Applicability of the Linear CVP Model in the Indian Cement Sector

Mihir Dash*

ABSTRACT

The Cost-Volume-Profit (CVP) model is a model for analyzing a firm's cost and revenue structure, and it is widely used in practice to examine the possible impacts of a range of strategic decisions. In spite of its theoretical appeal, however, the CVP model has had very little application empirically.

This study examines the applicability of the CVP model empirically for the Indian cement sector using linear regression. The results of the study indicate that though the simple CVP model with linear cost and revenue functions does offer some interesting insights, there are anomalies in several cases. Thus, the CVP model with nonlinear cost and revenue functions may be more appropriate in explaining the cost and revenue structure for companies in the Indian cement sector.

Keywords: Cost-Volume-Profit (CVP) model, cost and revenue structure, linear regression.

INTRODUCTION

The Cost-Volume-Profit (CVP) model is a model for analyzing a firm's cost and revenue structure, summarizing the consequence of changes in sales volume on the firm's costs, revenues, and profits. The simple CVP model was introduced by Hess (1903) and Mann (1903-07), with linear cost and revenue functions. Even though it is relatively simplistic, it is a very versatile technique for profit planning, and it is extensively used in practice to examine the possible consequences of a range of strategic decisions, including pricing policies, product mixes, market expansions/contractions, outsourcing, plant utilization, and so on (Brealey and Myers, 1991; Horngren et al, 1994).

The simple linear CVP model has several inadequacies. The model assumed linear cost and revenue functions, which prevented it from capturing some significant nonlinear phenomena, such as the range of profitability and the optimal point. Several studies have incorporated nonlinear costs and revenues in the CVP model (Guidry et al, 1998). Also, the CVP model was a deterministic model, and was thus not effective in the case of decision-making under uncertainty. Several extensions to the CVP model were proposed to include uncertainty conditions (Jaedicke and Robichek, 1964; Hilliard and Leicth, 1975); and Adar et al (1977) and Kottas et al (1978) proposed general models for CVP analysis under uncertainty. Further, Kottas and Lau (1978) applied simulation techniques for stochastic CVP analysis. Also, the CVP model was essentially a single-variable model, applicable only in the case of a single product or a fixed product mix. González (2001) proposed an extension of the CVP model for multiproduct firms. Some other extensions of the CVP model are: learning effects (McIntyre, 1977), capital structure (Guidry et al, 1998; Kee, 2007; Prihadyanti, 2011), cost stickiness (Banker et al, 2013), and several others.

In spite of its theoretical appeal and its several extensions, the CVP model has had very little application empirically. Xishuan and Huifang (2008) employed a linear regression model to empirically test the CVP model, with profit as the dependent

*Alliance University Bangalore, India

variable, and sales volume, variable costs, and fixed costs as the independent variables; however, this specification clearly suffers from multicollinearity. The present study analyses the applicability of the linear CVP model empirically for the Indian cement sector using linear regression.

Model Specification

The study considers the simple CVP model with linear cost and revenue functions. The model assumes a linear cost function $TC=FC+vx$ and a linear revenue function $TC=px$. The viability condition for the firm (i.e. the condition for the firm to be profitable at some level of production) is that $P>V$, and, under this assumption, the break-even point is given by $BEP= \frac{FC}{p-v}$

A simple sustitution yields the equation $TC=\frac{pFC}{v}+\frac{p}{v}TC$

implying a linear relationship of TR on TC, with a negative intercept, and, under the assumption of viability, a slope greater than one. On the other hand, a similar substitution yields the equation $TC=FC+\frac{v}{p}TR$ also implying a linear relationship of TC on TR, with positive intercept, and, under the assumption of viability, a slope lying in the unit interval, i.e. between zero and one.

In particular, the regression coefficients above are linked with the percentage contribution margin, 1 - v/p, which is equivalent to the rate of change of contribution margin with respect to total revenue, and thus would be closely related with profitability. The regression coefficients can thus be used as a basis for comparison of profitability performance between companies in the same industry, and between different sub-segments of an industry.

Methodology

The objective of the study is to explore the applicability of the linear CVP model as discussed in the preceding section in explaining the cost and revenue structure in the Indian cement sector. The data for the study was collected for a sample of twenty-two large cement companies and seven small/medium cement companies from the Capitaline[1] database, based on data availability. The sample companies were further classified into region (North and South India). The study period was 2003-2012. The data pertaining to the costs and revenues for each company was obtained from the income statement. The costs included raw materials costs, power & fuel costs, employee costs, other manufacturing expenses, selling & administrative expenses, and miscellaneous expenses, while the revenues included the sales turnover.

The cost-revenue relationship was analysed using linear regression in accordance with the models specified in the preceding section. The regression results are presented in Table 1. The regression coefficients were used to compare the profitability performance of North and South India based companies as well as large and small/medium companies using two-way ANOVA without interaction. The results of the two-way ANOVA tests are presented in Tables 2 and 3.

Findings

The results in Table 1 show that all of the regressions were statistically significant, with a coefficient of determination of at least 85%, except for Cement Corporation of India, with a coefficient of determination of 61.0%.

Table : results of regression of TR on TC and TC on TR

			TR on TC		TC on TR			
	region	size	slope	intercept	slope	intercept	R^2	F Stat
ACC	N	L	1.32**	609.66	0.73**	-274.99	96.70%	253.89**
Ambjua Cements	N	L	1.39**	604.88*	0.71**	-350.05	98.20%	429.69**
Andhra Cements	S	L	1.41**	-36.54	0.68**	33.54*	95.60%	131.86**
Birla Corporation	N	L	1.47**	-14.59	0.61**	150.05	88.80%	63.17**
Burnpur Cement	N	L	1.17**	1.18*	0.86**	-0.94*	99.60%	2170.35**
Cement Corporation of India	N	L	1.21**	-15.6	0.51**	102.19*	61.00%	12.52**
Chettinad Cement Corporation	S	L	1.72**	-34.38	0.57**	31.14	98.20%	437.37**
Gujarat Sidhee Cement	N	L	1.28**	-23.16	0.77**	23.61	98.10%	412.01**
Heidelberg Cement India	N	L	1.22**	36.89	0.80**	-15.98	97.80%	356.96**
India Cements	S	L	1.39**	123.66	0.68**	10.83	95.10%	155.05**
JK Cements	N	L	1.36**	55.52	0.72**	-15.1	98.00%	299.52**
JK Lakshmi Cement	N	L	1.73**	64.29	0.70**	-11.75	95.70%	177.32**
KCP	S	L	1.42**	8.27	0.68**	0.95	97.00%	258.39**
Kalyanpur Cements	N	L	0.84**	33.42*	1.08**	-19.55	89.80%	70.49**
Madras Cements	S	L	1.57**	57.21	0.63**	-10.71	98.00%	395.82**
Mangalam Cement	N	L	1.51**	-17.79	0.61**	35.26	92.80%	103.38**
Prism Cement	N	L	1.08**	265.26**	0.92**	-237.45**	99.60%	2101.64**
Sanghi Industries	N	L	1.37**	29.62	0.70**	-4.16	96.40%	214.92**
Saurashtra Cement	N	L	1.18**	-8.09	0.83**	14.59	97.70%	332.58**
Shree Cement	N	L	1.54**	175.28	0.64**	-87.45	98.30%	470.76**
Shree Digvijay Cement	N	L	1.14**	28.12	0.83**	-10.2	94.20%	130.82**
Ultra Tech Cement	N	L	1.43**	177.88	0.70**	-96.8	99.50%	1408.53**
Gangotri Cement	N	SM	1.05**	-0.04**	0.95**	0.04	99.90%	4915.11**
Barak Valley Cements	N	SM	1.04**	14.39**	0.93**	-11.35*	96.40%	213.68**
Nirman Cements	N	SM	1.18**	-0.48	0.81**	0.53*	95.00%	133.58**
OCL India	N	SM	1.43**	-1.88	0.69**	9.75	98.80%	569.60**
Sainik Finance & Industries	N	SM	0.80**	3.73*	1.07**	-2.55	85.00%	45.43**
Anjani Portland Cement	S	SM	1.61**	1.5	0.61**	0.61	98.10%	418.66**
Bheema Cements	S	SM	1.16**	7.36	0.79**	-1.16	91.20%	83.05**

[1] www.capitaline.com

First considering the linear regressions of total revenues on total costs, it was found that all of the regression coefficients were greater than one, except for Kalyanpur Cements and Sainik Finance & Industries, both of which had incurred losses during the study period. The regression coefficients of Barak Valley Cements, Gangotri Cement, and Prism Cement were relatively low, less than 1.10, indicating that these companies may be at risk of loss. On the other hand, the regression coefficients of JK Lakshmi Cement and Chettinad Cement Corporation were relatively high, greater than 1.70, indicating higher profitability.

However, the regression constants were negative only for ten of the sample companies, and significant only for Gangotri Cement; for the remaining nineteen sample companies, the regression constants were positive, and significant for six of these. This could have resulted from the slump in demand in the construction sector during the study period. Another possibility could be that some of the sample companies have undertaken expansion strategies, which could increase the fixed costs without an immediate increase in sales.

Similarly for the linear regressions of total costs on total revenues, it was found that all of the regression coefficients were less than one, except for Kalyanpur Cements and Sainik Finance & Industries, and were relatively high (greater than 0.90) for Barak Valley Cements, Gangotri Cement, and Prism Cement, corresponding with the linear regressions of total revenues on total costs. Once again, the regression constants were positive for only thirteen of the sample companies, and significant for three of these; for the remaining sixteen of the sample companies, the regression constants were negative, and significant for three of these.

In summary, the linear CVP model seems to be appropriate only for the following sample companies (i.e. only fourteen of the twenty-nine sample companies): Burnpur Cement, Gujarat Sidhee Cement, JK Cements, Madras Cements, Mangalam Cement, Prism Cement, Shree Cement, Shree Digvijay Cement, Ultra Tech Cement, Gangotri Cement, Barak Valley Cements, Sainik Finance & Industries, Anjani Portland Cement, and Bheema Cements.

Table 2: results of two -way ANOVA for regression coefficients of TR on TC

	Coeff	Std. Error	t Stat	p-value
Intercept	1.337	0.100	13.408	0.000**
[region= North India]	-0.218	0.089	-2.464	0.021*
[region= South Ind ia]	-	-	-	-
[size= large enterprises]	0.184	0.089	2.071	0.048*
[size= small/medium enterprises]	-	-	-	-

R^2 = 27.4%, F Stat = 718.91, p = 0.000**.

Table 3: results of two-way ANOVA for regression coefficients of T C on TR

	Coeff	Std. Error	t Stat	p-value
Intercept	0.747	0.061	12.264	0.000**
[region= North India]	0.124	0.054	2.300	0.030*
[region= South India]	-	-	-	-
[size= large enterprises]	-0.118	0.054	-2.172	0.039*
[size= small/medium enterprises]	-	-	-	-

R^2 = 26.7%, F Sta t = 623.23, p = 0.000**.

The results of the ANOVA tests indicate that South India based cement companies were significantly more profitable than North India based cement companies, and that large cement companies were significantly more profitable than small/medium cement companies.

Discussion

The results of the study indicate that the simple CVP model with linear cost and revenue functions is applicable for only a section of companies in the cement sector, and there are anomalies in several cases. The results of the study suggest that nonlinear cost and revenue functions may be more appropriate than the simple linear CVP model in explaining the cost and revenue structure of cement sector. This may be investigated further by considering quadratic cost and revenue functions, extending the simple CVP model.

Despite the anomalies, the regression coefficients were found to be in conformance with CVP theory. In particular, the

regression coefficients from the model can be used to compare company profitability performance within the sector, and between sub-segments of the sector. Of course, the relationship of the regression coefficients with company profitability needs to be empirically validated.

The results of the study indicate that South India based cement companies were significantly more profitable than their North Indian counterparts. This could be due to cost efficiencies of the South Indian cement companies, particularly in terms of lower distribution costs. This needs to be investigated further.

The results of the study also indicate that large cement companies were significantly more profitable than small/medium cement companies. This could reflect an economy of scale, with larger companies perhaps having a more efficient distribution network. This also needs to be analysed further.

There are some limitations inherent in the study. The sample size used for the study was limited, and based on data availability. Thus, the results of the study may not be generalisable for the entire cement sector, particularly for small, regional players. The study period also poses some difficulties, mainly due to unfavorable market conditions during the global financial crisis of 2008-09; on the other hand, there is a need to study the applicability of the CVP under these unfavorable market conditions. Another limitation is that the models used in the study assume a constant product mix.

There is great scope for further research in this area. Broader models can be developed, bringing in additional variables, including the product mix. The analysis can also be performed in other sectors. Also, specific models can be developed for CVP analysis for service sectors.

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