An Econometric Analysis of the Scale of Operation in the Chittagong Sea-port

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Abstract

The role and importance of a sea-port cannot be over-emphasized in view of the amount of cargo that is transported through sea-ports worldwide. This paper examines the recent growth in the Chittagong sea-port by using production function to get more insights into the sea-port operation and to find the possibilities for further expansion to earn higher rate of return for investment. The analysis based on the Cobb-Douglas production function has shown that operations are of increasing returns to scale in the Chittagong Port. This returns to scale depends to a larger extent upon changing demand for sea-port services and corresponding development to cope with this demand. In view of the rapidly rising tonnage handled and the other services provided for ships and the other related business activities performed by the Chittagong Port, it is quite natural to find this increasing returns to scale. The findings will help to expand sea-port facilities to yield higher rate of return for investment.

1. Introduction

The role of Chittagong sea-port, the largest sea-port of Bangladesh, can hardly be over-emphasized in the economy of Bangladesh. About 90% of the sea-born trades are being handled presently by this port. Being situated at the estuary of the river Karnaphuli, it has considerable advantage in term of location and infrastructure. Geographical location of Chittagong Port places it halfway between the ASEAN and SAARC countries. This advantage provides an opportunity to extend it services beyond the geographical boundaries of Bangladesh. Nepal, Bhutan, and seven North-eastern states of India (Meghalaya, Assam, Arunachal, Nagaland, Monipur, Mizoram and Tripura) can effectively use the Chittagong Port.

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The Chittagong Port being the principal Port of Bangladesh has very special role to play in the national development process. The responsibilities of the Chittagong Port are to render necessary facilities and services in proper and efficient way so that it may be able to boost up national economy. Inefficient port may hamper economic development through dismal operating procedure and inadequate facilities. The process of trade liberalization and globalization indeed results in an increase of world as well as regional trade and cross-border networks and flows of goods and services. In the globalized economy Bangladesh is seeking to explore opportunities to further expand international economic activities for sustainable development. To meet this objective, Chittagong Port must be able to offer increased level of efficiency compared to other sea-ports in today's global environment.

It now has the potential to develop into a regional hub of container and cargo transshipment. The Port presently handles over 30 million tons of cargo. The present growth of containerized and overall cargo is about 12% and 6.5% respectively per annum. To combat this upward trend, the Port Authority has undertaken a number of development projects to expand and improve its facilities and services.

The recent growth of the Chittagong Port is analyzed in this paper by estimating production function to get more insights into the sea-port operation and to find the possibilities for further expansion. The result will also help to evaluate the development projects undertaken by the Port Authority to yield higher rate of return.

2. Study Design

2.1 Research Questions

The study will examine the scale of operation in the Chittagong Port. This will help to find justification for the further expansion of facilities. The returns to scale depend to a larger extent upon changing demand for sea-port services and corresponding development to cope with this demand. The returns to scale can be classified as constant, increasing and decreasing returns to scale. Constant returns to scale implies that output will be double if inputs are doubled. The decreasing returns to scale, on the other hand, states that the rate of increase in output will be less than the rate of increase in inputs. In case of increasing returns to scale the rate of increase in output will be greater than the rate of increase in inputs. If any farm faces the increasing returns to scale, it may expand its facilities more easily

if cost and profit earnings support it. In this study the scale of operation will be examined to get more insight into the matter.

2.2 Organization of the study

The study has been organized as follows: The introductory section is followed by the study design in section 2 which presents the research questions, methodology and sources of data. Section 3 presents a brief Overview of Chittagong Port. The scale of operation is analyzed in section 4. The estimation of the model has been explained in section 5. Finally, conclusion is presented in section 6.

2.3 Methodology

The conventional Cobb-Douglas production function will be used to analyze the scale of operation of Chittagong sea-port. The equation is as follows-

$Q = A K^a L^b e^{z(T/L)}$

Where, Q = Gross output (gross port revenue, 2000 price)
A = Technology
K = Capital inputs (Capital employed book value, 2000 price)
L = Labour inputs (wages and salaries, 2000 price)
T = Total tonnage handled
L = Number of employees
$e^{z(T/L)}$ = proxy of technological improvements*
T/L = tonnage handled per unit of labour

2.4 Source of Data

Almost all relevant data have been collected from the offices of Chittagong Port Authority. Data were collected from the records available at relevant sections of the Port Authority. Port's cargo handling, income and expenditure, capital employed, wages and salaries data are available annually. They have been collected from the Port's administrative reports, yearbooks, budget statistics etc.

3. An Overview of Chittagong Port

The volume of cargo at Chittagong Port increased manifolds over the last 15 years. For instance, total volume of cargo increased by about three-time between1990-91 to 2006-07. On the other hand containerized cargo increased by about 10 times over the same period. Table-1 depicts the picture of the Chittagong

* The same proxy has been used by Dr. S.W.S.B. Dasanayaka. For details please see reference.

Port during the said time period. The trends of cargo and container handling can be seen in figure-1 and figure-2. (Please see the appendix).

Macroeconomic activities of a country directly affect the cargo handling activities of sea-port. So, the rate of growth of cargo handling can be related to the growth of GDP. This can be shown in the following table 2. During 1990-91 to 2006-07 the average growth rate of cargo and container handling increased by 6.77% and 14.71% respectively per year; whereas GDP growth was 5.34% per year during the same period. So, the ratio between GDP growth rate and container handling growth rate is about 1:3, which reflects the role of Chittagong Port in the economy of Bangladesh. It can be assumed from this relationship that if our economy grows

Table 1: Average annual cargo and container handling between 1990-91 to 2006-07

	Total cargo handling			Total container handling		
year	Import in lac ton	export in lac ton	total in lac ton	Import in lac ton	export in lac ton	total in lac ton
1990-91	62.82	9.19	72.01	5.46	3.43	8.89
1991-92	62.67	7.7	70.37	6.8	4.03	10.83
1992-93	64.96	11.2	76.16	8.45	5.34	13.79
1993-94	67.28	11.69	78.97	10.05	6.21	16.26
1994-95	89.25	13.54	102.79	13.41	7.73	21.14
1995-96	88.51	14.5	103.01	15.34	8.01	23.35
1996-97	91.17	14.37	105.54	17.72	8.98	26.7
1997-98	95.6	15.27	110.87	19.96	10.22	30.18
1998-99	122.06	16.94	139	23.51	10.51	34.02
1999-00	133.87	17.56	151.43	26.09	12.06	38.15
2000-01	149.1	19.98	169.08	32.35	14.19	46.54
2001-02	160.88	19.91	180.79	32.55	14.09	46.64
2002-03	183.19	22.61	205.8	37.24	15.78	53.02
2003-04	189.86	24	213.86	43.7	18.42	62.12
2004-05	216.76	27.11	243.87	51.98	21.23	73.21
2005-06	231.7	29.26	260.96	57.08	23.67	80.75
2006-07	238.36	32.89	271.25	61.15	27.96	89.11

Source: CPA, Traffic section

at higher rate in future, the volume of cargo handling will increase as well. The total cargo handling capacity is increased by 6.43% per year over this period, which is not sufficient enough to meet this higher rate of cargo handling.

4. Scale of Operation Analysis

The following conventional Cobb-Douglas production function is used as the main tool, which generally includes the basic ingredients of sea-port operations.

Table 2: Compound Rate of growth per-year from 1990-2007 (in %)

Serial no	Types of Cargo (in lac ton)	Compound Rate of growth per-year from 1990-2007 (%)
1	Total Import cargo	9.05
2	Total export cargo	8.93
3	Total cargo	6.77
4	Total container import cargo	16.54
5	Total container export cargo	14.28
6	Total container cargo	14.71
7	Total cargo handling capacity	6.43
8	GDP	

$$Q = AK^aL^be^{z(T/L)}$$

Where,

Q	=	Output (gross port revenue, 2000 prices),
K	=	Capital inputs (capital employed book value, 2000 prices)
L	=	Labour inputs (wages and salaries paid, 2000 prices)
a and b	=	capital and labour ratios,
$e^{(T/L)}$	=	proxy for technological improvement;
T	=	Total tonnage handled,
L	=	number of employees,
(T/L)	=	tonnage per unit of labour.

Using natural log (= ln) form, this production function can be transformed into econometric model by introducing error term (U) as follows:

$$\ln Q = \ln A + a \ln K + b \ln L + (T/L) \ln e^z + U \quad \text{.....(1)}$$

$$\ln Q = A + a \ln K + b \ln L + U \quad \text{.....(2)}$$

In equation 2, the proxy is not used to show the direct relationship between inputs and outputs.

5. Estimation of Models for the Chittagong Sea-port

5.1 First model

A. Descriptive statistics of the variables- (SPSS result)

From the table 3, it can be seen that the frequency distribution of variables (Output, labour, Capital and tonnage per labour) are not normal. The skewness coefficient is less than of unity. In a Guassian distribution, one would expect these data to have kourtosis coefficients of 2.66 for all variables under consideration.* kourtosis, generally, either much higher or lower indicates extreme leptokurtic or extreme platykurtic (Parkinson, 1987). Our results show that the distribution of LQ, LK, Ll and log T/L are platykurtic. Generally, values for skewness zero and kurtosis value 3 represents that the observed distribution is perfectly normally

Table 3

Variables	N	Mean	Std. error	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
LQ	17	6.0218	.26231	-.469	.550	-.895	1.063
LK	17	7.8003	.21214	-.172	.550	-.823	1.063
Ll	17	3.4616	.31528	-.854	.550	-.821	1.063
log T/L	17	5.3692	.39250	-.024	.550	-.444	1.063

LQ = lnQ. Natural Log transform of Output
LK = lnK. Natural Log transform of Capital
Ll = lnL. Natural Log transform of Labour

distributed. So, skewness and platykurtic frequency distribution of the variables indicates that the distributions are not normal. So, we can easily use the OLS for estimating the model.

B. The model is estimated through OLS method by using **SPSS & SHAZAM statistical software** and the results as follows (SPSS result): (For details please see the appendix).

$$\ln Q = \underset{}{0.627} + \underset{(0.984)}{0.413 \ln K} + \underset{(0.195)}{0.361 \ln L} + \underset{(0.0599)}{0.172 (T/L)} \quad \underset{(0.061)}{\text{------(1)}}$$

$R^2 = 0.99$

Adj. $R^2 = 0.98$

Durbin-Watson = 1.313

F = 291.92

* Kendall (1943) calculated the expected normal kurtosis equal to 3(n-1/n+1). Where, n = sample size.

The figures in the parentheses show the standard deviation. Statistically these results may be interpreted as: the partial coefficients of labour and capital are significant at 0.05% level. Standard errors are very low. More than 98% of variation of the output of Chittagong Port is explained by the variation of explanatory variables. F statistic is significant at 0.01%. Durbin-Watson test is sufficiently low, which indicates that the positive first order serial correlation is absent.

Economically these results may be interpreted as: holding the labour and technological change constant, if the capital input increases by 1 % on the average, the output goes up by about 0.46%. And holding the capital inputs and technological change constant, if the labour input increases by 1 % on the average, output goes up by 0.39 %. If we add the two output elasticity-coefficients of factor inputs, we obtain an economically important parameter called the returns to scale parameter, which gives the response of output to proportional change in inputs. The sum of these capital and labour elasticity coefficients is 0.85653 which suggests that the Chittagong Port has been operating under decreasing returns to scale during sample period.

5.2 Second model

In order to cope with the increasing traffic which caused the rapid changes in the capital-output ratios over time, the Port Authority heavily invested in the Chittagong Port. However, this tentative conclusion is influenced by the technological proxy. Therefore, by dropping out the technological proxy, second model is estimated for the Chittagong Port in order to show the direct relationship between inputs and outputs. The result is presented below- (the figures in the parentheses show the standard deviation).

$$\ln Q = -0.811 + 0.712 \ln K + 0.369 \ln L \quad \ldots\ldots\ldots\ldots (2)$$
$$(0.564) \quad (0.097) \quad (0.065)$$

$R^2 = 0.98$

$Adj.R^2 = 0.979$

$DW = 1.45$

$F = 381.967$

Statistically these results may be interpreted as: capital and labour partial coefficients are significant at 0.05% level. Standard errors are very low. More than 98% of variation of output of this Port is explained by the variation of explanatory variables. F statistic is significant at 0.01%. The DW statistic is significant at 0.05 % level, which indicates the absence of the first order serial correlation.

Economically these results may be interpreted as: holding the labour input constant, if the capital input increases by 1 % on the average, output goes up by 0.712%. Likewise, holding the capital input constant, if the labour inputs increases by one percent on the average, output goes up by 0.369%. The sum of labour and capital partial coefficient is 1.091 which suggests that the operation of the Chittagong sea-port has been operating under increasing returns to scale during the same period.

6. Conclusion

The main contents of this analysis may be concluded:

1. For further expansion of its facilities it is necessary to evaluate the existing returns to scale of Chittagong Port and this paper examines the existing returns to scale of this Port. The analysis based on the Cobb-Douglas production function has shown that the operations of the Chittagong Port has been operating under increasing return to scale during the sample period. The returns to scale depends to a larger extent upon changing demand for sea-port services and corresponding development to cope with this demand. In view of the rapidly rising tonnage handled and the other services provided for ships and the other related business activities performed by the Chittagong Port, it is quite natural to find increasing returns to scale in our estimated models.
2. According to the results of these regressions the productivity growths in the Chittagong Port was quite fast. This fast growth indicates that demand for the Port's services have been increasing during the past decade and in turn, it shows that there are more possibilities to expand port facilities in order to reduce the sea-port congestion which automatically creates by excess demand.
3. This result also gives an important policy implication that capital has more sensitivity to output rather than labour in Chittagong Port which is very much compatible with the factor endowments of the country.

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Appendix

Table 3

year	Import in lac ton	expor t in lac ton	total in lac ton	Capital employe d in crore taka	Output (gross port revenue in crore taka)	labour inputs (wages and salaries in crore taka)	Num ber of empl oyee	T/L (ton)	Q/k
1990-91	62.82	9.19	72.01	974.2	159.27	11.56	7556	121.63	2.21
1991-92	62.67	7.7	70.37	1160.86	168.73	11.89	7556	101.91	2.40
1992-93	64.96	11.2	76.16	1277.51	187.57	12.53	7556	148.23	2.46
1993-94	67.28	11.69	78.97	1390.19	205.56	13.59	7556	154.71	2.60
1994-95	89.25	13.54	102.79	1540.16	260.4	18.87	7556	179.20	2.53
1995-96	88.51	14.5	103.01	1688.56	315.86	24.15	7759	186.88	3.07
1996-97	91.17	14.37	105.54	1849.37	324.32	29.43	7800	184.23	3.07
1997-98	95.6	15.27	110.87	2009.38	345.22	31.28	8086	188.84	3.11
1998-99	122.06	16.94	139	2219.72	374.51	32.94	8086	209.50	2.69
1999-00	133.87	17.56	151.43	2404.56	421.79	37.84	8086	217.17	2.79
2000-01	149.1	19.98	169.08	2665.69	477	37.21	8086	247.09	2.82
2001-02	160.88	19.91	180.79	2868.96	531.35	40.9	8086	246.23	2.94
2002-03	183.19	22.61	205.8	2991.19	530.65	42.98	8086	279.62	2.58
2003-04	189.86	24	213.86	3403.6	557.36	40.04	7860	305.34	2.61
2004-05	216.76	27.11	243.87	3829.39	649.78	47.35	7759	349.40	2.66
2005-06	231.7	29.26	260.96	4241.27	741.12	57.23	7759	377.11	0.00
2006-07	238.36	32.89	271.25	4651.36	830.02	65.16	7759	423.89	0.00

Table 4 : Transformed variables into Real value SHAZAM result

year	Real output (gross port revenue in crore taka)	Real capital (in crore taka)	Real labour (wages and salaries in crore taka)	CPI=consumer Price Index	R =100/PI
1990-91	266.2443	1628.525	19.32432	59.821	1.671654
1991-92	265.1945	1824.534	18.68762	63.625	1.571709
1992-93	284.4685	1937.471	19.00299	65.937	1.516599
1993-94	302.6279	2046.654	20.00736	67.925	1.472212
1994-95	364.0227	2153.046	26.37906	71.534	1.397937
1995-96	400.6698	2141.946	30.63438	78.833	1.268504
1996-97	401.8287	2291.348	36.46343	80.711	1.238988
1997-98	405.8451	2362.253	36.77318	85.062	1.175613
1998-99	406.1534	2407.270	35.72319	92.209	1.084493
1999-00	431.1018	2457.645	38.67539	97.840	1.022077
2000-01	477.0000	2665.690	37.21000	100.000	1.000000
2001-02	520.8956	2812.513	40.09529	102.007	0.9803249
2002-03	503.4296	2837.753	40.77528	105.407	0.9487036
2003-04	500.4040	3055.790	35.94836	111.382	0.8978111
2004-05	534.3717	3149.247	38.94011	121.597	0.8223887
2005-06	569.3871	3258.480	43.96862	130.161	0.7682793
2006-07	597.2613	3347.000	46.88748	138.971	0.7195746

Table 5 : SPSS result: Log transformation

Year	Real output	Real capital	Real wages and salaries	Log output	Log Capital	Log labour	Tonnage per unit of labour	Log tonnage per labour
1990-91	266.2443	1628.53	19.32	5.58	7.4	2.96	121.63	4.8
1991-92	265.1945	1824.53	18.69	5.58	7.51	2.93	101.91	4.62
1992-93	284.4685	1937.47	19	5.65	7.57	2.94	148.23	5
1993-94	302.6279	2046.65	20.01	5.71	7.62	3	154.71	5.04
1994-95	364.0227	2153.05	26.38	5.9	7.67	3.27	179.2	5.19
1995-96	400.6698	2141.95	30.63	5.99	7.67	3.42	186.88	5.23
1996-97	401.8287	2291.35	36.46	6	7.74	3.6	184.23	5.22
1997-98	405.8451	2362.25	36.77	6.01	7.77	3.6	188.84	5.24
1998-99	406.1534	2407.27	35.72	6.01	7.79	3.58	209.5	5.34
1999-00	431.1018	2457.65	38.68	6.07	7.81	3.66	217.17	5.38
2000-01	477	2665.69	37.21	6.17	7.89	3.62	247.09	5.51
2001-02	520.8956	2812.51	40.1	6.26	7.94	3.69	246.23	5.51
2002-03	503.4296	2837.75	40.78	6.22	7.95	3.71	279.62	5.63
2003-04	500.404	3055.79	35.95	6.22	8.02	3.58	305.34	5.72
2004-05	534.3717	3149.25	38.94	6.28	8.05	3.66	349.4	5.86
2005-06	569.3871	3258.48	43.97	6.34	8.09	3.78	377.11	5.93
2006-07	597.2613	3347	46.89	6.39	8.12	3.85	423.89	6.05

Figure-1: Trends of cargo handling over time from 1990-2007

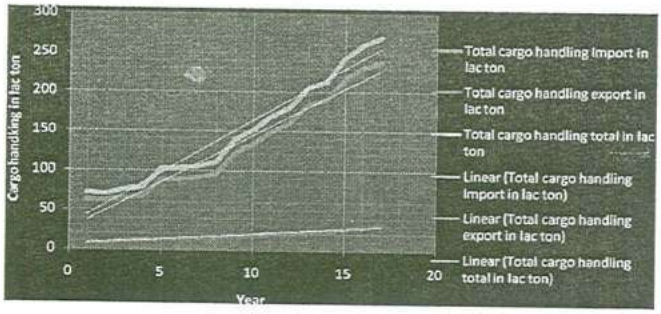
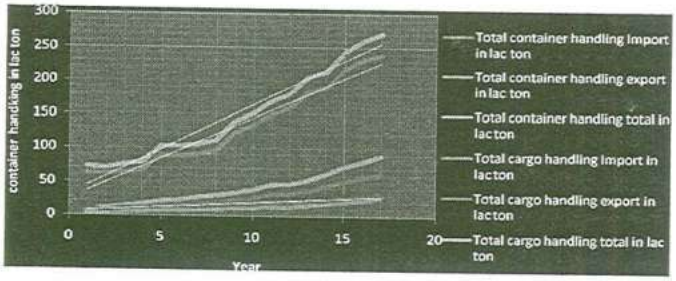


Figure-2: Trends of container handling over time from 1990-2007



First model

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.627	.984		.637	.535	-1.499	2.753
	LK	.413	.195	.334	2.119	.054	-.008	.835
	Ll	.361	.061	.434	5.918	.000	.229	.493
	log transfer of T/L	.172	.099	.257	1.730	.107	-.043	.386

a Dependent Variable: LQ

$$\ln Q = 0.627 + \underset{(0.984)}{0.413 \ln K} + \underset{(0.195)}{0.361 \ln L} + \underset{(0.0599)}{0.172 (T/L)} \quad \underset{(0.061)}{\text{———(1)}}$$

$R^2 = 0.99$

Adj. $R^2 = 0.98$

Durbin-Watson = 1.313

F = 291.917

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.085	3	.362	291.917	.000(a)
	Residual	.016	13	.001		
	Total	1.101	16			

a Predictors: (Constant), log transfer of T/L, Ll, LK

b Dependent Variable: LQ

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin - Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.993(a)	.985	.982	.03520	.985	291.917	3	13	.000	1.313

Coefficients (a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.811	.564		-1.439	.172	-2.020	.398
	LK	.712	.097	.576	7.369	.000	.505	.920
	Ll	.369	.065	.443	5.669	.000	.229	.508

a Dependent Variable: LQ