907	86.374	109.944	117.015	-1.638
UP & Uttaranchal	10417	9916	139.112	174.687	185.360	-1.083
Assam	1548	1570	22.414	26.656	27.928	0.399
MP & Chattisgarh	3962	4277	66.181	81.182	85.682	1.615
Others	436	502	9.912	12.619	13.431	1.875
West Bengal	5606	5942	68.078	80.176	83.806	2.136
Orissa	1465	1678	31.660	36.805	38.348	3.185
Jammu & Kashmir	235	342	7.719	10.144	10.871	3.394
Maharashtra	15595	17474	78.937	96.879	102.261	8.056
Punjab	6255	6853	20.282	24.359	25.582	11.283
Karnataka	5911	7067	44.977	52.851	55.213	11.294
Rajasthan	3358	5452	44.006	56.507	60.258	12.885
Gujarat	10943	12795	41.310	50.671	53.479	15.218
Haryana	3070	4265	16.464	21.145	22.549	19.638
Himachal Pradesh	282	530	5.171	6.078	6.350	21.032
Kerala	3484	5491	29.099	31.841	32.664	56.286
Tamil Nadu	14617	20246	55.859	62.406	64.370	66.140
Goa	220	549	1.170	1.348	1.401	142.278
Pondicherry	233	610	0.808	0.974	1.024	174.111
Dadra & N Haveli	127	960	0.138	0.220	0.245	781.302
Daman & Diu	53	1386	0.102	0.158	0.175	1811.058
India	110179	129074	846.343	1028.610	1083.291	7.974
* Estimated by assuming the average annual growth rate during 1991-2001 to remain constant						

The figures on application of fixed capital per establishment indicate that overall, there is an increase in this measure. It becomes more evident when we look at the figures on labour-capital ratio. Overall, in 2003-04 the labour-capital ratio has remained only slightly more than a quarter (27.23 percent) of that in 1990-91. In states such as Punjab, AP, Kerala, Rajasthan, UPU, MPC, J&K, Delhi, Haryana and Tamilnadu, the rate of reduction in labour-capital ratio has been slower than that in India as a whole. On the other hand, Chandigarh, Goa, HP, Assam, Pondicherry, Gujarat, Karnataka, BJ, Maharashtra, Orissa and WB, the rate of reduction in labour-capital ratio has been faster.

The average change in NVA in response to the average change in the number of factories has been positive in India (801.35 percent). States such as WB, Gujarat, Orissa, and Karnataka have shown the said rate higher than India's. On the other hand, the rate has been negative for states such as AP, UPU, BJ, Delhi and Chandigarh.

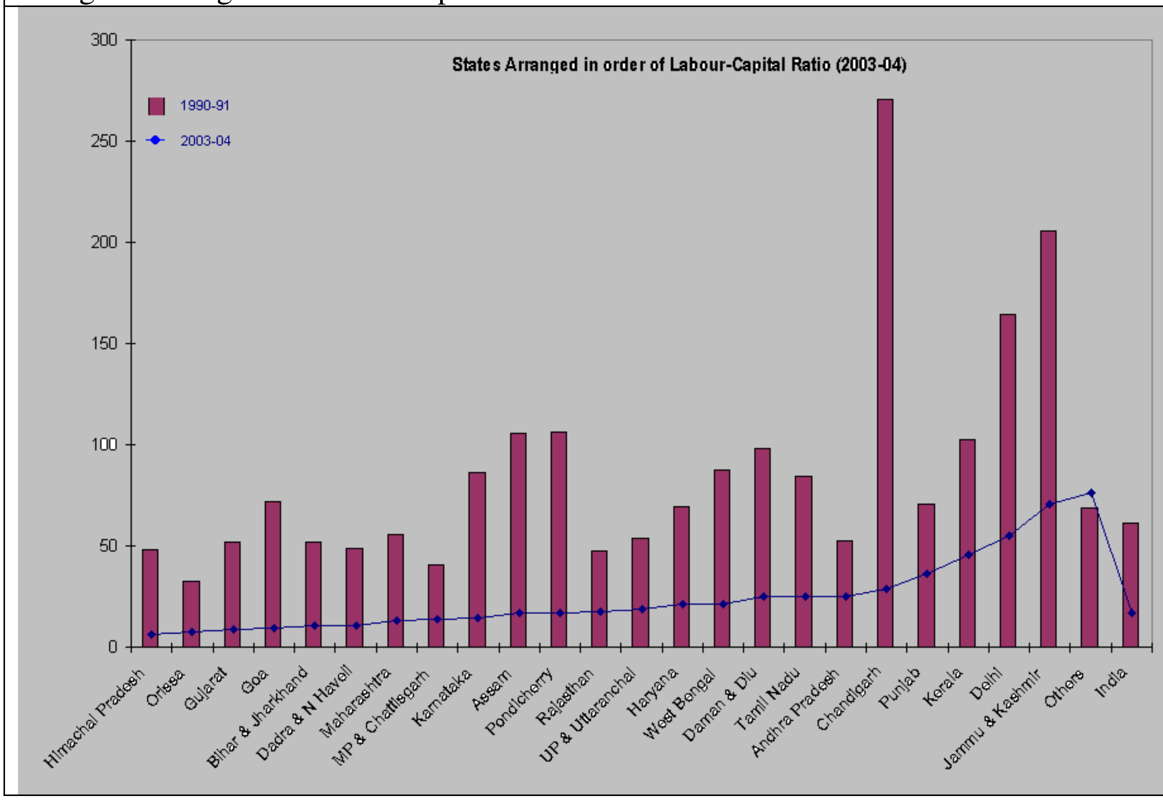
Table-III. Labour, Capital per Establishment and Labour Capital Ratio in Industrial Sector, India						
State/Union Territories	Labour per Establishment		Capital per Establishment*		Labour/Capital Ratio**	
	1990-1991	2003-2004	1990-1991	2003-2004	1990-1991	2003-2004
Andhra Pradesh	54.7267	58.3781	1.0378	2.3116	52.736	25.255
Assam	70.3831	72.6070	0.6667	4.2647	105.575	17.025
Bihar & Jharkhand	105.7090	69.4644	2.0352	6.6427	51.940	10.457
Chandigarh	41.3051	33.9848	0.1525	1.1859	270.778	28.658
Dadra & N Haveli	44.7244	54.0219	0.9134	4.9621	48.966	10.887
Daman & Diu	49.8491	43.2013	0.5094	1.7477	97.852	24.718
Delhi	41.8633	36.1207	0.2546	0.6584	164.453	54.857
Goa	78.6773	62.7632	1.0955	6.8103	71.822	9.216
Gujarat	61.7241	56.9996	1.1970	6.7049	51.565	8.501
Haryana	82.4020	74.6227	1.1915	3.5484	69.156	21.030
Himachal Pradesh	190.0000	69.3453	3.9645	10.7808	47.925	6.432
Jammu & Kashmir	57.7745	78.8070	0.2809	1.1166	205.712	70.575
Karnataka	70.8772	71.7999	0.8195	5.0133	86.489	14.322
Kerala	78.0600	57.6600	0.7638	1.2620	102.203	45.690
MP & Chattisgarh	105.2749	73.3935	2.6058	5.2229	40.401	14.052
Maharashtra	79.4583	63.7559	1.4211	4.7769	55.913	13.347
Orissa	104.5870	74.4833	3.2389	9.6038	32.291	7.756
Pondicherry	92.9657	64.6525	0.8755	3.7714	106.181	17.143
Punjab	64.1023	49.0876	0.9060	1.3507	70.753	36.342
Rajasthan	71.8669	44.9879	1.5185	2.5700	47.329	17.505
Tamil Nadu	65.8541	57.4234	0.7789	2.2929	84.549	25.044
UP & Uttaranchal	75.7426	61.6341	1.4111	3.2380	53.678	19.035
West Bengal	132.1762	86.7161	1.5144	4.0543	87.277	21.389
Others	60.1009	41.9104	0.8716	0.5508	68.958	76.088
India	74.0840	60.9734	1.2131	3.6671	61.070	16.627
* Rs Crore; ** Person per Crore of Rs; [Rs. One Crore = Rs. 10 million]						

Table-IV: Response of Labour Productivity to Capital-Labour Ratio								
Parameters	1990-91 (Linear Model); R^2=0.104				2003-04 (Exponential Model); R^2=0.567			
	Coeff	See(coef)	t-Value	p-level	Coeff	See(coef)	t-Value	p-level
Intercept	0.468594	0.111791	4.1917	0.000378	0.015893	0.558582	0.0285	0.977558
K/L Ratio	0.110240	0.068919	1.5996	0.123961	1.776117	0.318340	5.5793	0.000013
Model	$L_P = a_0 + a_1(K/L) + u$; See=standard error				$L_P = b_0 + b_1\ln(K/L) + v$; See=standard error			

VII. The Response of Labour Productivity to Changes in Capital-Labour Ratio: The gross measure of productivity of labour (L_P) is the ratio of NVA to the number of labourers (the total number of persons engaged in a factory) who raise production. It has been observed that increase in the capital-labour ratio enhances the productivity of labour. In Table-IV we present the regression coefficients of labour productivity as a function of capital-labour ratio. We have used two regression models. For 1990-91 data, we have used the linear model (that fits better than the other model) while for 2003-04 we have used the exponential model. We find that in 1990-91 the relationship was positive but quite weak. It became much stronger in 2003-04 and cannot now be considered inconsequential by any standard.

The changes in capital-labour ratio and the consequent rise in the output-labour ratio (that may be considered as a gross measure of L_P) may occur in two ways; first, when labour is replaced by capital, in which the average number of workers per factory decreases with an increase in the capital-labour ratio, and the second when fixed capital per factory increases but without a decrease in the number of workers per factory. These two processes have their own implications. We do not observe any instance of the second process in our study.

Fig.-II. Changes in Labour-Capital Ratio in the Post Globalization Period 1991-2004



VIII. Substitution of Capital for Labour: The post-globalization period has shown a tendency to increase in capital-labour ratio with decrease in the number of workers per industrial establishment. To look into this aspect more closely, we have fitted the CES production function to our data. The CES function specified as:

$$\log(NVA) = \log(A) + (-r/b)\log[dL^{-b} + (1-d)K^{-b}] + u$$

tries to explain output (NVA here) in terms of inputs (labour, L and capital, K) and the parameters of efficiency (A), returns to scale (r), distribution (d) and substitution (b). For our data in which we measure L and K per factory in different states, the estimated parameters of the CES production function are presented in Table-V. We note that for 1990-91, there was an almost perfect substitutability of capital for labour. The returns-to-scale parameter was about 0.9 and the distribution parameter was pretty close to unity. This scenario was completely changed in 2003-04. The distribution parameter associated with labour has been pushed to zero and the substitution parameter increased to be very high. Thus, there was a move from an almost linear production function to the Leontief type function with fixed proportions of labour to capital.

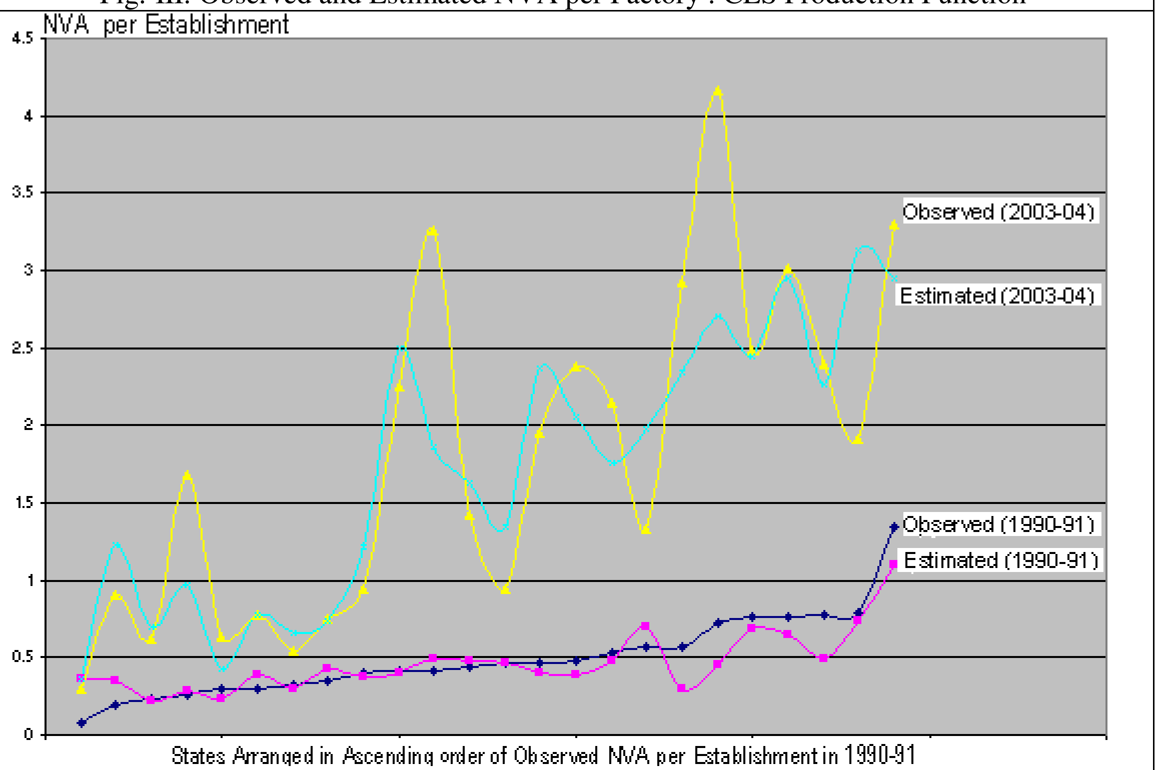
These (statistical) findings are quite atypical. There may be several reasons for the same. First of all, a question is: should we measure NAV, L and K per factory, knowing well that in each state the data on the number factories are obtained by aggregating a collection of factories of different sizes, producing different products, using different technologies, employing capital and labour very differently? Such vast dissimilarities among the factories (in any state) may not be represented by the measures such as NVA per factory, fixed capital per factory, etc. Secondly, the assumption of a uniform returns to scale in all states and constancy of the substitution parameter over the states may not be very appropriate. Lastly, estimation of parameters of the CES production function has been problematic and largely unstable.

Table-V: Estimated Parameters of CES Production Function (NVA per Establishment)

Year	A (Efficiency)	r (Returns to scale)	d (Distribution)	b (Substitution)	SSQD	R^2
1990-91	3.545183636	0.89062191	0.978471577	-0.990598737	3.9574	0.7461
2003-04	0.604884676	0.84480377	$\rightarrow 0$	$\rightarrow \infty$	1.9250	0.6969

Estimation by minimization of sum of squared deviations (SSQD) by Differential Evolution

Fig.-III: Observed and Estimated NVA per Factory : CES Production Function



IX. Variable Returns to Scale in Different States: In what follows, we drop the practice of measuring NVA, L and K per factory and use the aggregate data on these variables. We want to analyze the response of aggregate NVA to aggregate manpower (persons engaged) and aggregate fixed capital. We also drop the CES model in favour of the more popular Cobb-Douglas model - assume that the elasticity of substitution (between labour and capital) is unity - but we visualize that returns to scale may be scale dependent. We assume that in more industrialized states there would be less scope to increase production in proportion to further employment of labour and capital while in less industrialized states such scopes may be abundant.

In view of these notions, we choose the Zellner-Revankar (ZR) production function as our model. The ZR production function generalizing the Cobb-Douglas production function for a variable returns to scale is specified as:

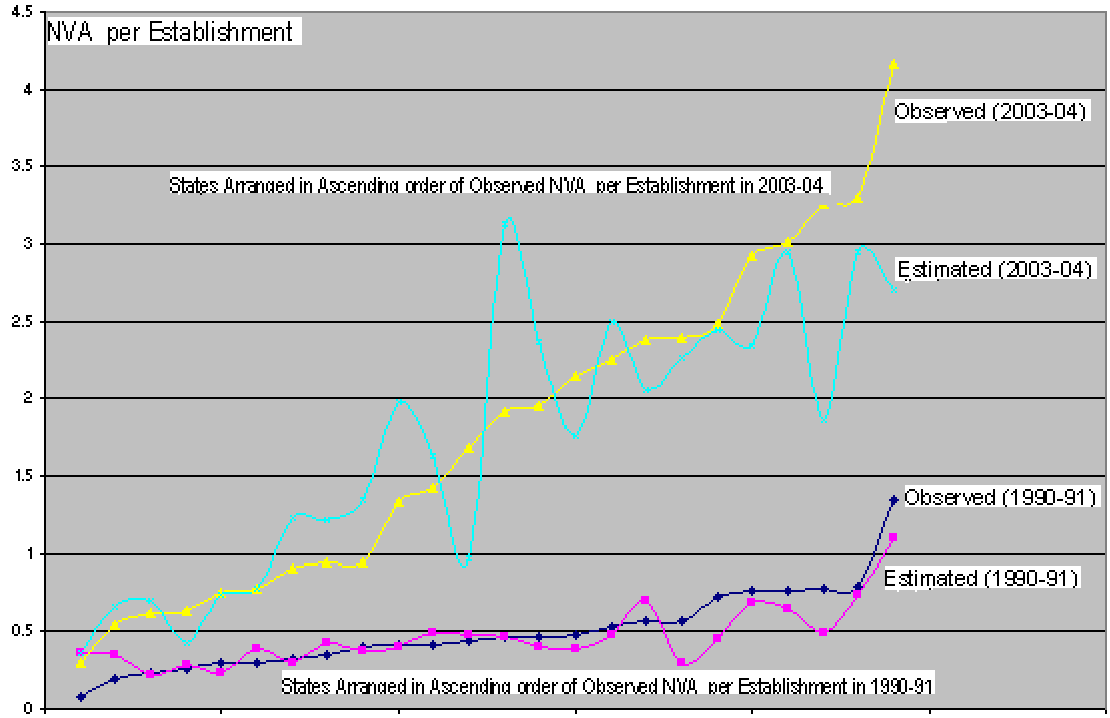
$$\log(NVA) + \theta NVA = a_0 + a_1 \log(L) + a_2 \log(K) + \varepsilon$$

where $a_0 = \log(A)$; $a_1 = \alpha b$; $a_2 = \alpha(1-b)$. A is the efficiency parameter, b is the elasticity of output (NVA) with respect to labour, $\alpha = a_1 + a_2$ is the returns to scale parameter and θ is the parameter that attributes variability to the returns to scale. If θ is zero, the ZR function is reduced to the Cobb-Douglas function. The returns to scale function varies inversely with NVA such that $\alpha(NVA) = \alpha/(1+\theta NVA)$.

Table-VI: Net Value Added (Observed and Estimated) in 1990-91 and 2003-04 [CES Production Function]

States/Union Territories	NAV/Establishment 1990-91		NAV/Establishment 2003-04	
	Observed	Expected	Observed	Expected
Andhra Pradesh	0.19605	0.35510	0.90361	1.22774
Assam	0.47416	0.38652	2.38276	2.05971
Bihar & Jharkhand	0.76210	0.64077	3.01795	2.94468
Chandigarh	0.23729	0.21811	0.62281	0.69858
Dadra & N Haveli	0.57480	0.30255	2.91808	2.33872
Daman & Diu	0.26415	0.28766	1.68470	0.96944
Delhi	0.29424	0.23013	0.63324	0.42497
Goa	0.71818	0.45694	4.16750	2.70613
Gujarat	0.40830	0.39758	2.25600	2.49464
Haryana	0.53290	0.47991	2.14381	1.76339
Himachal Pradesh	1.34043	1.10365	3.30172	2.94401
Jammu & Kashmir	0.32340	0.30022	0.54886	0.66397
Karnataka	0.46845	0.40186	1.95894	2.36124
Kerala	0.35075	0.42596	0.74506	0.73628
MP & Chattisgarh	0.75896	0.68556	2.48605	2.44438
Maharashtra	0.76973	0.48774	2.39841	2.26684
Orissa	0.78703	0.73400	1.91592	3.12725
Pondicherry	0.41631	0.49481	3.26056	1.85655
Punjab	0.29688	0.38191	0.77544	0.77978
Rajasthan	0.46337	0.46590	0.94887	1.34273
Tamil Nadu	0.39632	0.37792	0.94342	1.21933
UP & Uttaranchal	0.44399	0.47217	1.42833	1.63213
West Bengal	0.57046	0.69891	1.32996	1.97350
Others	0.07798	0.36255	0.29719	0.36549

Fig.-IV: Observed and Estimated NVA per Factory : CES Production Function



In course of our analysis we have found that Maharashtra has such a large NVA that it may pull others in its favour and cause problems in estimation. That is, it may be considered as an outlier. Hence, we have estimated the parameters of ZR function twice: first by excluding Maharashtra and then by including it. The estimated parameters are presented in Table-VII and Table-VIII.

A perusal of Table-VII suggests that when Maharashtra is excluded from estimation, the elasticity of output wrt labour = $\hat{a}_1/(\hat{a}_1+\hat{a}_2)$ is approximately 0.961768/1.144696 = 0.8402 for 1990-91 while it is as small as 0.238876/1.050688 = 0.2274 for 2003-04. The estimated returns to scale parameters are 1.144696 and 1.050688 for 1990-91 and 2003-04 respectively.

Inclusion of Maharashtra into estimation makes a difference as expected. A perusal of Table-VIII suggests that the elasticity of output wrt labour = $\hat{a}_1/(\hat{a}_1+\hat{a}_2)$ is, approximately, 0.843262/1.018968 = 0.8276 for 1990-91 and 0.19338/0.984466 = 0.1964 for 2003-04. The estimated returns to scale parameters are 1.018968 and 0.984466 for 1990-91 and 2003-04 respectively.

It might not be appropriate to assert that the returns-to-scale parameter has changed significantly during 1991-2004 period. But the output elasticity of labour has almost surely experienced a sea change. Now NVA is rather inelastic to labour.

Table-VII:Estimated Parameters of Zellner-Revankar Production Function (Maharashtra Excluded)					
Year	a_0	a_1	a_2	Theta	Log-Max l*
1990-91	0.973871	0.961768	0.182928	0.000223385	-12.41949
2003-04	4.393562E-15	0.238875551	0.811812083	3.30968012E-05	-5.85391

Table-VIII: Estimated Parameters of Zellner-Revankar Production Function (Maharashtra Included)					
Year	a_0	a_1	a_2	Theta	Log-Max l*
1990-91	1.299543	0.843262	0.175706	3.44147502E-005	-16.38979
2003-04	0.150756	0.193380	0.791086	1.26334108E-005	-8.53031

Table-IX: Net Value Added (Observed and Expected) and Returns to Scale Function (Expected)						
State	Year 1990-91 [Maharashtra Excluded]			Year 2003-04 [Maharashtra Excluded]		
	Observed V	Expected V	$\hat{\alpha}(V)$	Observed V	Expected V	$\hat{\alpha}(V)$
Mahrashtra	12004	Excluded	0.310931	41910	Excluded	0.440155
Tamil Nadu	5793	2967.119	0.498981	19101	17627.79	0.643732
UP & Uttaranchal	4625	3333.411	0.563015	14163	13197.53	0.715362
Gujarat	4468	2911.074	0.572897	28865	18793.19	0.537343
West Bengal	3198	3903.813	0.667701	7903	12344.41	0.832846
MP & Chattisgarh	3007	2429.578	0.684742	10633	9423.11	0.777183
Andhra Pradesh	2981	5131.373	0.687129	13375	15494.15	0.728294
Karnataka	2769	2240.561	0.707234	13844	13819.05	0.720542
Bihar & Jharkhand	2598	2150.609	0.724329	8773	8013.21	0.814261
Punjab	1857	2709.962	0.809072	5314	5587.422	0.893536
Haryana	1636	1687.522	0.838324	9143	7240.575	0.806606
Rajasthan	1556	1744.666	0.849441	5173	7288.745	0.897096
Kerala	1222	1872.243	0.899228	4091	4533.829	0.925391
Orissa	1153	1217.144	0.91025	3215	7415.752	0.94964
Delhi	1016	871.6976	0.932954	2024	1450.255	0.984723
Assam	734	728.4102	0.983446	3741	3494.692	0.934930
Himachal Pradesh	378	404.4084	1.055565	1750	2504.296	0.993165
Goa	158	108.2147	1.105672	2288	1716.868	0.976725
Pondicherry	97	132.0217	1.120419	1989	1207.481	0.985794
Jammu & Kashmir	76	68.85155	1.125587	188	272.3837	1.044191
Dadra & N Haveli	73	33.03846	1.126329	2801	2265.659	0.961548
Chandigarh	70	57.92778	1.127072	164	177.687	1.045016
Others	34	180.1787	1.136068	149	198.0301	1.045532
Daman & Diu	14	12.28079	1.141128	2335	1374.975	0.975315

In Table-IX and Table-X we have presented the estimated returns-to-scale function for different states in 1990-91 and 2003-04. We find in Table-IX that states such as Gujarat, Haryana, Assam, HP, Goa, Pondicherry, J&K, DNH, Chandigarh, DD and "Others" have experienced a decline in the returns-to-scale function, while it has appreciated for the rest of the states. It may be noted that the second category of the states experiencing increase in the returns-to-scale function is industrially somewhat more advanced than many of the states in the first category. However, inclusion of Maharashtra in estimation changes this conclusion. We observe in Table-X that the returns-to-scale function for all states has declined in 2003-04 (vis-à-vis 1990-91). Industrial establishments in all the states in 2003-04 are running under diminishing returns to scale.

Table-X: Net Value Added (Observed and Expected) and Returns to Scale Function (Expected)						
State	Year 1990-91 [Maharashtra Included]			Year 2003-04 [Maharashtra Included]		
	Observed V	Expected V	$\hat{\alpha}(V)$	Observed V	Expected V	$\hat{\alpha}(V)$
Maharashtra	12004	5712.628	0.72108	41910	24793.72	0.653795
Tamil Nadu	5793	5085.653	0.84959	19101	20774.45	0.805565
UP & Uttaranchal	4625	4682.491	0.879051	14163	14503.84	0.848192
Gujarat	4468	4046.841	0.883168	28865	27537.43	0.73275
West Bengal	3198	4235.639	0.917941	7903	12046.29	0.909183
MP & Chattisgarh	3007	2717.987	0.923409	10633	9949.534	0.881539
Andhra Pradesh	2981	5247.355	0.924159	13375	16487.99	0.855416
Karnataka	2769	2408.163	0.930315	13844	15208.49	0.851102
Bihar & Jharkhand	2598	2272.395	0.93534	8773	8316.347	0.900187
Punjab	1857	2461.575	0.95776	5314	5298.891	0.937049
Haryana	1636	1557.54	0.964656	9143	7425.954	0.896415
Rajasthan	1556	1591.184	0.967177	5173	6977.06	0.938616
Kerala	1222	1587.994	0.977845	4091	4211.389	0.950816
Orissa	1153	1086.131	0.980079	3215	7027.115	0.960928
Delhi	1016	772.5873	0.984543	2024	1360.418	0.975026
Assam	734	632.2117	0.993863	3741	3376.92	0.95483
Himachal Pradesh	378	356.7525	1.005883	1750	2448.097	0.978328
Goa	158	105.8633	1.013458	2288	1705.69	0.971865
Pondicherry	97	124.4737	1.015578	1989	1188.015	0.975446
Jammu & Kashmir	76	68.89757	1.01631	188	265.2904	0.997588
Dadra & N Haveli	73	36.48752	1.016415	2801	2229.911	0.965782
Chandigarh	70	58.81026	1.01652	164	182.0753	0.99789
Others	34	163.3863	1.017777	149	195.2313	0.998078
Daman & Diu	14	14.84138	1.018478	2335	1336.425	0.971305

Table-XI: Regression Results of *Estimated* $\alpha(V)$ on L/C Ratio for 1990-91 and 2003-04 [Based on the Zellner-Revankar Model - Maharashtra Excluded]								
	Year 1990-91 [R Square = 0.1715; F=4.55]				Year 2003-04 [R Square = 0.1688; F=4.47]			
	Coefficient	SEE (Coef)	t-Value	p-level	Coefficient	SEE (Coef)	t-Value	p-level
b_0	0.704544	0.084711	8.317033	0.0000	0.772603	0.051449	15.01694	0.0000
b_1	0.001768	0.000829	2.134087	0.0442	0.003505	0.001658	2.11362	0.0461

Table-XII: Regression Results of *Estimated* $\alpha(V)$ on L/C Ratio for 1990-91 and 2003-04 [Based on the Zellner-Revankar Model - Maharashtra Included]								
	Year 1990-91 [R Square = 0.1196; F=2.99]				Year 2003-04 [R Square = 0.1534; F=3.99]			
	Coefficient	SEE (Coef)	t-Value	p-level	Coefficient	SEE (Coef)	t-Value	p-level
b_0	0.916891	0.025801	35.53754	0.0000	0.860010	0.031280	27.49376	0.0000
b_1	0.000436	0.000252	1.728590	0.0979	0.000611	0.000306	1.99678	0.0584

A linear regression of returns-to-scale function on labour-capital ratio has indicated (Table-XI) that the coefficient is positive and statistically significant at 5 percent (prob. level) when Maharashtra is excluded from estimation. However, when Maharashtra is included, the coefficient for the year 2003-04 is significant at 6 percent, but for the year 1990-91 it is significant at 10 percent (Table-XII). These findings indicate that decreasing labour-capital ratio in the post-globalization period has led to diminishing returns to scale in industrial sector of the Indian Economy.

Fig.-V: Observed and Expected NVA by Zellner-Revankar Production Function (Maharashtra Excluded)

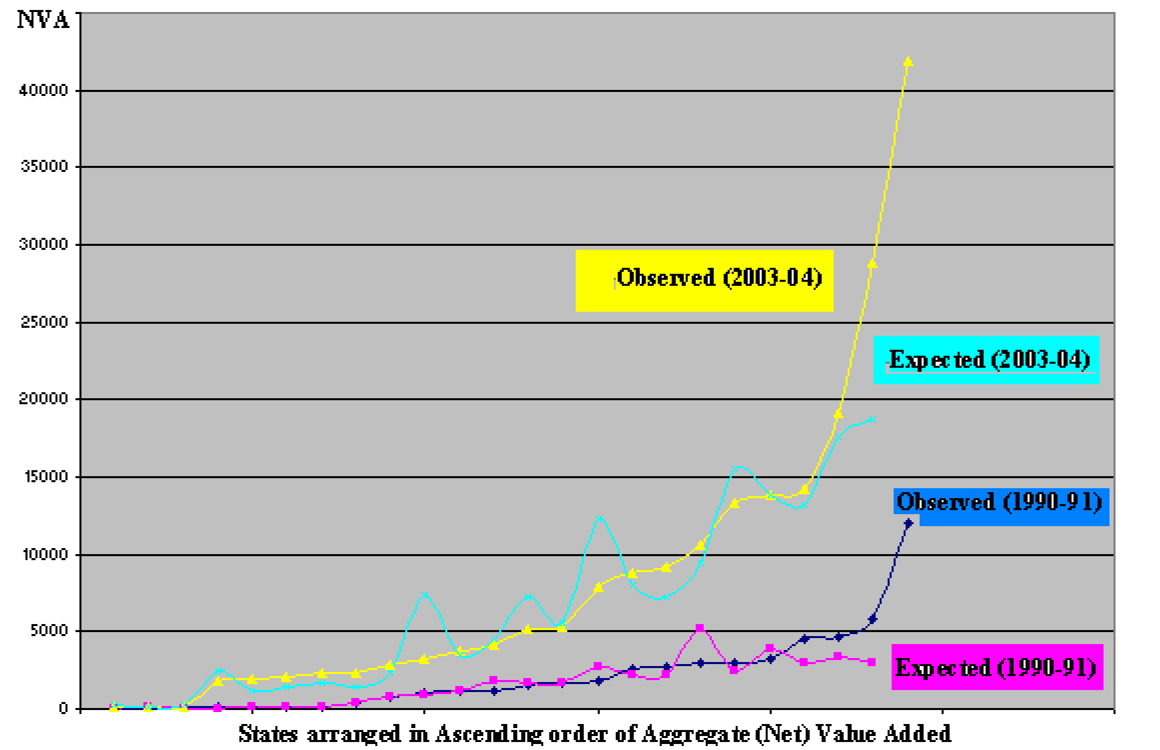
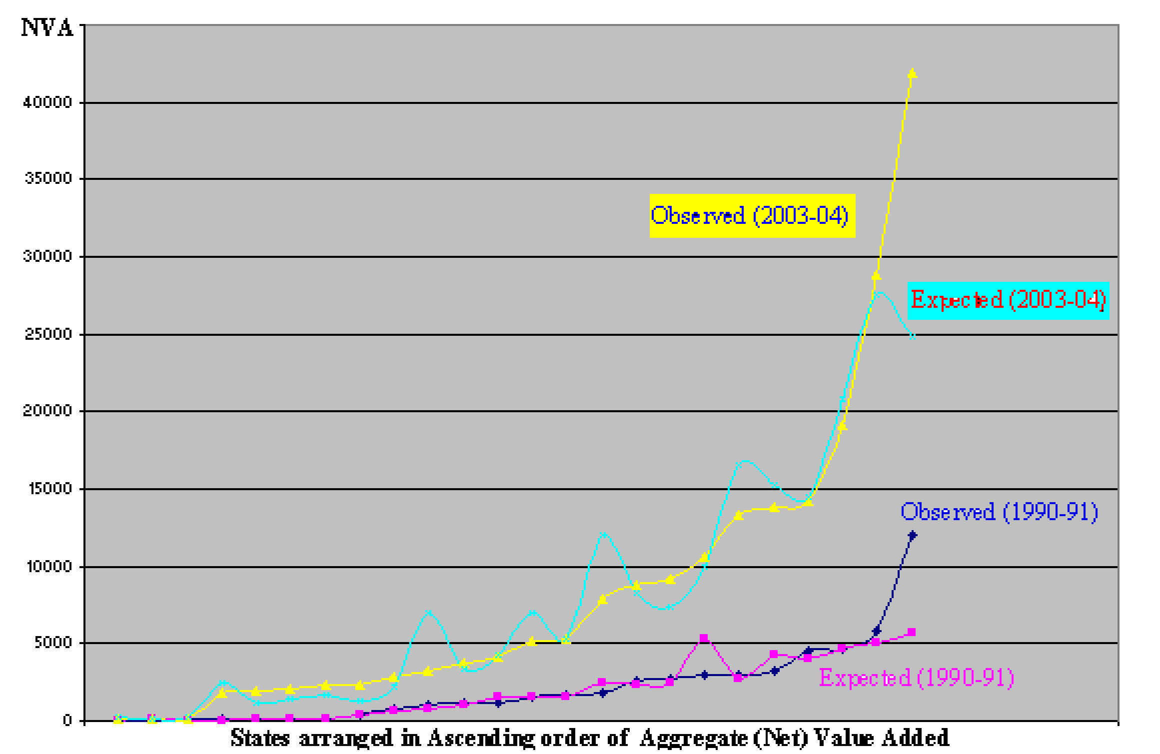


Fig.-VI: Observed and Expected NVA by Zellner-Revankar Production Function (Maharashtra Included)



X. Analysis by Transcendental Production Function: Now we fit the transcendental production function to the aggregate data on NVA, labour and capital. The transcendental production function is specified as:

$$\log(NVA) = k_0 + k_1 \log(L) + k_2 \log(K) + k_3 L + k_4 K + \upsilon;\ \ k_3,\ \ k_4 \leq 0$$

This function permits variable elasticity of production as well as substitution. In case $k_3 = k_4 = 0$, it degenerates to the Cobb-Douglas production function. We have fitted this function to the data (Maharashtra included) for 1990-91 and 2003-04 by two different methods of estimation: the least absolute deviation (LAD) and Ordinary Least Squares (OLS) methods. The reason for using LAD is our observation that Maharashtra may be an outlier and pull the least squares estimator to it. The estimated parameters are presented in Table-XIII. We find that for 1990-91 data, there is not much difference in the LAD and OLS estimated parameters. Further, k_1 alone is significantly different from zero. However, for 2003-04 data, k_2 and k_3 both are significantly different from zero. As for 1990-91, output elasticity of labour alone is significant. For 2003-04, labour has taken a back seat, capital is a significant input and the significance of k_3 indicates that any further increase in labour would have a dampening impact on output. This finding appears to be convincing since it explains the observed decrease in labour-capital ratio in the post-globalization period.

Fig.-VII: Observed and Expected NVA by Transcendental Production Function (Maharashtra Included)

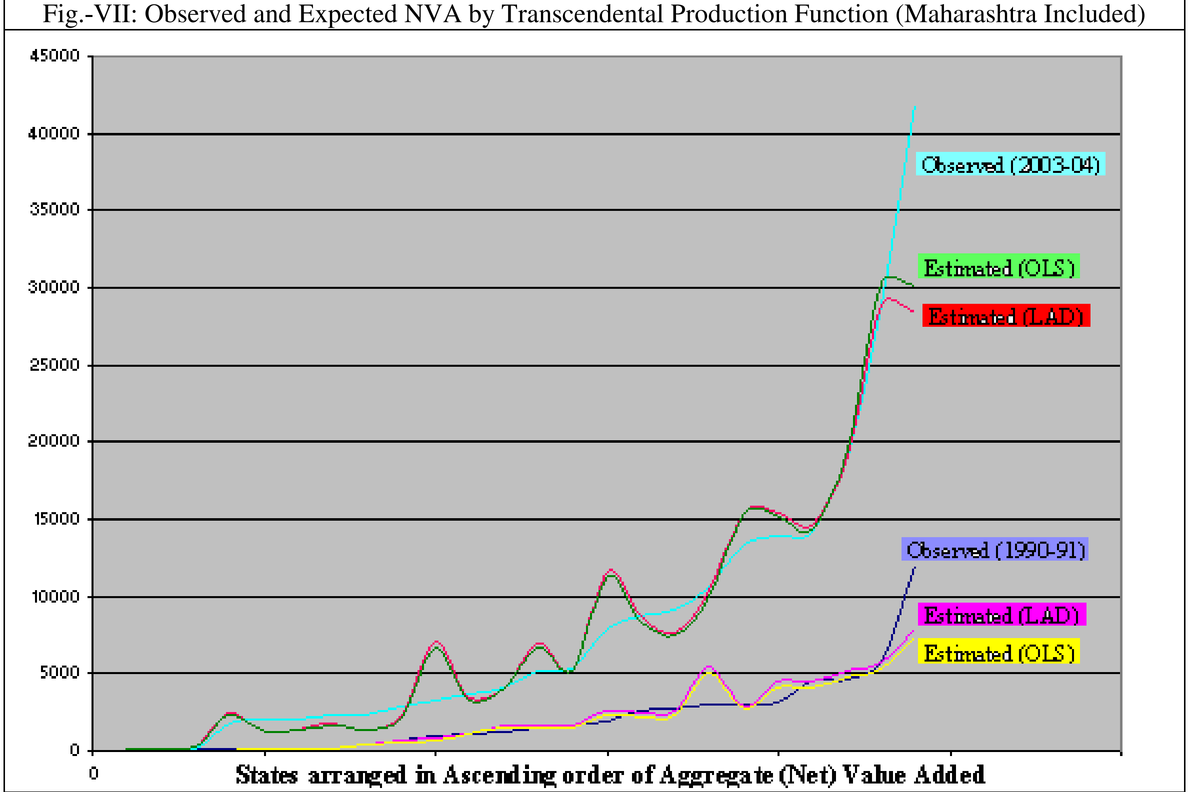


Table-XIII: Estimated Parameters of Transcendental Production Function							
	Estimator	k_0	k_1	k_2	k_3	k_4	Loss
1990-91 R^2=0.95	Lad	1.48210727	0.819161997	0.17005704	-0.0000396015	-0.000000000000	5.79
	OLS	1.41286166	0.812234958	0.17084822	-.00000000000	-0.000000000000	4.02
	SEE	1.7003	0.2879	0.2431	0.000001	0.000062	
2003-04 R^2=0.96	Lad	0.00000000	0.180462435	0.83229991	-0.0002050381	-0.000002614988	5.33
	OLS	0.33709163	0.209116573	0.77306248	-0.0001860569	-0.000000516616	2.16
	SEE	1.2510	0.1762	0.1249	0.000001	0.000007	
LAD=Least Absolute Deviation Estimator; OLS; Ordinary Least Squares Estimator; SEE=Standard Error							

XI. Analysis by Diewert Production Function: The Diewert production function (Diewert, 1971) is a generalization of the Leontief production function, specified as

$$NVA = \left[c_1 L + c_2 K + c_3 L^{0.5} K^{0.5}\right]^{\rho} + \xi \; ; \; 0 \le c_i \le 1; \; \sum_{i=1}^{3} c_i = 1 .$$

We have fitted Diewert function to the data for 1990-91 and 2003-04. In our analysis it was found that Andhra Pradesh and Maharashtra might be the outliers. To counter the possible adverse effects of outliers on estimation, we have adopted two strategies. First, the parameters have been estimated by OLS as well as LAD procedures. Secondly, we have dropped AP and Maharashtra, and from the remaining data for 22 states, the OLS estimates of parameters have been obtained. The estimated parameters are presented in Table-XIV. The estimated values of NVA have been presented in Table-XV, which have also been graphically presented in Fig.-VIII and Fig.-IX. The estimated parameters of Diewert function clearly indicate that in the post-globalization period there has been a large substitution of capital for labour. The returns to scale also have declined.

Fig.-VIII: Observed and Expected NVA by Diewert Production Function 1990-91

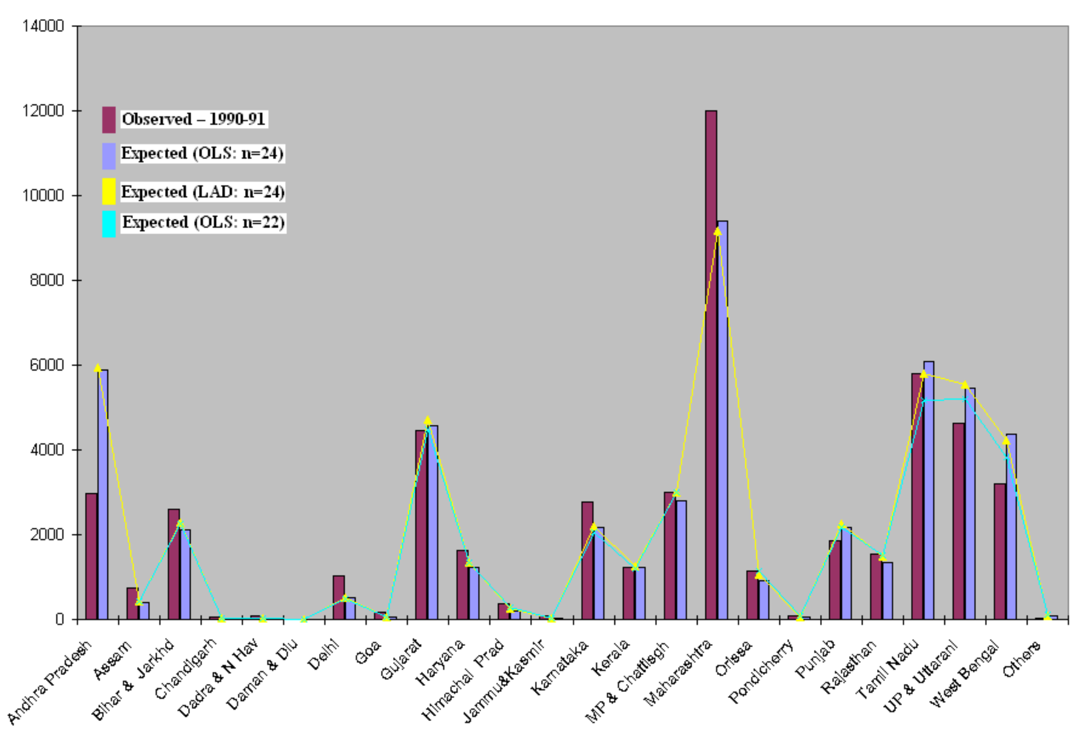


Table-XIV: Estimated Parameters of Diewert Production Function						
Year	Parameters Method	c_1	c_2	c_3	ρ	R^2
1990-91	OLS_{24}	0.978763201	0.0212367988	0.00000000	1.23151197	0.9604
	LAD_{24}	0.614701746	0.00000000	0.385298254	1.15031484	0.9654
	OLS_{22}	0.297095575	0.000000000	0.702904425	1.08662881	0.9652
2003-04	OLS_{24}	0.168076674	0.107661192	0.724262134	1.08124727	0.9683
	LAD_{24}	0.00000000	1.000000000	0.000000000	0.917359764	0.9629
	OLS_{22}	0.00000000	1.000000000	0.000000000	0.909263923	0.9637

Table-XV: Net Value Added :,Observed and Expected for Diewert Production Function								
State/UT	Observed	Estimated			Observed	Estimated		
		OLS_{24}	LAD_{24}	OLS_{22}		OLS_{24}	LAD_{24}	OLS_{22}
Andhra Pradesh	2981	5875.893	5937.531	XX	13375	16081.808	14438.413	XX
Assam	734	395.704	433.764	435.111	3741	2469.093	3233.323	3010.759
Bihar & Jarkhd	2598	2107.984	2281.966	2254.990	8773	6882.646	8542.878	7886.916
Chandigarh	70	23.278	25.169	26.038	164	103.966	194.105	185.287
Dadra & N Hav	73	12.992	19.762	25.546	2801	1529.588	2366.047	2209.261
Daman & Diu	14	4.123	6.190	7.928	2335	912.272	1272.053	1194.284
Delhi	1016	518.687	510.986	480.152	2024	1014.623	1118.453	1051.268
Goa	158	45.150	60.758	70.995	2288	1133.686	1894.533	1772.465
Gujarat	4468	4581.785	4715.255	4479.152	28865	32970.153	33553.023	30604.929
Haryana	1636	1241.323	1349.368	1333.396	9143	6315.889	6831.583	6319.477
Himachal Prad	378	207.751	263.615	295.835	1750	1664.419	2795.541	2606.455
Jammu&Kasmir	76	27.366	31.159	33.148	188	175.693	233.712	222.729
Karnataka	2769	2175.042	2205.261	2069.237	13844	14305.868	14907.293	13695.185
Kerala	1222	1229.165	1257.742	1194.052	4091	3453.049	3336.830	3106.277
MP & Chattisgh	3007	2787.958	3007.000	2995.768	10633	8646.830	9764.235	9003.867
Maharashtra	12004	9399.738	9159.804	XX	41910	35507.040	32720.771	XX
Orissa	1153	900.868	1049.009	1129.394	3215	5302.870	7236.754	6690.872
Pondicherry	97	54.059	67.499	75.002	1989	779.336	1213.632	1139.907
Punjab	1857	2174.338	2270.970	2175.037	5314	4376.813	4351.482	4041.342
Rajasthan	1556	1332.183	1496.726	1527.504	5173	5526.935	6365.498	5892.003
Tamil Nadu	5793	6093.078	5793.000	5165.900	19101	22310.935	19101.000	17509.556
UP & Uttaranl	4625	5468.641	5543.673	5198.707	14163	13856.856	13620.269	12522.783
West Bengal	3198	4379.956	4234.318	3828.253	7903	10490.287	10464.555	9643.754
Others	34	76.133	99.520	113.647	149	127.619	174.033	166.287

XII. Considering Variable Elasticity of Substitution and Returns to Scale: So far we did not consider the possibilities of variable elasticity of substitution. Now we turn to the same. We use the Constant Marginal Share (CMS) production function of Bruno (1968) specified as $NVA = AK^{\alpha}L^{1-\alpha} - mL$ or $NVA/L = A(K/L)^{\alpha} - m$, which implies that productivity of labour increases with capital-labour ratio at a decreasing rate (see section VII – for what our data indicate). The CMS production function contains the linear production function as a special case. It defines the elasticity of substitution, $\sigma = 1 - [m\alpha/(1-\alpha)](L/NVA)$. When the output-labour ratio increases (e.g. with economic growth), the elasticity of substitution in this function tends to unity and thus the CMS tends to the Cobb-Douglas production function.

Next we apply Zellner-Revankar generalization on Bruno's production function to permit variability to returns to scale and elasticity of substitution. The estimated parameters of these production functions are presented in Table-XVI. Estimated NVA and elasticity of substitution and returns-to-scale functions are presented in Table-XVII. The observed and estimated NVA are presented in Fig.-X for visualization of the fit of these models.

Fig.-IX: Observed and Expected NVA by Diewert Production Function 2003-04

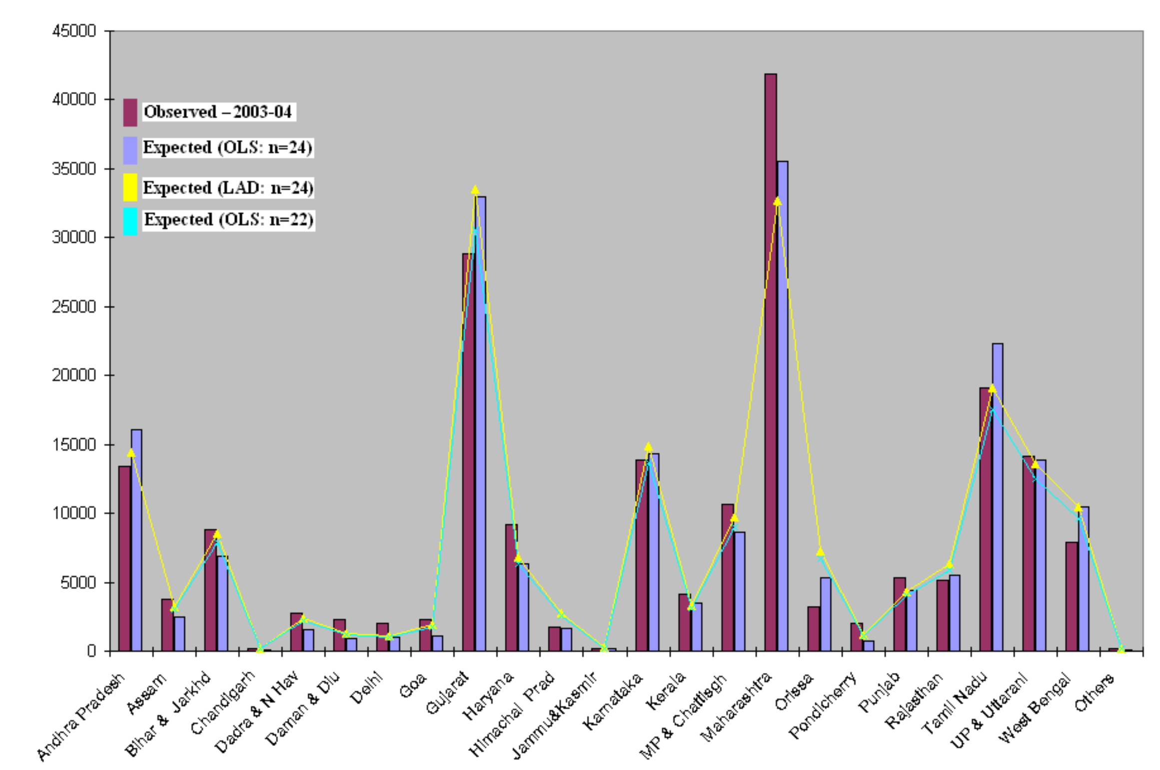


Table-XVI: Estimated Parameters of Bruno and Bruno-Zellner-Revankar Production Functions								
Year	A	α	m	ρ	θ	$\ln(l^*)$	R^2	Model
1990-91	0.028568	0.2338961	0.0042499	-	-	-	0.86009	Bruno *
2003-04	0.229756	0.7410565	0.0024374	-	-	-	0.95089	
1990-91	0.390938	0.2471963	-0.0002339	0.7102755	-7.8827266E-05	-179.25	0.98247	Bruno & ZR **
2003-04	0.852339	0.3397814	0.0135536	0.8096587	-2.0072827E-05	-203.78	0.99116	
* Estimated by Least Squares; ** Estimated by Max Likelihood maximizing iterated Least Squares (Zellner & Revankar, 1969)								

In the estimates of Bruno's function (Table-XVI) the values of m is positive for 1990-91 as well as 2003-04. Secondly, the capital elasticity of production (α) in 1990-91 was 0.23, which increased to 0.74 in 2003-04. In Bruno-Zellner-Revankar estimates, the value of m increased so as to alter its sign. The capital elasticities of production in Bruno and Bruno-ZR are comparable for 1990-91. But they are quite different for 2003-04, although in both estimates they are larger than those in 1990-91. The returns-to-scale parameter (ρ) has appreciated in 2003-04.

A perusal of Table-XVII and Fig.-XI conjointly indicates that for most of the industrially developed states, the elasticity of substitution function has shown a decline, which is quite large in Delhi, Kerala, Tamilnadu, Punjab and West Bengal. Gujarat is a notable exception to this general tendency. Returns-to-scale function has appreciated in most of the states; it has shown a large increase in Gujarat, Haryana, Andhra Pradesh and Karnataka in particular. A large decline in Maharashtra, however, is conspicuous.

Table-XVII: Net Value Added (Observed and Expected) for Bruno and Bruno-Zellner-Revankar Production Functions and their Elasticity of Substitution and Returns-to-Scale Functions

States/Uninon Territories	Obse-rved	Bruno (1990-91)		Bruno-Zellner-Revankar (1990-91)			Obse-rved	Bruno (2003-04)		Bruno-Zellner-Revankar (2003-04)		
		Est(B)	$\sigma(B)$	Est (BZR)	$\sigma(BZR)$	$\rho(BZR)$		Est(B)	$\sigma(B)$	Est (BZR)	$\sigma(BZR)$	$\rho(BZR)$
Andhra P	2981	5866.717	0.638	4197.683	1.021	0.928	13375	16033.290	0.549	14058.540	0.549	1.107
Assam	734	583.650	0.807	718.471	1.011	0.754	3741	2927.385	0.787	3569.248	0.787	0.875
Bihar & JH	2598	2555.174	0.820	2225.033	1.011	0.893	8773	7655.300	0.839	7256.834	0.839	0.983
Chandigarh	70	42.129	0.774	120.208	1.013	0.714	164	149.108	0.620	415.915	0.620	0.812
HNH	73	41.169	0.899	93.492	1.006	0.714	2801	1904.690	0.871	2326.824	0.871	0.858
DD	14	14.608	0.755	47.782	1.015	0.711	2335	1131.004	0.821	1876.414	0.821	0.849
Delhi	1016	637.613	0.815	836.183	1.011	0.772	2024	1082.765	0.602	2073.986	0.602	0.844
Goa	158	108.401	0.858	195.499	1.008	0.719	2288	1442.808	0.895	1795.883	0.895	0.849
Gujarat	4468	4802.320	0.804	4070.897	1.012	1.096	28865	32529.370	0.824	29507.360	0.824	1.925
Haryana	1636	1607.928	0.799	1521.955	1.012	0.815	9143	6876.031	0.757	7458.249	0.757	0.992
Himachal	378	391.457	0.816	479.437	1.011	0.732	1750	2036.235	0.854	2113.194	0.854	0.839
J&K	76	53.888	0.768	136.235	1.014	0.715	188	198.546	0.000	658.915	0.000	0.813
Karnataka	2769	2436.453	0.804	2310.184	1.012	0.909	13844	14980.070	0.744	13444.860	0.744	1.121
Kerala	1222	1476.780	0.711	1454.005	1.017	0.786	4091	3511.752	0.460	4529.155	0.460	0.882
MP & C	3007	3243.764	0.820	2664.179	1.011	0.931	10633	9409.450	0.794	9123.866	0.794	1.029
Maharashtra	12004	8546.112	0.866	11315.530	1.008	13.213	41910	34800.580	0.815	41240.560	0.815	5.100
Orissa	1153	1290.739	0.828	1160.292	1.010	0.781	3215	5988.397	0.729	5121.107	0.729	0.866
Pondicherry	97	115.757	0.710	213.663	1.017	0.716	1989	1007.243	0.862	1579.656	0.862	0.843
Punjab	1857	2525.893	0.720	2153.380	1.017	0.832	5314	4572.129	0.558	5459.514	0.558	0.906
Rajasthan	1556	1771.331	0.799	1557.978	1.012	0.810	5173	6157.933	0.669	6254.198	0.669	0.903
Tamil Nadu	5793	5649.545	0.784	5390.037	1.013	1.307	19101	21723.040	0.575	18880.220	0.575	1.313
UP & Utt	4625	5525.941	0.779	4583.738	1.013	1.118	14163	14330.530	0.699	13364.110	0.699	1.131
West Bengal	3198	4293.413	0.699	3611.386	1.018	0.950	7903	10977.590	0.545	9944.008	0.545	0.962
Others	34	166.742	0.000	262.427	1.059	0.712	149	144.020	0.015	535.733	0.015	0.812

B=Bruno; ZR=Zellner-Revankar; BZR=Zellner-Revanker generlization of Bruno's CMS; Est=Estimated

Fig.-X: Observed & Expected NVA by Bruno and Bruno-Zellner-Revamkar Functions - 1990-91 & 2003-04

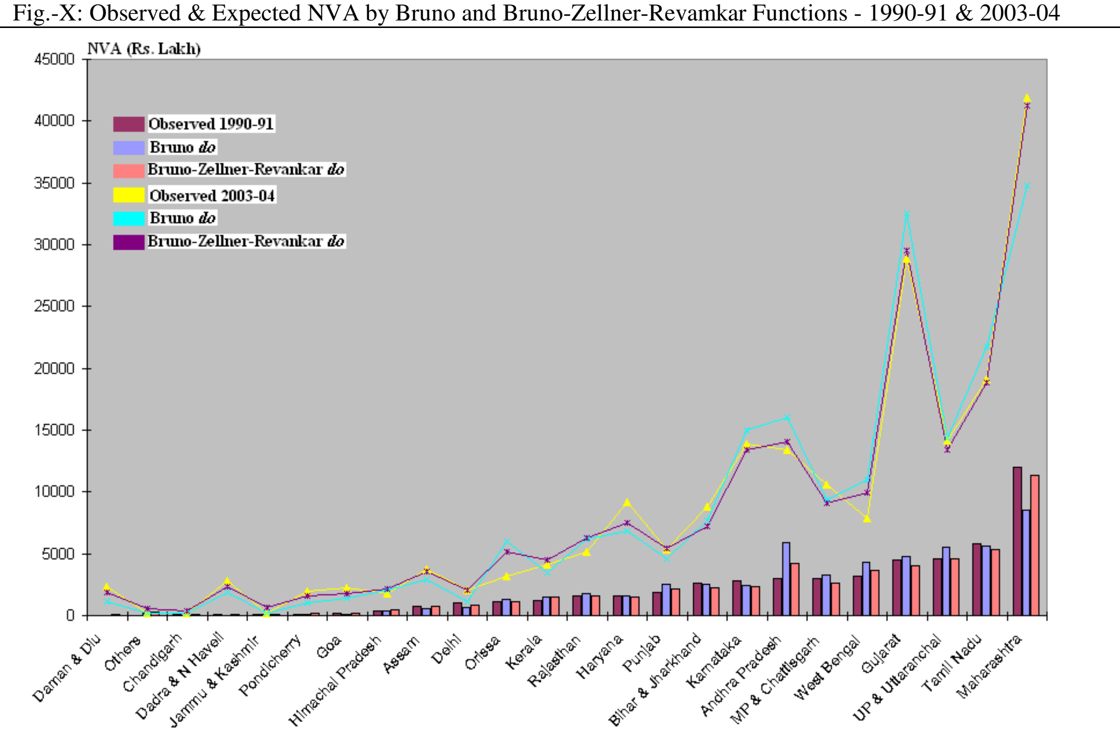
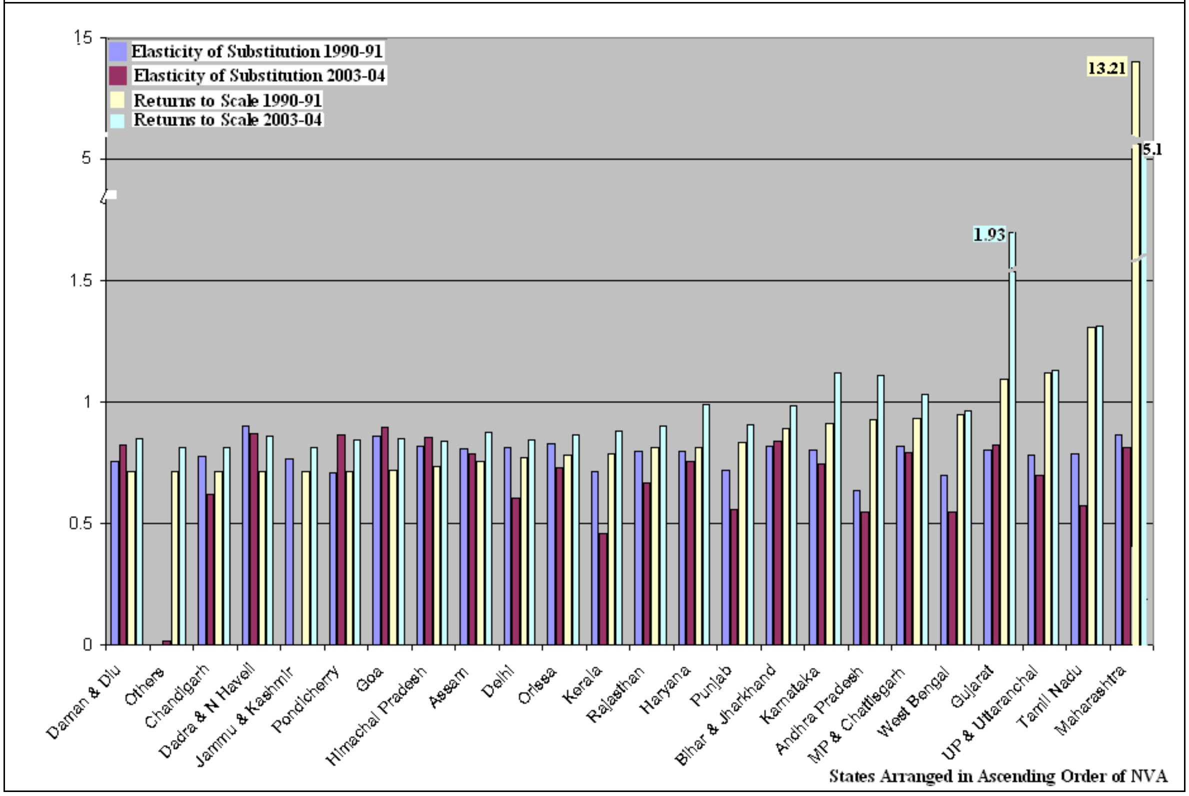


Fig.-XI: Elasticity of Substitution and Returns-to-Scale functions Estimated by Bruno and Bruno-Zellner-Revamkar Production Functions - 1990-91 & 2003-04



XIII. Concluding Remarks: *If* (i) the data used in our analysis really represent the industrial scenario emerging in the post-globalization period, (ii) the gross aggregation of indicators of industrialization over varied types and sizes of factories in different states have not reduced them to mere numbers devoid of sense or substance, and (iii) production functions fitted to state-level aggregate data can be used (see Shaikh, 1974, 1980; Felipe and Fisher, 2001) to analyze the structure of manufacturing sector at the national level, *then* our analysis has clearly indicated that the rise in industrial output is accountable to substitution of capital for labour in almost all states. Elasticity of substitution has declined in most of the industrialized states. In the pre-globalization period the industries experienced increasing returns to scale. Although Bruno-ZR production function indicates persistence of increasing returns, but in view of the relationship found in our data (positive m) it might not give a true picture. It is more likely that globalization has given way to diminishing returns to scale. Along with a rise in industrial output, globalization has possibly led to a decline in regional disparities in terms of population-deflated indices of employment of manpower and capital, and the resultant output. We have not investigated the effects of biased technological changes (Sato, 1970) that occurred in the post-globalization period. A study of that aspect may further explain the observed structural changes in the industrial sector of India.

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