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Economics

AN ESTIMATION OF PRODUCTION FUNCTION IN THE AGGREGATE MANUFACTURING SECTOR OF SOUTHERN STATES OF INDIA IN THE POST-REFORM PERIOD

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ABSTRACT

The production function is purely a technical relation, which connects factor inputs and outputs. It describes the laws of proportion, i.e., the transformation of factor inputs into outputs at any particular time period. The production function represents the technology of a firm or an industry, or the economy as a whole, and it includes all the technically efficient methods of production. In this paper, an effort is made to estimate production function in the aggregate manufacturing sector of southern states for the reference period between 1991-92 and 2010-11. The results assessed the importance of skilled labour component in the states such as Karnataka, Andhra Pradesh and Kerala. With regard to the type of technology adopted by the states, it could be observed that the manufacturing sector of Andhra Pradesh, Karnataka and Kerala were adopting labour intensive technology since the co-efficients of wage (β2) was greater than capital co-efficient (β1). The manufacturing sector of Tamil Nadu was known for capital intensive technology based on the co-efficients (β1>β2).

Keywords: Capital –labour ratio (K/L), co-efficient of labour (β), Marginal productivity of capital (MPK), Marginal productivity of labour (MPL),Marginal Rate of Substitution of labour for capital (MRTSLK).

INTRODUCTION

The performance of the supply side of an economy is often identified with the growth rate of potential output. Potential output is not observed in reality, however, and has to be approximated. The use of the production function method for the measurement of potential output growth takes into account different sources of an economy's productive capacity, namely the contributions of labour, capital and total factor productivity, the latter containing information about technological and allocative efficiency and hence about the supply-side functioning. Using the production function, one can discuss changes in the supply-side performance on the basis of the observed simultaneous developments in the quantity of labor, capital and total factor productivity. For instance, an increase in the rate of capital growth accompanied by a rise in trend total factor productivity may signal some improvement in the supply-side performance. Observing an increase in the rate of the capital growth while trend total factor productivity stagnates, one can, in contrast, deduce that the supply side is functioning ineffectively. The production function thus represents a useful and powerful tool for the macro economic analysis and evaluation of the governmental structural policies. (*Hajkova, Dana* and *Hurník, Jaromír*; 2007).

The production function is purely a technical relation, which connects factor inputs and outputs. It describes the laws of proportion, i.e., the transformation of factor inputs into outputs at any particular time period. The production

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function represents the technology of a firm or an industry, or the economy as a whole, and it includes all the technically efficient methods of production. Production functions involve and can provide measurements for the following concepts, and one among them is the efficiency of production, which this paper plans to estimate:

1. The marginal productivity of the factors of production

2. Factor intensity

3. The returns to scale

The organizational efficiency is measured by the co-efficient β0. Intuitively it is clear that if two firms have the same K(fixed capital), L(wages and salaries of employees), β1, β2(co-efficient of Labour) and still produce different quantities of output, the difference is due to the superior organization and entrepreneurship of one of the firms, which result in different efficiencies. The more efficient firm will have a larger β0 than the less efficient one.

Cobb-Douglas Production Function is one of the most widely used production function in economics and management research. This production function not only satisfies the basic economic law but also easy in its computation and interpretation of the estimated parameters. The objectives of applying Cobb- Douglas production function is to estimate the co-efficient of inputs, their marginal productivities, factor shares in total output and degree of returns to scale. It is based on unitary elasticity of substitution of inputs and this production function has been widely applied in empirical studies.

METHODOLOGY

The basic data source of the study was Annual Survey of Industries (ASI) published by the Central Statistical Organization (CSO), Government of India covering the period from1998-99 to 2010-11.All the referred variables were normalized by applying Gross Domestic Product (GDP) deflator. The GDP at current and constant prices were obtained by referring to Economic Survey, published by the Government of India, Ministry of Finance and Economic Division, Delhi .The reference period chosen for the study covers post-liberalization period between 1991-92 and 2010-11.

The following model was applied to the data on output and input for estimating the C-D function

$Y=AK^{\alpha}L^{\beta}R^{\gamma}$

Where Y = output(Net value added)

K = Fixed capital

L = wages & salaries of Employees

A = Efficiency parameter

α = Co- efficient of capital

β = Co- efficient of Labour

The logarithm of both sides of the above model was taken to convert the equation into linear form; its log transformation is specified below:

$$\log Y = \log A + \alpha \log K + \beta \log L + u.$$

The efficiency parameter (A) and the co-efficients of the inputs were estimated by applying the above equation. Parameters 'α', and 'β' represent individually the proportionate change in output for a proportionate change in Capital and Labour. The two co-efficients taken together to measure the aggregate proportionate change in output for a given proportionate change in labour, capital and raw material. This implies that α + β shows the degree of returns to scale.

If α + β >1, it would imply that the output increase would be more than proportionate to the increase in inputs, if α + β < 1, it would imply that the output increase would be less than proportionate to the increase in inputs and if α + β = 1 the output would just increase proportionately to the rate of increase of inputs. This implies that the CD production function

can represent any degree of returns to scale.

i) Marginal productivity of labour (MPL)

Marginal productivity of labour may be defined as the ratio between a change in output in a given economy or industry for a given time period and change in employment of that economy or industry for similar period. The MPL is derived from the OLS method following Cobb-Douglas production function:

$$MPL = \beta (O/L)$$

$$= \beta (APL)$$

ii) Marginal productivity of capital (MPK)

MPK is the additional output resulting from the use of an additional unit of capital (ceteris paribus, or assuming all other factors are fixed). It is the partial derivative of the production function with respect to capital.

$$MPK = \alpha (O/K)$$

$$= \alpha (APk)$$

iii) Marginal Rate of Technical Substitution of labour for capital (MRTSLK)

In economic theory, the Marginal Rate of Technical Substitution (MRTSLK) or Technical Rate of Substitution (TRS) is the amount by which the quantity of one input has to be reduced when one extra unit of another input is used so that output remains constant MRTSLK $= MP_L \div MP_K$ where MP_L and MP_K are the marginal products of labour and capital, respectively. In other words it shows the rate at which one input (e.g. capital or labor) may be substituted for another, while maintaining the same level of output. The MRTSLK can also be seen as the slope of an isoquant at the point in question.

iv) Capital –labour ratio (K/L)

It is known as capital intensity. A business is considered capital intensive based on the ratio of the capital required to the amount of labor that is required.

Results and discussion:

i) Marginal productivity of labour (MPL)

Details regarding marginal productivity of labour is presented in **Table -1**

Table 1: Marginal productivity of labour (MPL)

Year	Andhra Pradesh	Karnataka	Kerala	TamilNadu	X	σ	C.V
1991-92	0.0020	1.5400	0.0480	0.7700	0.5966	0.7244	122.79
1992-93	0.0020	1.5464	0.0452	0.7652	0.5897	0.7276	123.37
1993-94	0.0021	1.5075	0.0455	0.7923	0.5869	0.7129	121.48
1994-95	0.0021	1.5869	0.0458	0.7952	0.6075	0.7475	123.05
1995-96	0.0025	1.9712	0.0587	0.9825	0.7537	0.9277	123.08
1996-97	0.0025	1.9321	0.0573	0.9721	0.7410	0.9101	122.82
1997-98	0.0026	1.8823	0.0565	0.9434	0.7212	0.8861	122.87
1998-99	0.0025	1.9293	0.0609	0.9488	0.7354	0.9061	123.21
1999-00	0.0025	1.9211	0.0550	0.9671	0.7364	0.9055	122.95
2000-01	0.0025	1.9290	0.0570	0.9717	0.7401	0.9088	122.8
2001-02	0.0026	1.9657	0.0566	0.9502	0.7438	0.9233	124.13
2002-03	0.0025	2.0092	0.0582	0.9438	0.7534	0.9417	124.98
2003-04	0.0027	2.0349	0.0576	0.9692	0.7661	0.9550	124.65

2004-05	0.0030	2.3034	0.0649	1.0696	0.8602	1.0792	125.46
2005-06	0.0030	2.2418	0.0652	1.0965	0.8517	1.0538	123.73
2006-07	0.0032	2.3253	0.0618	1.1081	0.8746	1.0923	124.89
2007-08	0.0032	2.3314	0.0665	1.1124	0.8784	1.0941	124.56
2008-09	0.0032	2.3592	0.067	1.0783	0.8769	1.1041	125.91
2009-10	0.0031	2.1669	0.0646	1.0885	0.8308	1.0204	122.82
2010-11	0.0033	2.2943	0.0673	1.1431	0.8770	1.0799	123.13
x	0.0027	1.9889	0.0580	0.9734	0.7557		
σ	0.0004	0.2787	0.0072	0.1186			
c.v	15.4040	14.0130	12.4520	12.184			

Source: Calculations are based on ASI data.

MPL ratio across states showed that during the post -reform period as a whole it was 0.7557. From 0.59 in 1991-92, it had increased to 0.7557 at the end of the period. Across the four southern states it was maximum for the state of Karnataka (1.9889) followed by Tamil Nadu (0.9734), Kerala (0.0580) and Andhra Pradesh (0.0027).

ii) Marginal productivity of capital (MPK)

Details regarding marginal productivity of labour are presented below in **Table -2.**

Table 2: Marginal productivity of capital (MPK)

Year	**Andhra Pradesh**	**Karnataka**	**Kerala**	**TamilNadu**	**X**	**σ**	**C.V**
1991-92	0.6220	0.0980	0.3240	0.1940	0.3095	0.2280	73.6641
1992-93	0.6419	0.0948	0.3217	0.1932	0.3129	0.2382	76.1221
1993-94	0.6451	0.0925	0.3162	0.1960	0.3124	0.2399	76.7689
1994-95	0.6889	0.0938	0.3240	0.1888	0.3239	0.2610	80.5935
1995-96	0.7261	0.0920	0.3162	0.1934	0.3319	0.2783	83.8488
1996-97	0.6961	0.0908	0.3307	0.1894	0.3267	0.2652	81.1685
1997-98	0.7134	0.0827	0.3027	0.1853	0.3211	0.2766	86.1475
1998-99	0.6909	0.0761	0.3416	0.1853	0.3234	0.2681	82.8859
1999-00	0.7022	0.0801	0.3086	0.1861	0.3192	0.2718	85.1462
2000-01	0.7026	0.0806	0.3227	0.1908	0.3242	0.2710	83.5997
2001-02	0.7053	0.0802	0.3150	0.1873	0.3219	0.2730	84.7964
2002-03	0.7097	0.0830	0.3243	0.1808	0.3244	0.2753	84.8552
2003-04	0.7223	0.0852	0.3314	0.1879	0.3317	0.2793	84.2066
2004-05	0.7420	0.0919	0.3264	0.1890	0.3373	0.2864	84.9140
2005-06	0.7413	0.0895	0.3302	0.1929	0.3385	0.2861	84.5198
2006-07	0.7635	0.0953	0.3068	0.1964	0.3405	0.2950	86.6249
2007-08	0.7528	0.0935	0.338	0.1957	0.3450	0.2898	83.9846
2008-09	0.7493	0.0900	0.3380	0.1873	0.3412	0.2906	85.1695
2009-10	0.7485	0.0851	0.3294	0.1912	0.3386	0.2910	85.9608

2010-11	0.7647	0.0843	0.3292	0.1949	0.3433	0.2983	86.8838
x	0.7110	0.088	0.3240	0.1900	6.5676		
σ	0.0400	0.006	0.0110	0.0040			
c.v	5.6640	7.0600	3.2470	2.2450			

Source: Calculations are based on ASI data.

MP_K ratios of southern states during post- reform period showed that it was positive for all the states, which implied that capital has contributed positively to output by all the southern states. The mean MP_K was 0.328 from the beginning to the end of the period. It is also evident from the analysis that there were not many variations across the states. It varied between 0.08879 and 0.7114. The maximum marginal productivity performance was recorded by Andhra Pradesh and the minimum productivity performance was recorded by Karnataka.

iii) Marginal Rate of Substitution of labour for capital (MRTSLK)

Marginal rate of Technical substitution of labour for capital (MRTSLK) is shown in **Table- 3.**

Table 3:Growth of MRTSLK

Year	**Andhra Pradesh**	**Karnataka**	**Kerala**	**TamilNadu**	**X**	**σ**	**C.v**
1991-92	0.0032	15.7140	0.1481	3.9691	4.9587	7.40181	149.2697
1992-93	0.0032	16.3110	0.1404	3.9609	5.104	7.69347	150.7344
1993-94	0.0032	16.3000	0.1439	4.042	5.1224	7.68338	149.9969
1994-95	0.0031	16.9090	0.1415	4.2125	5.3164	7.97102	149.9317
1995-96	0.0035	21.4370	0.1856	5.0789	6.6762	10.1173	151.5429
1996-97	0.0036	21.2810	0.1733	5.1333	6.6477	10.0412	151.0476
1997-98	0.0036	22.7530	0.1867	5.0902	7.0082	10.7573	153.4952
1998-99	0.0037	25.3630	0.1783	5.1217	7.6666	12.0336	156.9618
1999-00	0.0036	23.9790	0.1784	5.1963	7.3394	11.3516	154.6664
2000-01	0.0036	23.9360	0.1767	5.0933	7.3023	11.3372	155.2545
2001-02	0.0036	24.5170	0.1797	5.0725	7.4431	11.6222	156.1471
2002-03	0.0036	24.2170	0.1796	5.2209	7.4052	11.4658	154.8344
2003-04	0.0037	23.8960	0.1738	5.1592	7.3082	11.3142	154.8148
2004-05	0.0041	25.0730	0.1987	5.6581	7.7334	11.8529	153.2691
2005-06	0.0041	25.0560	0.1976	5.6842	7.7353	11.8433	153.1058
2006-07	0.0041	24.3980	0.2016	5.6430	7.5618	11.5245	152.4045
2007-08	0.0042	24.9320	0.1967	5.6841	7.7043	11.7833	152.9439
2008-09	0.0042	26.2070	0.1982	5.7556	8.0413	12.4007	154.2125
2009-10	0.0041	25.4550	0.1962	5.6936	7.8372	12.0377	153.5969
2010-11	0.0043	27.2140	0.2045	5.8646	8.3218	12.8844	154.8264
X	0.0037	22.7470	0.1790	5.1167	7.0117		
σ	0.0004	3.5856	0.0207	0.6140			
C.v	10.2730	15.763	11.5530	12.0010			

Source: Calculations are based on ASI data.

It is evident that MRTSLK values during post -reform period were positive and the mean MRTSLK was 7.0117 which implied that MP_L was greater than MP_K. The inter - state ratio was maximum for Karnataka and minimum for Kerala. MRTSLK varied widely across the states indicating differences in the marginal productivity ratios. The growth of capital- labour ratio during the reference period is discussed in the **Table -4.**

Table 4: growth of capital –labour ratio (K/L)

Year	Andhra Pradesh	Karnataka	Kerala	TamilNadu	X	σ	C.v
1991-92	2.3880	1.5399	1.3541	1.6264	1.7271	0.4550	26.3455
1992-93	2.5440	2.1107	1.2936	1.8429	1.9478	0.5231	26.8560
1993-94	3.0811	2.2128	1.5428	2.2381	2.2687	0.6301	27.7720
1994-95	2.8061	2.8700	1.4601	3.0154	2.5379	0.7238	28.5211
1995-96	2.4076	3.3858	2.3845	3.0634	2.8103	0.4962	17.6570
1996-97	2.9961	3.9908	1.8787	3.4526	3.0796	0.8979	29.1553
1997-98	3.0814	5.2652	2.8045	3.4293	3.6451	1.1099	30.4492
1998-99	3.6341	8.7977	2.6028	3.8611	4.7240	2.7705	58.6479
1999-00	3.5197	7.3384	2.4487	4.2219	4.3822	2.1014	47.9521
2000-01	3.4479	7.3303	2.5959	4.0448	4.3548	2.0709	47.5556
2001-02	4.0043	8.6271	2.8330	4.0030	4.8669	2.5669	52.7417
2002-03	3.7073	8.9333	2.9887	4.7253	5.0887	2.6603	52.2783
2003-04	4.7344	9.1260	2.5435	4.8989	5.3257	2.7517	51.6672
2004-05	4.4983	8.8967	2.6955	4.8736	5.2410	2.6160	49.9142
2005-06	4.7973	8.7636	2.6581	5.4147	5.4084	2.5295	46.7691
2006-07	6.0779	9.0238	2.8739	5.5725	5.8870	2.5202	42.8091
2007-08	7.4501	10.560	2.9624	6.1814	6.7887	3.1450	46.3280
2008-09	8.1773	14.495	3.5926	6.7155	8.2453	4.5847	55.6043
2009-10	11.518	10.869	3.4316	7.0303	8.2123	3.7522	45.6906
2010-11	15.402	17.845	4.6584	9.2475	11.788	5.9731	50.6701
X	4.2436	6.7069	2.3473	4.0105	4.3271		
σ	2.3523	3.5570	0.6706	1.5436			
C.v	55.433	53.0358	28.5689	38.488			

Source: Calculations are based on ASI data.

Capital- labour ratios of four southern states during post- reform period showed that the mean ratio across the state was maximum for Andhra Pradesh(4.2436), followed by Tamil Nadu(4.0105), Karnataka (6.7069) and Kerala (2.3473). The K/L ratios of southern different states have increased over the years which shows that higher quantum of fixed assets had been accumulated for a given unit of labour.

v) Factor intensity and returns to scale

Co-efficients of Cobb-Douglas production function which explains factor intensity and returns to scale is presented in the following **Table-5.**

Table- 5: Estimation of Factor Intensity and Returns to Scale

States	Efficiency parameter (A)	Capital (β1)	Wages (β2)	Economics of scale (s)	R^2	D.W statistics	β1/s	β2/s
Andhra Pradesh	-0.913** (-6.199)	0.206 (1.358)	1.251** (7.114)	1.457	0.975	0.993	14	86
Karnataka	-1.040* (-2.445)	0.039 (0.236)	1.299 (5.137)	1.338	0.958	0.702	3	97
Kerala	-0.164 (-0.332)	0.378 (1.043)	0.708* (2.085)	1.086	0.924	2.354	35	65
Tamil Nadu	-0.364 (-1.477)	0.701* (2.580)	0.355** (2.133)	1.056	0.978	1.143	66	34

Source: Calculations are based on ASI dat.
Foot note: * significant at 1 percent level,** Significant at 5 percent level. Figures in parentheses indicate `t' values.

Efficiency parameter A or the organizational efficiency was negative in all the states. This implied that in the southern states the contribution of entrepreneurship to output was negative.

Capital co-efficient β1 is positive in all the states which implied that there existed positive relationship between output and capital. But it is statistically significant in the state of Tamil Nadu. Wage co-efficient β2, was also positive and statistically significant for all the states. This implied that there existed positive relationship between inputs - output and wages. It was statistically significant for all the states.

The sum of co-efficient (s) β1and β2 shows increasing returns to scale in all the states. It was also surprising to note that the R^2 was high in all the states. The percentage share of factor inputs presented indicated that the percentage share of wage was higher in three out of the four states than capital. It was maximum for Karnataka (97 percent) followed by Andhra Pradesh (86 percent), Kerala (65 percent) and Tamil Nadu(34 percent).

CONCLUSION

The result assess the importance of skilled labour component in the states such as Karnataka, Andhra Pradesh and Kerala. With regard to the type of technology adopted by the states, it could be observed that the manufacturing sector of Andhra Pradesh, Karnataka and Kerala were adopting labour intensive technology since the co-efficients of wage (β2) was greater than capital co-efficient (β1). The manufacturing sector in Tamil Nadu was known for capital intensive technology based on the co-efficients (β1>β2).

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