Macroeconomic and Microeconomic Determinants of Efficiency of Indian Construction & Engineering Firms: An Investigation

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Abstract

In an intensely competitive business world, it is of great importance that the firms must perform efficiently for long-term sustainability. The present study made a modest effort to shed some light on the efficiency of the select 47 construction and engineering firms and the different microeconomic and macroeconomic factors affecting such efficiency during the period 1999-2000 to 2018-2019. For the purpose of this study, Stochastic Frontier Analysis was used primarily to determine the firm level efficiency scores. Subsequently, the determinants of such firm level efficiency were looked into using Panel Censored Tobit Regression Model. The results of the study showed that leverage, size, age, openness, exchange rate and price factor were the important determinants of the efficiency of the construction and engineering firms during the period of study.

Key Words: Efficiency, Construction & Engineering Firms, Leverage, Size, Openness, Age, Exchange Rate, Price Factor.

INTRODUCTION

Infrastructure plays an instrumental role in stimulating economic growth and development (Mitra, Sharma & Veganzones , 2011) especially for a country like India. India is one of the fastest growing emerging economies of the globe. With 2.7 US$ trillion GDP, India is the fifth largest economy in the world. Moreover, India is the home of nearly 1.35 billion (17.7% of the world population) people which make it the second largest country in terms of population after China. With positive population growth rate, India is expected to overtake China which is currently experiencing negative population growth and by 2030 India is expected to have a population of nearly 1.5 billion. Such a huge population base along with rising urban population will become the engine of economic growth and development for India in coming years. However, the gap in the infrastructural development is one of the key concerns for the Indian economy. Thus, for having sustainable economic growth and development the lacuna in the infrastructure must be removed (Rajan, 2007). Among the constituent of the broad Bombay Stock Exchange (BSE) classified capital goods industry, construction and engineering industry is one of the most important organised sectors[1] consisting of construction companies and engineering companies.. The construction companies belonging to this sector are engaged in the activities of infrastructure development including construction of roads, highways, bridges, runways, real estate development, engineering, procurement and construction piling, diaphragm walling, ground treatment, tube leading, soil investigation, mine development

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[1] Asia Index Private Limited: S&P BSE All Cap Thematic Indices Methodology (June, 2015),P.18.

metallurgical and material handling projects covering civil, mechanical, electrical and instrumentation engineering etc. The size of construction sector is expected to reach Rs. 54914.4 billion by 2024 with a compound annual growth rate of 15.9%.[2] On the other hand, the Indian engineering sector has two segments such as heavy engineering and light engineering and the firms belonging to this sector are driven by the demand for capacity creation in sectors such as infrastructure, power, mining, oil and gas, refinery, steel, consumer durables, fertilizers, automobiles, textiles, cement, paper and construction. Size of the capital goods industry (of which the engineering sector is one of the most important constituents) is approximately $92 billion in 2019 which is anticipated to reach $115.17 billion by 2025.[3] Considering the huge scope of infrastructure development, housing, commercial and industrial construction the role of the construction and engineering industry can never be undermined. The Government of India has already enhanced its infrastructure development expenditure from $ 75.9 billion in financial year 2017-18 to $89.2 billion in 2018-19.[4] The role of construction and engineering sector has become even more important with the very recent announcement of infrastructure development expenditure to the tune of $1.5 trillion by Government of India in next five years.[5] The interlinkages with other industries in the economy, ability for employment generation, infrastructure development and contribution to the exchequer, make the construction and engineering sector a significant contributor in playing a pivotal role in the context of the growth of the Indian economy. Moreover, there are a large number of companies present in this sector. In BSE alone there are 103 listed companies belonging to this sector which make the sector densely competitive. Thus, the construction and engineering firms operating in such an extremely competitive business environment must be very efficient to survive in the long run.

The objective of the maximization of the shareholders wealth is largely dependent upon the level of efficiency of the firm at which it is operating. In a highly competitive business environment, it is of utmost importance to manage the business with the highest degree of efficiency to sustain in the long run (Maji, 2018a). The efficiency and the productivity of the firms get influenced by numerous factors which can broadly be clustered into firm specific factors, industry specific factors and macro economic factors (Sufian, 2009). Effective usage of the available resources, inputs, human capital, technology, size or scale and managerial potential have direct impact on the cost effectiveness of the firm which ultimately influences its profit as well as market value. Perhaps this is one of the most prominent reasons for which many research scholars have delved into the exploration of the level of efficiency of the firms and the underlying factors responsible for such efficiency. Such a kind of analysis is of great importance to the managers of the firms to identify the weakness and the strength associated with their firms and enables them to adopt appropriate managerial decisions and strategies so as to achieve the objective of the wealth maximization and optimum utilization of the available resources (Kundi & Sharma, 2016). The efficient firms are expected to be more profitable, having high firm value, possessing the inherent capacity to cope up with dynamic macroeconomic environment and enjoying greater degree of sustainability (Maji, 2018b). Determination of the efficiency of the firms is believed to be much talked about issue in the domain of academic research in abroad and in India. Because of the interlinkages between the efficiency and firm value, this area has been able to grab the attention of the scholars and still continuing to be the one of the most popular domain of research across the world. In a perfectly competitive liberalized economy where the prices of the factors of

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2 https://www.businesswire.com/news/home/20200901005633/en/India-Construction-Industry-Databook-2020-and-Impact-of-COVID-19---Short-Term-Investments-Will-Be-Driven-by-Government-Spending-in-the-Infrastructure-Sector---ResearchAndMarkets.com

3 https://www.ibef.org/industry/indian-engineering-industry-analysis-presentation#:~:text=Engineering%20export%20reached%20US%24%2076.28,US%24%20200%20billion%20by%202030.

4 https://m.economictimes.com/news/economy/infrastructure/government-allocates-rs-5-97-lakh-crore-for-infra-spending-in-2018-19/articleshow/62740220.cms

5 https://www.bloomberg.com/news/articles/2019-12-31/india-plans-1-5-trillion-infrastructure-spending-to-spur-growth

production are market determined, the only way to sustain is to attain the optimum level of efficiency and such efficiency in turn gets augmented because of the openness of the economy leading to an increased competition which ensure that the resources are put to optimum use (Driffield & Kambhampati, 2003).

REVIEW OF LITERATURE

For a long period of time the researchers have tried to evaluate the efficiency of the firms operating across the world because productive efficiency of the firms is a good indicator of financial performance. The efficient firms are believed to be profitable, highly valued, better equipped to cope with macroeconomic volatility and thereby believed to enjoy greater sustainability. The relative efficiency score of firms can also be used as a good predictor of possibility of bankruptcy too (Becchetti & Sierra, 2003). Because of these reasons, the efficiency analysis has been used by the scholars to assess the performance of the firms in different countries.

A number of factors affect the level of efficiency of a firm. For example, level of efficiency of the firms always gets positively affected due to the openness of an economy. It primarily happens because of the increased competition in the market which ensures that the resources put to optimum use (Driffield & Kambhampati, 2003). Bigsten et al. (2004) in their study also concluded that the ability to export made a significant contribution towards enhancing the level of efficiency of the African manufacturing firms. A similar observation was also made by Van Biesebroeck (2005) in respect of the Sub-Saharan manufacturing plants. In Indian context, Gambhir & Sharma (2015) showed that the export oriented textile firms were found to be more efficient as compared to the other ones. The underlying rationale may be that only the efficient firms engage themselves in foreign trade and in turn get benefited from exporting (Van Biesebroeck, 2005). However, it must be also to be acknowledged that creation of appropriate ecosystem is quintessential to promote efficiency by means of export. Reduction of industrial tariffs, withdrawal of industrial licensing and product licensing, deregulation, removal of restriction on import and export due to the economic reforms measures make the manufacturing firms more efficient (Kathuria, Raj & Sen, 2012). On the contrary, Arora & Singh (2020) argued that the productivity growth declined in the post-liberalization regime as compared to the pre-reform era. Unfortunately, in India, the small firms also could not exploit the advantage stemmed out of the liberalization measures (Kambhampati & Parikh, 2005).

Another major determinant of the efficiency of the firms is the size of the business. Large size firms are found to be more efficient than the smaller ones (Pitt & Lee, 1981; Firth,Leung, Rui & Na , 2015; Lundvall & Battese, 2000; Söderbom & Teal, 2004; Halkos & Tzeremes, 2007; Kalaitzandonakes, Wu & Ma, 1992). The small firms are generally believed to be less efficient than the large scale firms because of the economies of scale (Alvarez & Crespi 2003). On the contrary, Hanousek, Kočenda & Shamshur (2015) documented that larger firms especially the firms with high debt burden are generally found to be inefficient as compared to the small sized firms. The study conducted by Alvarez & Crespi (2003) revealed that for the small size manufacturing firms operating in Chile, innovation, experience of the workforce and modernization of the physical capital had significant positive impact on the efficiency of the small manufacturing firmswhereas education of the owner, new organizations and production subcontracting established themselves as the major determinants of the efficiency of small firms operating in Pakistan (Burki & Terrel, 1998).

Some of the important factors influencing the efficiency of the small size firms were age of the firms, technological up gradation, location, Government assistance, innovation of new products, R&D intensity, foreign collaboration, subcontracting, politically significant regions, female participation in the workforce, export orientation, industry characteristic, customer satisfaction and financial integration (Hill & Kalirajan, 1993;

Pelham, 2000; Yang, 2006; Yang & Chen, 2009; Hall, Lotti & Mairesse, 2009; Le & Harvie, 2010; Ahmed & Ahmed, 2013). Amongst other, conglomerate firms are generally found to be more efficient than other forms of strategic firms (Weston & Mansinghka, 1971). Agostino & Trivieri (2019) pointed out that availability of trade credit enables the small and medium size firms to be more efficient.

The existing literature also identified different factors having significant impact on the efficiency of the large size firms. Some of the important factors identified by the earlier research studies were size of the firm, age of the firms, ownership structure, number of employees, profitability, prevalence of competition, liberalization, export intensity , import penetration, labour cost, foreign ownership, capitalization, subsidies, management costs, education of the owners, quality of human capital, liberalization, R & D, existence of crimes and political risk, infrastructure, product diversification and international diversification, use of technology, managerial efficiency, remuneration to the top management and workers, market to book value ratio, financial leverage, Government quality, taxes, foreign investment and training cost of the employees (Pitt & Lee, 1981; Blomström, 1986; Kumbhakar Ghosh & McGuckin, 1991; Zheng, Liu & Bigsten, 1998; Chuang & Lin, 1999; Piesse & Thirtle, 2000; Chapelle & Plane, 2005; Ismail & Sulaiman, 2007; Yu, Barros, Yeh, Lu, & Tsai, 2012; Forlani, 2012; Doaei, Ahmad Anuar & Ismail, 2015; Giokas, Eriotis & Dokas , 2015; Firth et al., 2015; Jain, Kundu & Newburry, 2015; Baek & Neymotin, 2016; Pilar, Marta & Antonio, 2018; Maji, Laha & Sur , 2020a; Mazorodze, 2020).

Hanousek et al. (2015) suggested that the efficiency of the firms also depends upon the control of the domestic owners and the importance of the minority shareholder. It is believed that the level of corruption reduces the investment efficiency of the firms (O'Toole &Tarp, 2014). On the other hand, use of information and communication technology enables the firms to be more efficient (Thatcher & Oliver, 2001; Castiglione & Infante, 2014). Early adopter of the state of the art information technology enjoys competitive advantages in the market place. However, as the same technology becomes common such competitive advantage vanishes with time (Weill, 1992). Firms try to obtain competitive advantage using the R & D and product innovation, that in turn makes the firms efficient (Chuang & Lin, 1999; Diaz-Balteiro, Herruzo, , Martinez & Gonzalez-Pachon, 2006; Ismail & Sulaiman, 2007). On the contrary, Crowley & McCann (2015) could not find any significant relationship between the innovation and the productivity of the Irish firms. Apart from this, ownership structure to a great extent dictates the efficiency of the firms (Blomström, 1986; McConaughy,Walker, Henderson Jr, & Mishra , 1998; Vining & Boardman, 1992; Golder, Renganathan & Banga 2004). Fahmy-Abdullah, Sieng & Isa (2018) in their study observed that the Malaysian textile manufacturing firms were found to be highly efficient. The outcome of the study also showed that the level of education of the workers, prevailing wage rate and intensity of the use of information and communication technology were the major determinants of such efficiency. Machmud, Nandiyanto & Dirgantari (2018) also found the Indonesian chemical firms to be highly efficient which was primarily driven by the existing market share rather than firm age, ownership and capacity utilization etc. during 2010 to 2015. On the contrary, findings of the study carried out by Ngo, Le, Tran, Nguyen & Nguyen (2019) revealed that the firm size and age, export orientation and foreign ownership were the most important factors affecting the efficiency of the manufacturing firms in Vietnam during 2010 to 2016. A comprehensive study on the Chinese manufacturing sector over the period from 1997 to 2002, Walheer & He (2020) also pointed out that foreign owned and private firms were found to be more efficient as well as technologically superior to the domestic and state owned counterparts. In a different approach Enison (2005) and Odior (2013) identified various macroeconomic factors affecting the firm efficiency.

In the context of Indian glass industry Kundi & Sharma (2016) revealed that more or less all the firms were found to be efficient but experienced foreign small size firms were found to be more efficient than the other firms. In another study, Kundi & Sharma (2015) showed that foreign controlled large scale cement companies operating in

India were more efficient than the small and medium counterparts. Gambhir & Sharma (2015) postulated that large size Indian textile firms were found to be more efficient as compared to the smaller ones because of the economies of scale. In the context of Indian textile firms Bhandari & Maiti (2007) found that size and age of the firms were the most important factors affecting efficiency and they also concluded that the private sector firms were observed to be more efficient as compared to the firms belonging to the public sector firms. Mahajan, Nauriyal & Singh (2018) showed that ownership type, size and capital imports positively affect the efficiency of the Indian pharmaceutical firms whereas the effect of age and size square were found to be adverse. In another study Mahajan (2020) observed the firm age and export intensity to be exerting negative effect on the productivity growth of Indian pharmaceutical firms. In the context of the state of Haryana, Sharma & Sehgal (2015) attempted to explore the impact of the macroeconomic and infrastructural variables on the efficiency of the firms. The outcome of the study revaled that innovation must be fostered and the resources must be put to optimum use to enhance the efficiency of the firms operating in India. Huang, Jiang & Miao, (2016) found that Government subsidies enhance the innovation efficiency of the firms. Moreover the marketing facility provided by the Government helps the firms in making more efficient (Cull, Xu, Yang, Zhou & Zhu, 2017).

In an effort to determine the efficiency of the Indian engineering industry, Golder, et al., (2004) suggested that foreign engineering firms were more efficient than the domestic counterparts and however no difference of efficiency was noticed between the private and public engineering firms. Moreover, the findings of the study also indicated the start of the process of convergence of efficiency of the foreign and domestic engineering firms operating in India. In a cross country framework, Park, Yoo, Lee, Kim & Kim (2015) showed that the Korean construction firms were found to be more efficient as compared to the Japanese and Chinese rivals. Sharma (2017) in a comprehensive study suggested that size, export orientation and technology transfer from developed countries are the major source of efficiency of Indian manufacturing firms. In a very recent cross-sectional study carried out by Singh, Ashraf & Ashish (2019) revealed that Indian manufacturing firms are highly efficient and such efficiency gets boosted by firm specific factors such as innovations capability through in house R & D or acquired patents, waste management systems and efficient workforce. Jangili (2019) in an effort to examine the effect of firm size and group affiliation found out that large size and group affiliated Indian firms were found to be less cost efficient. In recent time Maji (2018a; 2018b) and Maji et al., (2020a) tried to explore various microeconomic as well as macroeconomic variables affecting selected manufacturing sub-sectors in India. The outcome of these studies revealed that leverage, age, size, openness, growth, inflation and exchange rate were the major determinants of firm efficiency.

A number of studies have been carried out relating to the determination of efficiency for different sectors in India. However, there is a dearth of literature which has attempted to identify the efficiency and the determining factors (especially macroeconomic factors along with individual firm attributes) in the Indian construction and engineering sector.

OBJECTIVES OF THE STUDY

The present study will make a modest effort to shed some light on the following objectives:

1. To assess the level of efficiency of the firms operating in the construction and engineering sector.
2. To investigate into the different firm-specific and macroeconomic factors affecting such efficiency.

DATA AND METHODOLOGY

The study is predominantly analytical in nature. 47 construction and engineering firms were randomly selected from the total 103 BSE listed construction and engineering firms for the purpose of this study. The annual financial data on raw material cost, employee cost, power and fuel cost, gross block of asset, value of output, firm age, size, growth, leverage and openness for the select companies for the period from 1999-2000 to 2018-2019 were collected from the Capitaline Corporate Database. The macroeconomic data on economic growth as indicated by Index of Industrial Production (IIP), inflation as proxied by Wholesale Price Index (WPI), Money Supply (MS) as captured by broad money M3, interest rate as reflected by Call Money Rate (CMR) and exchange rate as measured by Real Effective Exchange Rate (REER) were collected from RBI, Database on Indian Economy. The selection of the firm specific and macroeconomic variables was done based on the insights obtained from the existing literature. However, while considering the macroeconomic variables it was noticed that IIP, WPI and MS possessed high degree of correlation with each other (See Appendix Table A.1). For example the correlation coefficients between IIP and WPI, IIP and MS and WPI and MS were found to be 0.943, 0.963 and 0.993 respectively. Existence of such a high degree of correlation may result in multicolineraity problem in the empirical estimation. In order to overcome such a problem Principal Component Analysis (PCA) was used to develop an indicator which captures the effect of these highly correlated macroeconomic variables. The new variable obtained was named as 'Price Factor' (PF). In determining PF, the factor loadings were not directly used as respective weights. Rather, in the first instance, factor loadings were determined using PCA and subsequently these factor loadings were normalized by scaling to unity sum as per the methodology suggested by Joint Research Centre-European Commission (2008). The final weights were 0.33 for IIP, 0.33 for WPI and 0.34 for MS to construct PF.(See Appendix Table A.2) The clubbing of these three macroeconomic variables can be justified using the following arguments. Firstly, as pointed out earlier that the pair wise correlations coefficients for IIP, MS and WPI were very high. Therefore, it was prudent to club these variables together using PCA. Secondly, as per the Quantity Theory of Money, inflation rises with an increase in the MS in the economy due to increased demand (Lucas, 1980). Similarly, it is also well documented in the literature that with an increase/decrease in the MS, the economic activity also expands/contracts (Friedman & Schwartz, 1963; Sims, 1972; Thornton, 1993; Ogunmuyiwa & Ekone, 2010).Therefore, following these couple of logics it can be inferred that with the increase in the MS both inflation and IIP rises. Further, following the Philips Curve Theory it can also be argued that unemployment rate and inflation are negatively associated with each other (Ram & Spencer, 1983). Therefore, as employment increases (which can only happen in the event of increasing real economic activity) the inflation in the economy will also rise clearly indicating that the economic activity and inflation are also positively associated. Similar kind of methodology was also adopted by Tripathi & Seth (2014) and Maji, Laha & Sur (2020b) to club these macroeconomic variables together while exploring the effect of macroeconomic variables on the stock market in Indian context. The detailed descriptions of the variables used in the study are presented in Table 1.

Table 1 : Descriptions of the Variables

Variables			**Descriptions**
Variables used in the production function	Inputs	Raw Material Cost (RMC)	Natural logarithm of Raw Material
		Employee Cost (EC)	Natural logarithm of Employee Cost
		Power and Fuel Cost (PWFC)	Natural logarithm of Power and Fuel Cost
		Gross block of Asset (GBA)	Natural logarithm of Gross block of Asset
	Output	Value of Output (VO)	Natural logarithm of Value of Output

Variables used as the determinants of efficiency	Firm-Specific Factors	Leverage	Debt/Equity
		Age	Natural logarithm of (current relevant year – year of inception)
		Size	Natural logarithm of total assets of the firm
		Growth	[(Current year Net Sales – Previous year Net Sales)/ Previous year Net Sales]*100
		Openness	(Export + Import)/Total Sales
	Macroeconomic Factors	Exchange Rate	Natural logarithm of Real Effective Exchange Rate
		Price Factor	[(0.33×ln(IIP)+0.33×ln(WPI)+0.34×ln(MS)]
		Interest Rate	Natural logarithm of Call Money Rate
Source: Author's own compilation			

For the purpose of assessing the efficiency of the firms popular techniques like data envelopment analysis and Stochastic Frontier Analysis (SFA) were used by the researchers in the existing literature (Düzakın & Düzakın 2007; Driffield & Kambhampati, 2003; Sufian, 2009; Kathuria et al., 2012). For the purpose of determining the technical efficiency of the construction and engineering firms, SFA (Coelli, 1996) has been applied in the first stage under the panel data framework. Specific stochastic frontier production function model which has been estimated is as follows:

$$VO_{it} = \beta_0 + \beta_1 \quad (GBA_{it}) + \beta_2(RMC_{it}) + \beta_3\,(PFC_{it}) + \beta_4\,(EC_{it}) + (V_{it} - U_{it})$$

Where V represents random error which is associated with random factors outside the control of the firm, $_U$ represents one sided inefficiency component, Maximum likelihood Estimates of the parameters of the model can be obtained together with the variance parameters expressed as $s^2 = s_u^2 + s_v^2$ and $\gamma = \frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}$ The parameter, g, has a value between zero and one, such that the value of zero is associated with traditional response function. The model also estimates the value of Mu which is the inefficiency in the model and eta representing the change of inefficiency of the firms over the time.

Technical efficiency of a firm at a given period of time is defined as the ratio of the observed output to the frontier output which could be produced by a fully efficient firm, in which the inefficiency effect is zero. Thus technical efficiency is defined as

$$\text{Efficiency}_i = \frac{Y_i}{f(x;\beta)} = \frac{f(x;\beta)e^{-u_i}}{f(x;\beta)} = e^{-u_i}$$

In order to assess the effect of different firm-specific and macroeconomic factors on the technical efficiency Panel Censored Tobit Regression Model was applied in the second stage. The motivation of using Panel Censored Tobit Regression Model is that the value of the dependent variable i.e. efficiency varies between 0 to 1, as other models are incompetent to account for the censored and limiting value of the dependent variable. The econometric specification of the empirical model used in the study is as follows.

$$\text{Efficiency}_{it} = \lambda_0 + \lambda_1(\text{Leverage})_{it} + \lambda_2(\text{Growth})_{it} + \lambda_3(\text{Size})_{it} + \lambda_4(\text{Age})_{it} + \lambda_5(\text{Openness})_{it} + \lambda_6(\text{Exchange Rate})_{it} + \lambda_7(\text{Price Factor})_{it} + \lambda_8(\text{Interest Rate})_{it} + \varepsilon_{it}$$

Where l $_i$s are the parameters to be estimated, firm and time are denoted as 'i' and 't' respectively, i = 1,2, ...N and time t = 1,2, ...T.

ANALYSIS OF THE FINDINGS

In this section, firstly the production function was estimated using SFA and subsequently the microeconomic and macroeconomic determinants of such efficiency had been explored using panel censored tobit model.

Table 2 : Estimates of Production Function of Construction & Engineering Sector

Variables	Coefficients	t-ratio
Constant (β_0)	1.9212	3.8331
Gross Block of Assets (β_1)	0.8953	38.4125
Raw Material Cost (β_2)	0.0232	2.0001
Power and Fuel Cost (β_3)	-0.0001	-0.0200
Employee Cost (β_4)	0.0970	10.8321
Sigma-squared	1.8214	4.2512
Gamma	0.2975	1.7299
Mu	0.8214	0.7985
Eta	0.0092	0.8124
N	940	
Source: Source: Author's own compilation		

It can be seen from the analysis of the production function (Table 2) that the coefficients associated with the inputs such as gross block of assets (β_1), raw material (β_2) and employee cost all were found to be positive and statistically significant at 1% in respect of the construction & engineering sector. It shows that these inputs were used effectively by the construction and engineering firms to generate the output. However, the Construction and Engineering firms were found to be marginally inefficient in terms of the usages of power & fuel. The value of gamma in the production function was found to be 0.2975 however this value was not found to be statistically significant. It indicates that the stochastic frontier model may not be significantly different from the deterministic trend frontier where there is no random error term considered in the production function (Coelli, 1996). The value of sigma-squared was found to be 1.8214 which denotes the prevalence of the variation in the efficiency amongst the firms during the period of study. Mu (indicator of the existence of the inefficiency amongst the firms) and the eta (indicator of the change of inefficiency over the period of study) were found to be statistically insignificant.

Table 3 : Summary Statistics

Variables	Mean	S.D.	C.V.	Max	Min
Efficiency	0.51	0.30	58.82	0.94	0.05
Leverage	1.80	1.98	110.0	3.68	0.03
Growth	120.2	85.0	70.71	201.2	5.23
Size	7.32	8.84	120.76	10.20	3.61
Age	3.37	4.02	119.28	5.21	2.30
Openness	0.17	0.23	135.29	0.91	0.00
Exchange Rate	4.73	0.06	1.27	4.57	4.78
Price Factor	6.78	0.44	6.48	7.37	6.09
Interest Rate	1.89	0.35	18.52	2.64	1.27
Source: Author's own compilation					

The summary statistics of the different variables used in the study are presented in Table 3. Average efficiency score of the construction and engineering sector was found to be moderate (0.51) during the study period. The in-depth analysis as made in the study revealed that out of 47 sample firms 14 (30%) , 24 (51%) and 9 (19%) firms found place in the low (efficiency value less than 0.40) , medium (0.40 to 0.70) and high (above 0.70) efficiency categories respectively. A total of 81% of the firms in the sector were found to be within low and moderate levels of efficiency during the study period. The Coefficient of Variation (CV) of the efficiency score for the sector was found to be 58.82 which implies that there exists a notable variation in efficiency amongst the firms pertaining to the construction and engineering sector during the period of study. Prevalence of such inter-firm variation in efficiency is also confirmed by the statistically significant value (1.8214) of sigma-squared. The analysis of the Standard Deviation (SD) and CV for other firm specific factors such as leverage, age, size and openness also indicated the existence of inter-firm variation in terms of these firm characteristics. However, the inter-firm variation was found to be comparatively lower in case of growth of the firm. The mean and SD values of the macroeconomic factors such as exchange rate, price factor and interest rate were observed to be 4.73 ± 0.06, 6.78 ± 0.44 and 1.89 ± 0.35 respectively. Low SD and CV values corresponding to these selected time variant macroeconomic variables suggest that all these macroeconomic factors did not fluctuate abruptly during the period of study. It is to be noted that there cannot be any inter-firm variation for the macroeconomic variables used in the study as they remain same for all firms across all industries and changes with time only (Brooks, 2014). The year wise variation in the trends of the variables used in the study is exhibited in Figure A.1 in Appendix.

Table 4 : Determinants of Efficiency of Construction and Engineering Sector

Variables	Coefficients	Z-values	p-values	VIF
Leverage(λ_1)	0.0003958	3.18	0.001	1.03
Growth(λ_2)	-8.03e-09	-0.11	0.910	1.01
Size(λ_3)	0.0026769	22.55	0.000	1.75
Age(λ_4)	0.0009156	3.02	0.003	1.14
Openness(λ_5)	-0.0091646	-15.94	0.000	1.21
Exchange Rate(λ_6)	-0.0078868	-1.96	0.050	2.32
PF (λ_7)	0.0318849	58.36	0.000	2.75
Interest Rate (λ_8)	-0.0005423	-1.39	0.164	1.06
Constant (λ_0)	0.2888474	17.58	0.000	Mean VIF=1.53
N	849	Wald Chi square	7856.71	
Log-likelihood	2387.6107	p-value	0.0000	
Source: Author's own computations				

In Table 4, the results of the panel censored tobit model are presented to unearth the determinants of the technical efficiency of the construction and engineering firms during the study period. From the analysis of the determinants of the efficiency of construction and engineering firms it can be seen that leverage, size and age were found to have positive and statistically significant impact on the efficiency of the firms during the period of study. It is generally proposed that the firms which have greater amount debt in the capital structure are likely to more efficient and productive. The greater financial burden in the form of interest induces the firm to be more disciplined in conducting its business operations which ultimately results in higher efficiency (Majumdar, 1997). The findings

of the study reflect that the highly levered construction and engineering firms were more efficient as compared to the firms having lower degree of leverage during the study period which is in line with the studied carried out by Grossman & Hart (1982) and Opler & Titman (1993).

The positive effect of size and age of the firm on the efficiency is well documented in the existing literature. Large sized firms are in a better position to exploit the economies of scale which enables the firms to attain greater level of efficiency as compared to the smaller ones. In addition to this, large sized firms also enjoy greater bargaining power in the factor market and easy access to credits (Maji et al., 2020a). The outcome of the study supports this theoretical proposition (Firth et al., 2015; Lundvall & Battese, 2000; Söderbom & Teal, 2004; Halkos & Tzeremes, 2007). Similarly the study reveals that older firms were more efficient as compared to the younger and relatively inexperienced firms. The positive age effect intuitively signifies that as the firms get older there is learning curve effect which enables the firms to put in place prudent operating policies to reduce cost (Majumdar, 1997). Moreover, the experienced firms are also better able to put the available resources to optimum use which makes them efficient. However, it can be seen that openness had a statistically significant negative effect on the efficiency of the firm and the coefficient associated with the rate of exchange was also found to be negative which indicates that majority of the firms were heavily dependent on imports. Thus it can be said that that the import oriented construction and engineering firms were found to be inefficient during the period of study.

It is interesting to note that the effect of PF (which is actually a comprehensive index consisting of IIP, WPI and MS) on the efficiency of the construction and engineering firms was found to be positive and statistically significant. In the event of increasing MS the overall demand in the economy gets boosted and as a consequence the real economic activity also steps up. Such an increased demand in the economy creates opportunity to the firms to enhance the operational scale and as a result firms get benefited through increased efficiency on account of economies of scale. Moreover, the positive impact of PF also indicates that the firms could handle the challenges emanating from the increase in the price level. It may be due to the fact the during inflation the firms become more disciplined and organised so as to reduce the impact of increasing price through higher level of efficiency (Maji, 2018a). Therefore, the overall effect of the principal component 'PF' was noticed to be positive and statistically significant on the level of efficiency of the construction and engineering firms during the period of study. Firm growth amongst the microeconomic factors and interest rate amongst the macroeconomic variables were found to be the insignificant determinants of firm level efficiency during the study period.

Table 4 shows that none of the VIF values corresponding to any independent variable exceeded 3 and the mean VIF was 1.53 which is much less than the cut off value of 10. Moreover, none of the pair wise correlation coefficients amongst explanatory variables was found to be high. The three macroeconomic variables (IIP, WPI and MS) which were having high degree of positive correlation were already clubbed to construct a new variable (PF). Therefore, there is no multicolineraity problem in the estimated empirical model.

CONCLUSION AND POLICY IMPLICATIONS

Effort has been made in this study to explore the level of efficiency of the construction and engineering sector and also to illuminate the firm-specific and macroeconomic determinants of such efficiency. The results of the study showed that the construction and engineering firms could utilize the available resources such as gross block of asset, human resources and raw material effectively during the period of study. However, inefficiency in using the power and the fuel cost was also noticed among the construction and engineering during the period of study. The outcome of the study is also suggestive of the prevalence of the variation of efficiency among the firms during the

study period. Evaluation of the firm-specific and macroeconomic determinants of the efficiency of the construction and engineering firms revealed that the leverage, firm size, age, openness and inflation were the instrumental variables. The impacts of firm growth and rate of interest were found to be statistically insignificant. Thus it can be said that the firms that were highly levered were more efficient as compared the less levered firms which is consistent with the generally accepted theoretical argument. Similarly, the effect of size and age of the firms on the firm-level efficiency was found to be favourable which is well accepted in the literature.. The coefficient associated with the openness and rate of exchange was found to be negative which emphasized that the construction and engineering firms were very much dependent on import and thereby volatility in the rate of exchange had adverse effect on the level of efficiency. The effect of the PF comprising of IIP, WPI and MS on the efficiency was found to be exerting positive and statistically notable in the construction and engineering firms during the period of study.

As pointed out earlier, the average efficiency of the sector as a whole was found to be at moderate level and the efficiency level of majority of the firms were either low or moderate. Therefore, efforts should be made by the low and moderately efficient firms to ensure better use of the available resources to augment their efficiency. The coefficient associated with the power and fuel cost in the efficiency model for the sector as a whole was noticed to be negative. Thus appropriate managerial decisions are to be taken at the firm level to use this input more productively. Since, it was observed that the effects of openness and rate of exchange were found to be negative, it can be suggested that the construction and engineering firms should try to reduce the import dependence. The outcome of the study clearly indicated that small sized firms were found to be inefficient as compared to the older large sized firms. Therefore, it can be suggested that small firms can merge together to get converted into large sized firms with an aim to enhance operational efficiency due to economies of scale. Alternatively, the small firms can also continue to exist as the sub-contracting firms at the lower end of the value chain to survive efficiently in long run.

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APPENDIX

Table A.1 : Correlation Matrix

	Leverage	Growth	Size	Age	Openness	ER	IIP	WPI	MS	CMR
Leverage	1									
Growth	0.0406	1								
Size	0.0759	-0.0374	1							
Age	0.1187	-0.0386	0.3307	1						
Openness	-0.0865	-0.0214	0.3633	0.0714	1					
ER	0.0753	-0.0191	0.3891	0.1728	0.0218	1				
IIP	0.0534	0.0038	0.5147	0.2167	0.0607	0.5455	1			
WPI	0.1039	-0.0194	0.5129	0.2315	0.0393	0.5521	0.9431	1		
MS	0.0923	-0.0157	0.5197	0.2308	0.0441	0.5431	0.9632	0.9932	1	
CMR	0.0236	0.089	0.1023	0.0498	0.0011	0.2126	0.2279	0.2394	0.1923	1

Source: Author's own calculation

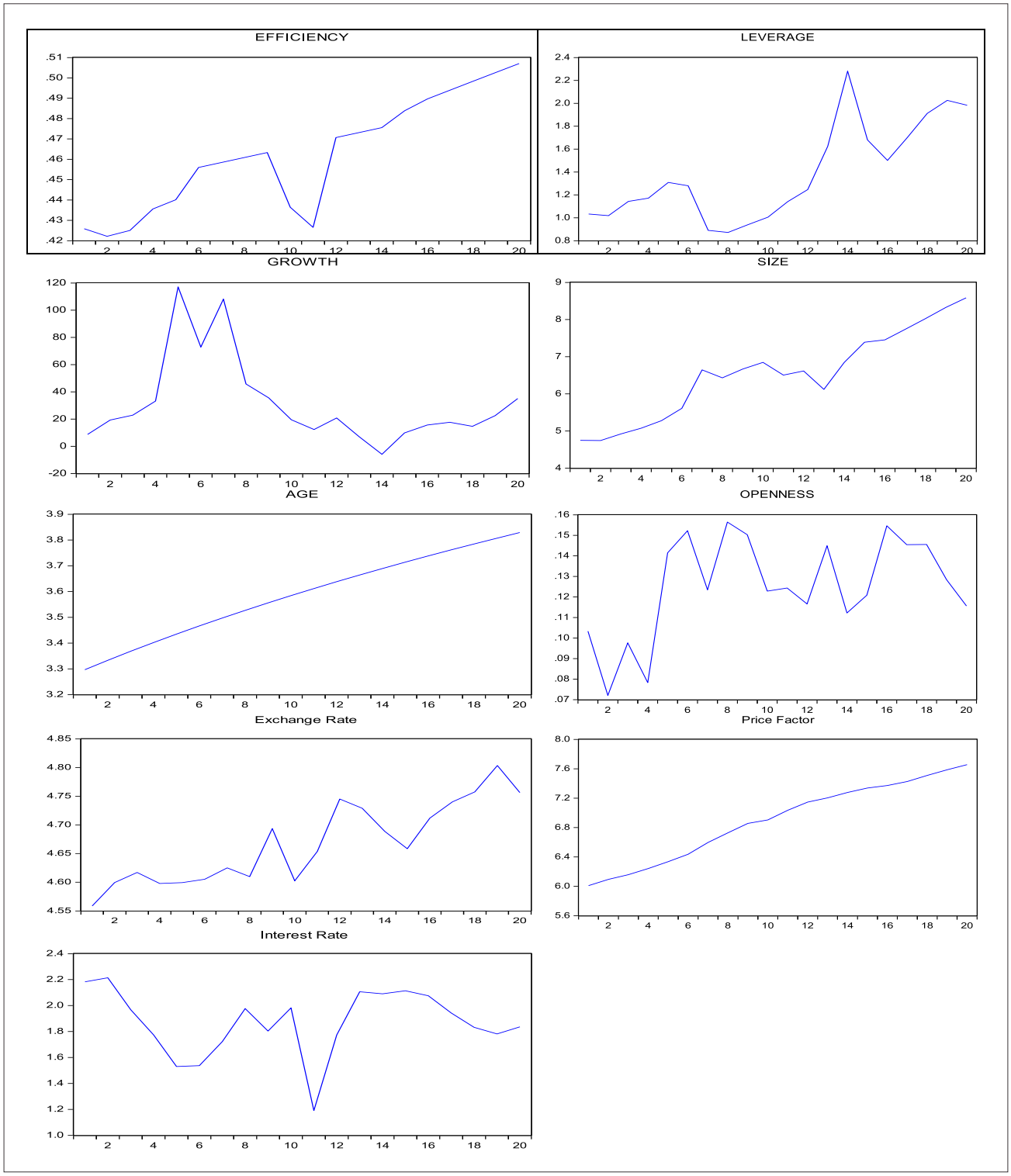
Table A.2: Result of PCA and Determination of Final Weights

Principal Component	Initial Eigen Values			Extractions sums of squared loadings		
	Total	percent of Variance	Cumulative percent	Total	percent of Variance	Cumulative percent
$lnPF_1$	2.937	97.914	97.914	2.937	97.914	97.914
$lnPF_2$	0.058	1.948	99.862	KMO Measure of Sample Adequacy = 0.644		
$lnPF_3$	0.004	0.138	100	X^2 = 88.194 (*p value* = 0.000)		

Principal Component $lnPF_1$						
Factors	Factor Loadings (A)	Squared factor loadings (B)	Normalized by scaled to unity sum	Weight	Normalized by scaled to unity sum	Final Weight
IIP	0.981	0.962	0.33	0.33	0.33	0.33
WPI	0.991	0.982	0.33	0.33	0.33	0.33
MS	0.997	0.994	0.34	0.34	0.34	0.34
Total	2.969	2.938	1	1	1	1
Explained Variation = Σ *Squared factor loadings*						2.938
$\frac{\textit{Explained Variation (EV)}}{\textit{Total Variation (TV)}}$						1

Source: Author's own calculation

Figure A.1 : Trends of the Variables



Note: 1, 2,.....20 in the x-axis of each graph is representing 1999-2000, 2000-2001,.....2018-2019. Due to the year format issues in the software, the financial years had to be denoted as 1,2,....20.

Source: Author's own representation