Productivity, Efficiency and Technological Change in Indian Ports[§]

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Abstract

This paper attempts to find out the relationship between productivity, efficiency and technological change in Indian ports. The use of comparative static framework has proved that Indian ports have witnessed a significant technological metamorphosis in terms of capital use. Increasing use of overhead capital has produced significant improvement in productivities. These findings have important implications for technology policy in the port sector in LDCs and particularly in India. When technology has become truly global and old geographical barriers have been narrowing, future growth of a port is highly contingent upon how fast it accommodates the new technology and improved services.

1. Introduction

There is no denying the fact that the question of efficiency is inextricably related to the appropriateness of the chosen technology, and more often than not the fault may lie in the institutional preparedness for scientific management which is necessary for the smooth functioning of the new technology (Rietveld and Nijkamp, 1993). However, technological change in the port sector may be broadly defined to include (i) advances in technological knowledge embodied in new capital goods mostly imported from developed nations, which are affected by collaboration agreements undertaken between domestic and foreign firms, (ii) adaptive changes to be introduced by firms in the importing LDCs which are required to make the technology suitable for local conditions (including process and product differentiations), and (iii) tools and information about the techniques of scientific management.

We would like to deal with the first aspect of technological change in terms of its power and ability to improve the productivity of labour. It is well known that if one of the two factors, capital and labour, increases at a very fast rate relative to the other, then the productivity of the other factor must increase at a faster rate. This paper is concerned with the performance of Indian ports in terms of labour productivity (LP) in relation to capital coefficients. Or, in other words, we try to study the effect of technological advancement as reflected in rising capital intensities on the productivity of labour in Indian ports.

There are no studies which have touched upon the impact of technology on development of Indian ports under a liberal economic regime.[1] Several reasons explain the choice of the Indian port sector. First, the port sector in several erstwhile developing countries

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has been undergoing transformation from a subsistence infrastructure resource into a more capital intensive, commercially and technologically oriented facility (UNCTAD, 2001). Second, considering the country's entry into the second stage of reform and when more than 75% of the country's foreign trade pass through seaports, the analysis will help to assess potential benefits of moving to a reformed port sector with advancement of better technology.

The paper proceeds as follows. Section 2 deals with the data and methodology. Section 3 outlines the concept and measurement of efficiency. Section 4 concentrates on the efficiency of input use in Indian ports in a comparative static framework. In Section 5, an attempt is made to identify the factors influencing labour productivities in Indian ports. Finally, summary and policy implications are briefed in Section 6.

2. The Data

The period of this study falls between 1981-82 and 2000-01.[2] The choice of the initial year (1981-82) is influenced by the fact that since the beginning of 80s India for the first time was embarked upon a path of relative globalization through liberal export import policy. In general, port facility can be taken as public infrastructure input from the supply side. A period of 20 years is assumed to be adequate to check the extent of the impact of new technology on factor productivity. However, technological issues like adoption of indigenous technology, import of know-how and/or techniques are basically embodied in our analysis and not separately dealt with. To be specific, adoption of advanced capital-intensive techniques is proxied by increasing capital/labor ratios (K/L).

The major sources of data have been collected from various issues of (i) *Basic Ports Statistics of India*, (ii) *Transport Statistics of India*, and (iii) *Profiles of Major Ports of India*. Year-wise capital expenditures are converted into real terms with the help of gross domestic capital formation deflators (base 1980-81=100), collected from various issues of *National Accounts Statistics*, published by the Government of India. Port traffic (Y) and labor (L) are taken in physical quantities.

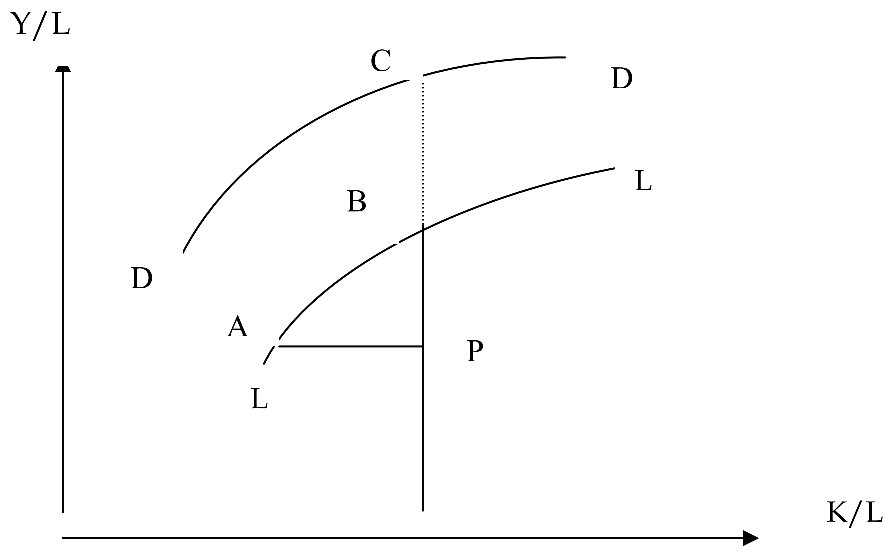
3. Concept and Measurement of Efficiency

Although methodological differences persist, there is a broad harmony in measuring productivity and efficiency of input use with the help of apparently different approaches. In existing literature, there are two different but interrelated techniques of measuring firm as well as industry efficiency. One is to proceed by estimating the average production function and the other by using the frontier production function (FPF), where the concept of "best practice" method is used to locate the maximum potential output of firms using different input combinations at the prevailing state of technological knowledge (Ishikawa, 1981).

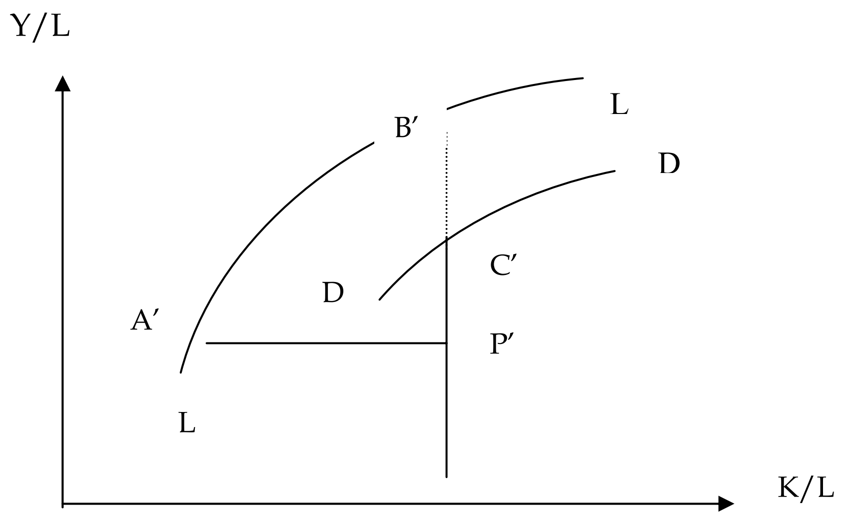
It may be mentioned here that port is an especial type of servicing unit. Therefore, all types of internal and external influences upon the functioning of the cargo handling system are reduced to labour and capital. In this study, a technique is said to be efficient (inefficient) when there is an upward (downward) shift of the productivity locus due to the adoption of new technology. Figure 1 graphically represents the concept of efficiency and in-efficiency respectively resulting from new technology adoption in a comparative static framework. In Figure 1(a), the curve LL is the labor-productivity locus prior to the adoption of new technology at time t_0. After adoption, the curve shifts to DD at time t_1 with corresponding higher values of Y/L. Let A be the observed position of a port on the old curve LL which shifts to C on DD after adoption. This movement from A to C can be divided into two parts. The first is from A to B which means that capital deepening process leads productivity to increase to B. But after adoption, productivity rises to C. The segment BC represents the gain in productivity due to efficient use of inputs with the help of advanced technology as manifested by higher capital per unit of labour (K/L).

Figure 1. Model for Measuring Efficiency

(a)



(b)



On the other hand, any downward shift of the locus is the consequence of inefficient use of inputs. The movement from A' to C' in Figure 1(b) is composed of two parts: A' to B' and B' to C'. Here as a reverse case of the drop in productivity from B' to C' is due to inefficient use of inputs even when productivity rises by P'C'. Thus, a rise in productivity does not necessarily mean efficient use of inputs when technology adoption augments the K/L ratio.

K/L

3.1 The Model

This phenomenon of efficiency can be shown empirically from the relationship between observed LPs and K/L ratios across the ports for different points in time. In this context, it may be mentioned that the linear homogeneous production function exhibiting constant returns to scale is equivalent to a function of one variable in per capita terms, i.e. LP = Y/L = f (K/L) where LP is output per labor. In our case, technological change in port infrastructure may be broadly understood to incorporate advances in the use of machinery and machine tools including construction as embodied in capital investment per unit of labour. To capture the intertemporal shift, we have used temporal dummy variables. The empirical test employs multiple regression of two non-linear equations of the forms:

$$\log(LP) = \alpha + \beta_1 \log(K/L) + \beta_2 [\log(K/L)]^2 + \beta_3 D, \quad (1)$$

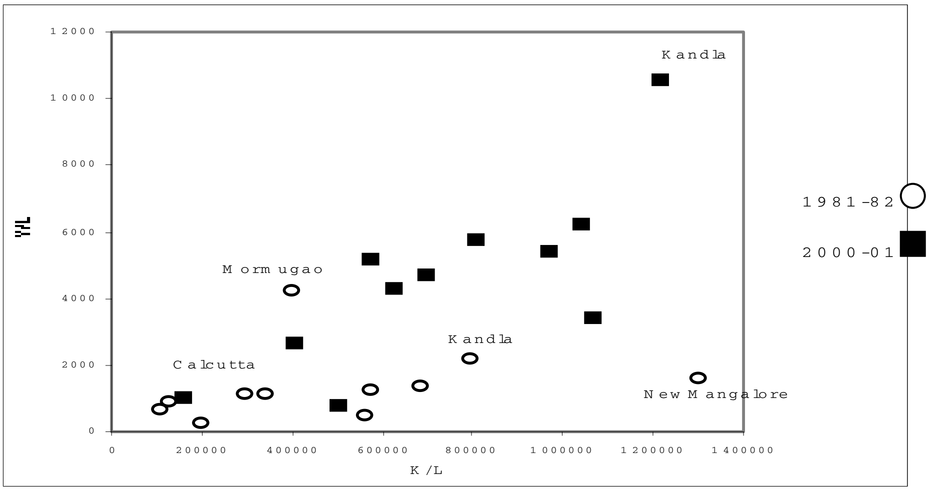
$$\log(LP) = \alpha + \beta_1 \log(K/L) + \beta_2 [\log(K/L)]^2 + \beta_3 D + \beta_4 [\log(K/L)] D, \quad (2)$$

where D represents the temporal dummy with D=1 for latter years and D=0 for others, Y, K and L represent port traffic, capital and labor.

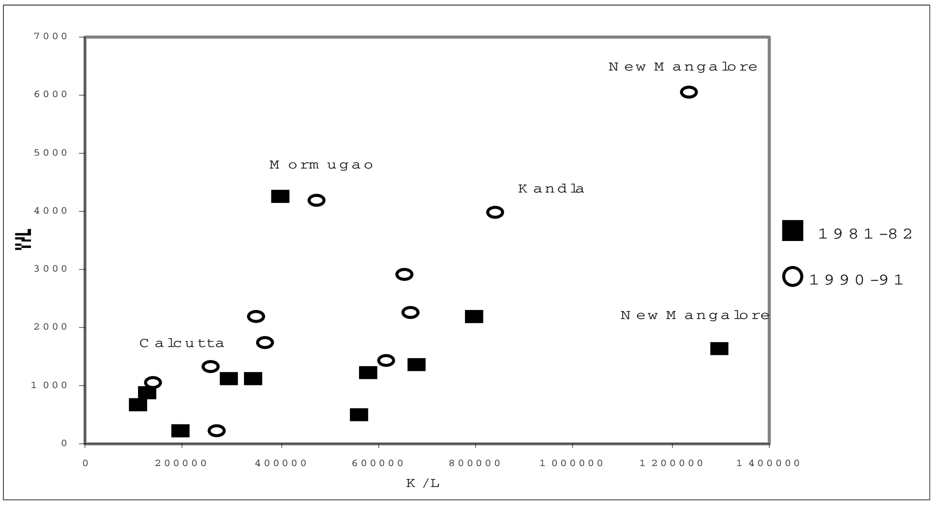
From equations 1 and 2 impact of K/L on LP over time can be estimated. Generally, the function dictates that in case of a positive association between the dependent and independent variables, the values of β_1, β_2, and β_3 should be greater than zero. However, the standard form of the production function specifically dictates here that the value of β_1 should be greater than zero while the value of β_2 should be negative. If the function shits upward (a special case where it moves in a northeasterly direction), the value of β_3 will be positive. But if, $\beta_3 < 0$, this implies a downward shift of the productivity locus. Whether it shifts in a southeasterly or southern direction, the production becomes inefficient in both the cases. Finally, β_4 represent the slope dummy of the curve. If $\beta_4 <0$, it implies that for large values of K/L the process becomes more inefficient. Positive values of β_3 and β_4 imply opposite results.

Figure 2. Scatter Diagram of Cross Section Data on Y/L against K/L

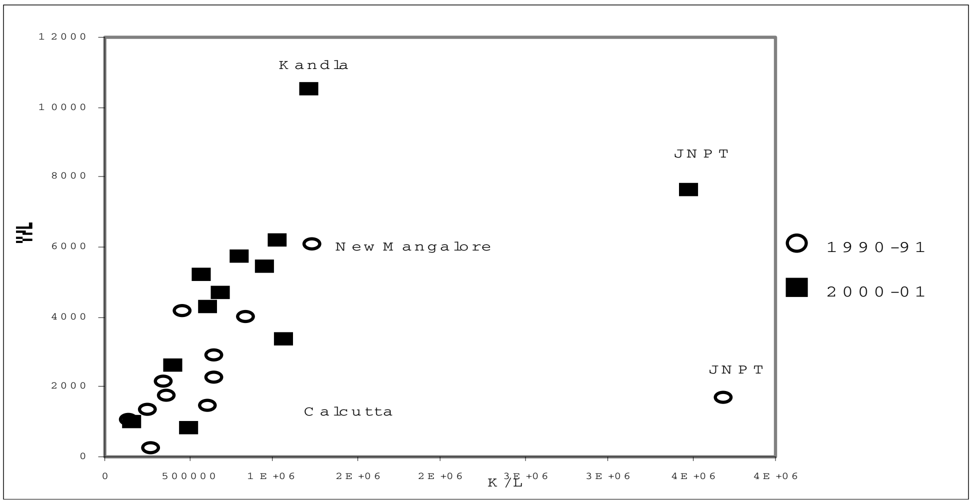
(a) 1981-82 and 2000-2001



(b) 1981-82 and 1990-91



(c) 1990-91 and 2000-2001



4. The Empirical Test of Efficiency

The empirical concept of technology is essentially an *ex post* economic characterization where technological possibilities depend on various economic and institutional factors. Here, we attempt to consolidate our findings in terms of the relationship between LPs and K/L ratios in Indian major ports. Three scatter diagrams of the cross-section data on LP against K/L for three pair of years, 1981-82 and 2000-2001, 1981-82 and 1990-91, and 1990-91 and 2000-2001, have been presented in Figure 2.

Table 1. Correlation Coefficients: Y/L and K/L

(a)

	Y/L(1)	K/L(1)	Y/L(2)	K/L(2)
Y/L(1)	1			
K/L(1)	0.257	1		
Y/L(2)	0.528	0.651	1	
K/L(2)	0.153	0.769	0.782	1

Notes: 1. Y/L(1) and K/L(1) correspond to 1981-82.
2. Y/L(2) and K/L(2) correspond to 2000-2001

(b)

	Y/L(1)	K/L(1)	Y/L(2)	K/L(2)
Y/L(1)	1			
K/L(1)	0.257	1		
Y/L(2)	0.672	0.844	1	
K/L(2)	0.281	0.993	0.842	1

Notes: 1. Y/L(1) and K/L(1) correspond to 1981-82.
2. Y/L(2) and K/L(2) correspond to 1990-91

(c)

	Y/L(1)	K/L(1)	Y/L(2)	K/L(2)
Y/L(1)	1			
K/L(1)	0.131	1		
Y/L(2)	0.615	0.51	1	
K/L(2)	0.059	0.977	0.57	1

Notes: 1. Y/L(1) and K/L(1) correspond to 1990-91.
2. Y/L(2) and K/L(2) correspond to 2000-01.

As evident from these diagrams, there seems to exist some homogeneity among LPs for the lower values of K/L, while for the larger values a wide dispersion is observed. Another observation is that the points in all the three scatter diagrams show a tendency to move towards the northeasterly direction over time. This shift indicates that (i) the major ports have become more capital using than before, and (ii) the productivities in general have increased in the later year relative to K/L ratios. One prima facie observation is that Indian ports are fast becoming more and more capital-intensive with positive impact on productivities. Hence, the hypothesis of efficiency as raised earlier is supported by these scatter diagrams.

Table 2. Regression Results

Year	Independent variable	Coefficient	t-value	Adj. R^2	SEE	DW	SC	F	N
1981-82 and 2000-01	Constant	58.528	1.389	0.682	0.57	1.77	0.091	14.87	20
	Log(K/L)	-8.753	-1.334						
	[Log(K/L)] Sq.	0.367	1.439						
	D	0.945	3.536						
	Constant	-24.089	-0.666	0.703	0.49	1.88	0.039	11.65	20
	Log(K/L)	4.589	0.809						
	[Log(K/L)] Sq.	-0.168	-0.755						
	D	-8.579	-1.828						
	Log(K/L) x D	0.722	2.036						
1981-82 and 1990-91	Constant	24.97	0.482	0.305	0.75	1.76	0.115	4.18	22
	Log(K/L)	-3.506	-0.433						
	[Log(K/L)] Sq.	0.163	0.519						
	D	0.486	1.524						
	Constant	14.884	0.281	0.304	0.75	1.56	0.211	3.36	22
	Log(K/L)	-1.738	-0.21						
	[Log(K/L)] Sq.	0.087	0.268						
	D	-5.878	-0.91						
	Log(K/L) x D	0.491	0.986						
1990-91 and 2000-01	Constant	-51.38	-1.876	0.464	0.65	1.76	0.116	7.68	24
	Log(K/L)	8.178	2.013						
	[Log(K/L)] Sq.	-0.281	-1.867						
	D	0.468	1.713						
	Constant	-50.23	-1.828	0.462	0.65	1.58	0.202	5.93	24
	Log(K/L)	8.147	2.001						
	[Log(K/L)] Sq.	-0.285	-1.89						
	D	-4.064	-0.854						
	Log(K/L) x D	0.338	0.953						

Notes: 1. Dependent variable = Log(Y/L) 2. D = 0 for the first year, and = 1 for the second year in all cases. 3. Regression is based on equations 1 and 2.

We have tried to unearth this phenomenon of efficiency in terms of shifts of the fitted curves (for equations 1 and 2) showing the relationship between LP and K/L for these combinations of years. As stated earlier, a functional relationship between Y/L and K/L is appropriate only when the production function is linear homogeneous. We have estimated the Cobb-Douglas production function for the observation year twice, once imposing the homogeneity restriction of $\alpha + \beta = 1$, and once without this restriction. We have statistically tested the linear homogeneity property of the production function in our case using the data on all the 12 major ports. Appropriate F-tests based on the restricted and unrestricted error sum of squares have been performed. It is interesting to note from the correlation matrices given in the Table 1 that there does not appear to be any reversal of technological level across the ports over time. Moreover, the relationship is very consistent across the ports over time.

The estimated results of the OLS estimation of equations 1 and 2 are presented in the Table 2. Interestingly, results indicate some sort of distinct nature of technological developments in Indian port sector.

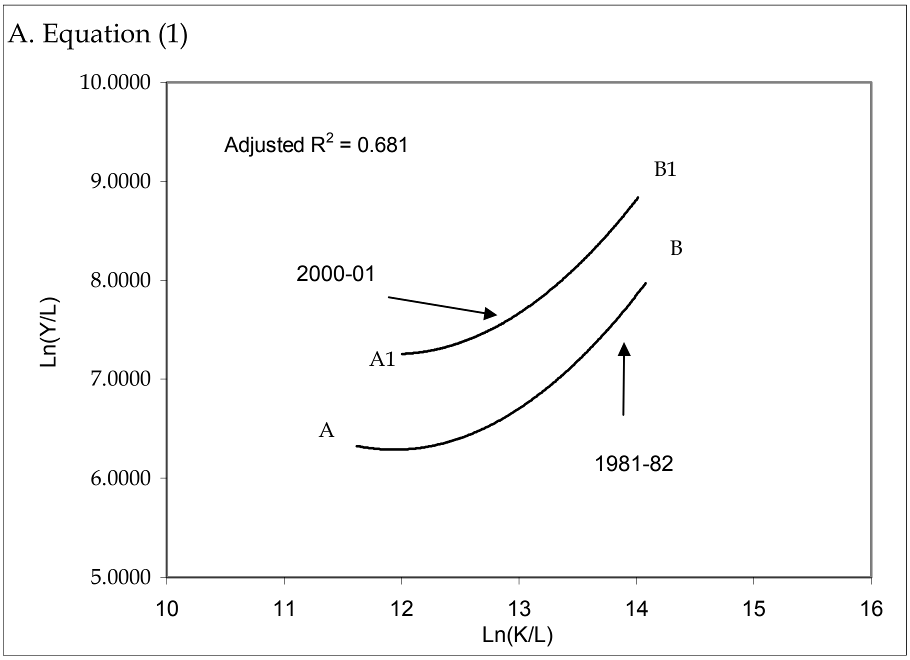
The observation period records statistically highly significant shift of the intercept dummy in the upward direction (positive). This bears clear testimony to a telling improvement in productivity through an upward shift of the productivity locus from AB to A_1B_1. The estimated results are drawn in Figure 3 (a and b). Statistically, inclusion of the slope dummy has reverted the direction of the productivity locus from one of exponential to downward sloping. This improvement over a period of 20 years may be the outcome of a natural rate of progression in a period of crucial importance for the Indian economy particularly from the viewpoints of foreign collaboration, technology import and free trade.

5. Factors influencing LP

Traditionally, efficiency in the port sector is influenced by both internal and external factors. To a large extent, the nature of influence of internal factors on productivity is linked with the intensity of inter- and intra- port competitions. Inter- and intra- port competitions depend on the level of development of the hinterland (the interior region served by each port) including good transport network. Attempts at explaining port competition in this fashion have also been extended to include other factors such as labour cost and productivity, rail connections, port access, and land availability (Kuby and Reid, 1992; Hoyle, 1999). Normally, healthy competition among ports (or in between terminals of a port) helps improve overall efficiency of the port (Estache and de Rus, 2000).

Figure 3. Fitted Relationship between Log(Y/L) and Log(K/L) with Temporal Dummy

(a)



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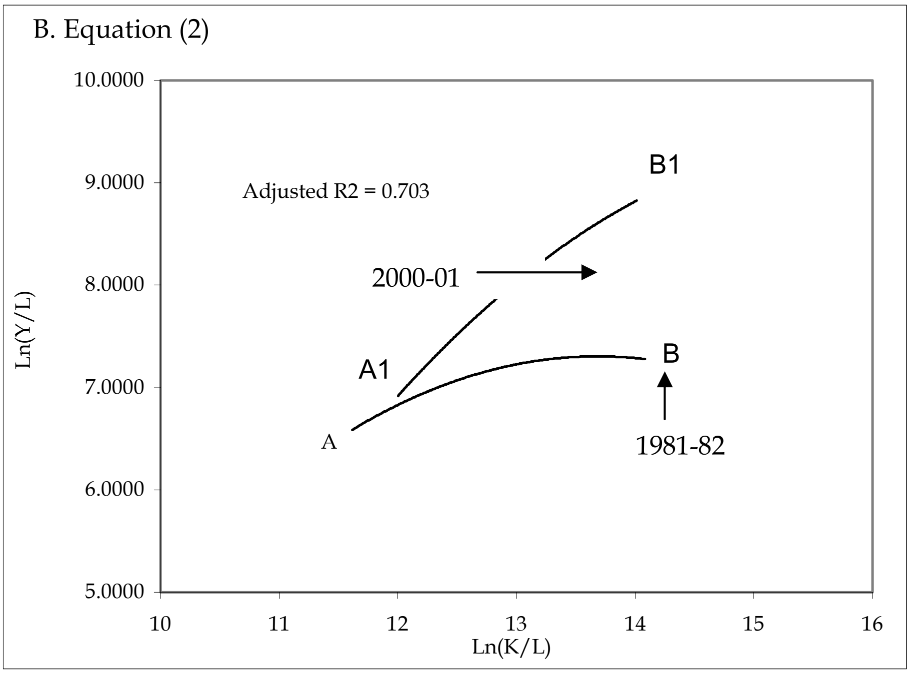
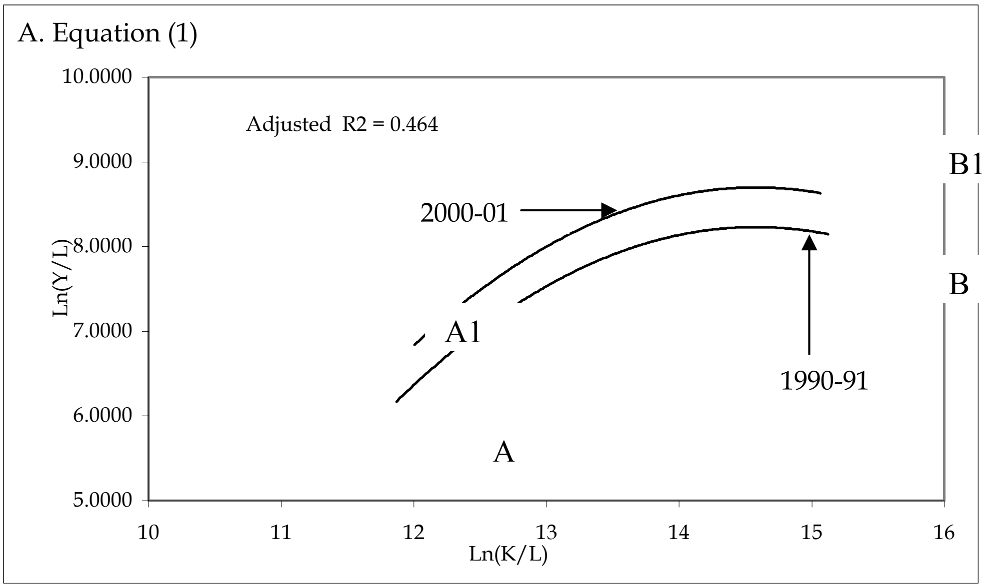


Note: Mormugao and Calcutta ports are deleted as outliers in Case (a) and Case (b) respectively and Jawarlal Nehru port is omitted because it was not in operation in 1981-82.

Figure 4. Fitted Relationship between Log (Y/L) and Log(K/L) with Temporal Dummy

(a)



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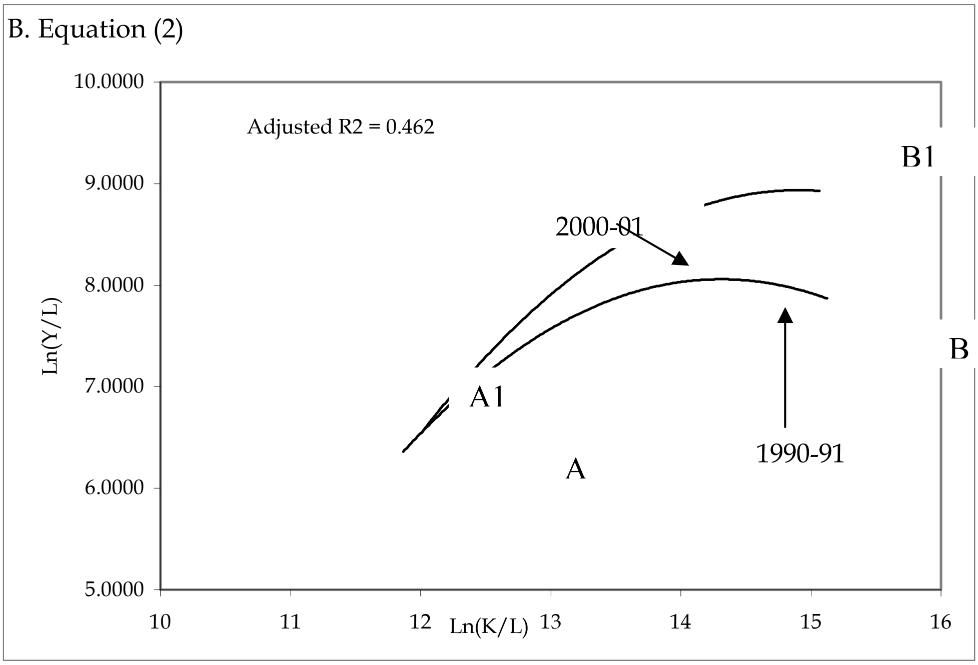

Of particular interest, low efficiency in the Indian port sector as pointed out by De Monie (1995), Peters (1997), and Haralambides and Behrens (2000) may be due to a number of factors, both internal and external. But in view of the fact that efficiency here is defined in terms of intertemporal productivity changes, we have chosen a set of supply-side factors which are likely to influence the level of and changes in productivity.

We have tried two types of regressions (linear and log-linear) with various combinations of the explanatory variables in order to identify the factors which determine LP in the aggregate. The dependent variable is LP – real value added per employee. The independent variables are (i) K/L, (ii) SKILL – measured by the ratio of skilled personnel (all employees minus daily wageworkers) to all employees, (iii) TRT – ship Turn-Round Time, which is the duration of the vessel's stay in port and is calculated from the time of arrival to the time of departure, (iv) RRT - Rate of Return on Turnover, derived from operating surplus divided by operating income of a port. We performed these regressions only for two combinations of data sets - (i) 1990-91 and 2000-2001 (case 1), and (ii) 1981-82 and 2000-2001 (case-2) separately. While Case 2 identifies factors which influence LP in the overall period, Case 1 helps to know the same in the post-liberalization period. Both linear and log-linear results of all the regressions are presented in Table 3.

Table 3. Estimated Coefficients of Regression on LP
(a) Equation form: Linear (Dependent variable = LP)

Years	Independent variable	Coefficient	t-value	Adj. R^2	SEE	F	DW	SC	N
Case 1. 1990-91 and 2000-01	Intercept	-955.77	-0.30	0.58	1578	8.24	2.00	-0.02	22
	K/L	0.01	3.31			(4, 17)			
	SKILL	4.93	0.14						
	RRT	23.62	0.56						
	TRT	-25.05	-0.15						
	Intercept	475.21	0.12	0.35	1968	4.71	2.18	-0.11	22
	SKILL	4.67	0.11			(3, 18)			
	RRT	123.52	3.31						
	TRT	-248.59	-1.31						
	Intercept	-985.31	-0.38	0.62	1506	17.93	1.95	0.01	22
	K/L	0.01	5.79			(2, 19)			
	SKILL	8.30	0.26						
Case 2. 1980-81 and 2000-01	Intercept	474.18	0.1	0.42	1970	4.75	1.7	0.05	20
	K/L	0.003	2.59			(4, 17)			
	SKILL	9.37	0.17						
	RRT	53.35	1.64						
	TRT	-211.6	-1.28						
	Intercept	1190.3	0.54	0.45	1916	6.69	1.67	0.06	20
	K/L	0.004	2.72			(3, 18)			
	RRT	54.46	1.76						
	TRT	-210.28	-1.3						

Table 3. Estimated Coefficients of Regression on LP
(b) Equation form: Log Linear (Dependent variable = Log (LP))

Years	Independent variable	Coefficient	t-value	Adj. R^2	SEE	F	DW	SC	N
Case 1. 1990-91 and 2000-01	Intercept Log(K/L) Log(SKILL) Log(RRT) Log(TRT)	-3.07 0.72 0.02 0.73 -0.66	-0.54 2.60 0.02 1.63 -1.60	0.58	0.58	8.21 (4, 17)	1.52	0.23	22
	Intercept Log(SKILL) Log(RRT) Log(TRT)	6.45 -0.36 1.43 -1.09	1.29 -0.32 3.49 -2.51	0.44	0.66	6.59 (3, 18)	1.89	0.02	22
	Intercept Log(K/L) Log(SKILL)	-9.32 1.09 0.63	-1.85 4.95 0.64	0.53	0.61	12.78 (2, 19)	1.46	0.27	22
Case 2. 1980-81 and 2000-01	Intercept Log(K/L) Log(SKILL) Log(RRT) Log(TRT)	-1.81 0.64 0.88 0.36 -1.80	-0.25 2.78 0.59 1.26 -2.59	0.53	0.68	6.99 (4, 17)	1.00	0.48	20
	Intercept Log(K/L) Log(RRT) Log(TRT)	1.86 0.65 0.38 -1.80	0.51 2.89 1.36 -2.64	0.55	0.70	9.55 (3, 18)	0.94	0.51	20

Note: Figures in parentheses represent degrees of freedom

From both the sets of equations (linear and non-linear), the most important variable (judged by the level of significance) in the determination of LP is K/L as before. Significance level of K/L also gets stronger in the post-liberalization period. Why K/L alone decides the fate of LP? One plausible reason may be that large amount of capital expenditure was incurred for (a) modernization of berths and cargo handling equipments, (b) specialized services and (c) container handling facilities. A look at Table 4 makes it clear about the growing use of modern container handling equipments in the Indian port sector in the post-liberalization period.

However, dropping the K/L, we find RRT as the second most influential factor in determining LP. As reported in all different combinations of regressions, there appears to be a strong relationship between capital intensity and rate of return. This is logically very consistent because higher rate of return and higher capital intensity work in the same direction. That is, technological level facilitates the opportunities for better rate of return thereby indicating the presence of scale economies. As a matter of fact, we have observed higher RRT in the Indian port sector in the post-1991 period (see Table 5).

Table 4. Container Handling Facilities at Indian Ports

Port#	Container Traffic ('000 TEUs)		No of Berths		No of SGs*		No of RTGs**	
	1990-91	2000-01	1990-91	2000-01	1990-91	2000-01	1990-91	2000-01
Jawarlal Nehru	88	850	2	3	2	10	4	17
Mumbai	230	390	6	8	2	2	2	3
Cochin	20	105	1	2	0	2	1	4
Tuticorin	15	100	0	1	0	2	0	4
Chennai	67	400	1	2	1	4	2	8
Haldia	8	60	1	1	0	0	0	0
Calcutta	60	150	4	5	0	0	1	3

Notes: # Combined share in Indian total container traffic is more than 85% in 2000-01. * Shore-side Gantry Cranes in the range between 35 tonnes to 40 tonnes. ** Rubber Tyred Gantry Cranes in the range between 35 tonnes to 40 tonnes.
Source: Indian Ports Association, New Delhi (www.ipa.nic.in)

Interestingly, contrary to popular belief, SKILL does not significantly influence LP in this analysis. This means skilled manpower still has very limited impact on overall labour productivity of the port.

As expected, TRT has always produced negative sign in all the regressions, although in most cases it is not statistically important. This may perhaps be due to the fact that on an average most of the Indian ports are yet to achieve a swift turnaround of vessels which is still is hovering around 4 to 5 days (see Table 6). There is a group of services related to turnaround of vessels, which include pilotage, towing and tying, berthing, loading and unloading, and ancillary activities. In general, Indian port authorities are still solely responsible for all such services which are associated with vessel's turnaround. Being an important catalyst for overall improvement of productivity, these services need immediate reform. Here, Government may think for different operators, public and/or private, for different services instead of one authority for many services.

Table 5. Rate of Return on Turnover (RRT) in Indian Ports

Ports	Year = 1985-86			Year = 1991-92			Year = 1999-2000		
	SIPT*	PTOS**	RRT	SIPT*	PTOS**	RRT	SIPT*	PTOS**	RRT
	(%)	(Rs. Cr.)	(%)	(%)	(Rs. Cr.)	(%)	(%)	(Rs. Cr.)	(%)
Kandala	11.22	2.29	48.28	13	1.09	33.54	16.4	2.39	50.43
Mumbai	18.65	2.35	34.91	19.02	3.42	31.06	12.2	6.47	36.81
Jawarlal Nehru	#	#	#	1.34	4.49	16.6	6.2	13.17	43.18
Mormugao	16.88	0.87	36.98	9.8	0.36	11.45	6.1	1.26	24.16
New Mangalore	2.04	0.74	20.78	5.28	1.66	42.16	5	4.85	50.99
Cochin	5.88	0.64	11.06	4.8	1.51	18.76	5.25	3.68	31.34
Tuticorin	3.2	1.3	39.84	3.34	1.3	32.46	4	3.01	46.91
Chennai	13.04	2.23	44.38	16.14	2.82	44.01	14.5	3.46	39.86
Vizag	13.1	1.45	33.36	12.78	1.46	24.54	14	3.03	38.54
Paradip	3.02	0.09	1.14	4.5	3.52	32.97	5	5.49	39.09
Calcutta	5.85	-0.64	-3.13	2.7	2.81	9.3	4	14.22	39.46
Haldia	7.12	1.96	30.13	7.3	3.62	32.81	7.35	7.51	39.46
Average		1.21	27.07		2.34	27.47		5.71	40.02

Notes: * Share in Total Indian Port Traffic. ** Per Tonne Operating Surplus. # Not in operation.
Source: Various issues of Basic Port Statistics of India, Ministry of Shipping, Government of India

Table 6. Average Turnaround Time of Indian Ports

Ports	1991-92	1995-96	1999-2000
	(Days)	(Days)	(Days)
Kandala	12.53	9.43	7.56
Mumbai	10.44	8.44	6.04
Jawarlal Nehru	5.66	4.67	2.94
Mormugao	8.49	5.39	4.84
New Mangalore	6.5	4.35	3.75
Cochin	6.9	4.06	3.61
Tuticorin	7.56	5.22	4.23
Chennai	9.44	6.2	6.58
Vizag	8.34	6.06	5.01
Paradip	8.28	7.55	4.16
Calcutta	10.23	8.37	6.25
Haldia	8.44	7.36	4.14
Average	8.57	6.43	4.93

Source: Various issues of Basic Port Statistics of India, Ministry of Shipping, Government of India

6. Summary and Implications

This study examined (i) the impact of advanced technology which is proxied by rising K/L ratios in Indian port sector on the efficiency of factor use, and (ii) the factors influencing labour productivities across major ports. First, increasing use of overhead capital has produced significant improvement in productivities. Second, there is ample evidence in favour of upward shift of the productivity locus. In essence, this implies that the ports of India have witnessed some kind of technological metamorphosis between 1980-81 and 2000-01. Third, the most important factors that influence labour productivities in an aggregate sense are the capital/labour ratio, and rate of return on turnover. These findings have important implications for technology policy in the port sector in LDCs and particularly in India.

Rising inefficiencies in ports have forced the Indian government to deregulate the port system with the objective of increasing financial viability, productive efficiency and transfer of appropriate technology. To reduce costs and increase productivity, the Indian reform strategy sought to deregulate, decentralize, and organize inter- and intra- port competitions.[3] As performance indicators for Jawarlal Nehru port show, the improvements have been dramatic since the privatization of the port in 1997; port charges and shipping tariffs have declined sharply, and labour and berth productivities have improved. Having seen the success of reform, Indian government therefore, has started leasing out container berths of other major ports through competitive bidding.

The level of technological development in Indian ports is such that they even did not use modern container handling equipments even 10 years ago. Now, due to the reforms, ports are trying to install sophisticated modern equipments at its terminals run by private operators which have created opportunities for skilled and specialized personnel. This has resulted in phenomenal increase in productivity. This integration of cargo handling activities has led to encourage necessity for adequate skilled personnel in the port sector.

In this short time span two broad lessons have emerged from India's port reform which have changed the way Indian port authorities used to function a decade ago. Firstly, competition can be effective – both among and within ports. Secondly, commitment of the government is vital in regulating the game even after port services have been privatized.[4] When technology has become truly global and old geographical barriers have been narrowing, future growth of a port is highly contingent upon how fast it accommodates with new technology and improved services.

Notes

1. There are some studies such as Ghosh and De (2000a and 2000b) and De and Ghosh, (2001) which have tried to understand the relationship between port performance and port traffic, but impact of technology on development of ports was not dealt with.
2. In India, there are 13 major ports in total namely Kandla, Mumbai, Jawarlal Nehru, Mormugao, Cochin, New Mangalore, Tuticorin, Ennore, Chennai, Vizag, Paradip, Calcutta, and Haldia.
3. There are also some exceptions. Current arrangements for cargo handling at some Indian ports in the container segment are not conducive for fast handling and turnaround. These ports namely Mumbai, Kolkata and Haldia rely on ship's own gear instead of any modern shore-side gantry cranes. Due to this, move of boxes per hour is abysmally low and thereby a port takes 3 to 4 days to clear a vessel from the berth. These shortcomings are especially critical for the container trade, as the waiting cost of capital-intensive container vessels is high. In the break bulk sector, the situation is much more dire. Mumbai port

being one of the busiest ports of the country normally unloads 2000 tonnes of per day and takes nearly 15 days to unload 20,000 tonnes of break bulk cargo.

4. Also question often arises about the degree of inter-port competition. There is no universal rule for the degree of competition and regulation desirable in a port with a particular volume of traffic, but for container ports there is acceptance of some thresholds (Kent and Hochstein, 1998; Estache and de Rus, 2000). Perhaps, in India, low container market size decides the intensity of inter-port competition and thereby the fate of newly built private container terminals.

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Key Words

Productivity, Efficiency, Technological Change, Port Traffic, Comparative Static Framework