Benchmarking Canadian Oil and Gas Companies

Mohamed Dia[1], Pawoumodom M. Takouda, Amirmohsen Golmohammadi

Department of Finance and Operations, Faculty of Management, Laurentian University,
935 Ramsey Lake Road, Sudbury, ON, Canada P3E 2C6

mdia@laurentian.ca[2], mtakouda@laurentian.ca, agolmohammadi@laurentian.ca

Keywords: Data Envelopment Analysis, Benchmarking, Efficiency, Oil and Gas companies, Canada.

Extended abstract

In Canada, the oil and gas industry is one of the most important economic sectors. The country has the third-largest crude oil reserves in the World. In 2015, on a daily basis, the industry produced 14.9 billion cubic feet of natural gas (fifth largest in the world) and a total of 3.7 million barrels of crude oil (sixth largest, 73% of it coming from oil sands and the rest from conventional oil). The same year, the companies from this industry were employing 425,000 persons across the country and comprised about 12% of the Toronto Stock Exchange (TSE). The industry spent a capital of $CAD 53 billion in 2015, and contributed to the government budgets by paying an average of $CAD 15 billion in taxes and royalties over the years 2013-2015 (Canadian Association of Petroleum Producers, 2016).

Several studies evaluated the performance of oil and gas companies and benchmarked them (Jung *et al.*, 2001; Victor, 2007; Wolf and Pollitt, 2008; Eller *et al.*, 2011; Rabbani *et al.*, 2014; Sueyoshi and Wang, 2014). In the pre-2000 period, a first set of studies analyzed the efficiency of mainly US and global oil and gas firms and its relations to their profitability (Sueyoshi, 2000; Thompson *et al.*, 1992; Thompson *et al.*, 1994; Thompson *et al.*, 1996a; Thompson *et al.*, 1996b). The second group of studies looked at the effects of government regulations on the performance of the companies, particularly in the UK (Kashani, 2005). In the recent years, in par with the growing importance of sustainability, some of the studies in this area have included environmental factors, such as greenhouse gas emissions, in their models (Song *et al.*, 2015; Sueyoshi and Goto, 2012; Sueyoshi and Wang, 2014; Sueyoshi and Goto, 2015; Zhang *et al.*, 2009).

In these studies, one of the methods that have been widely used in order to evaluate the performance of the companies is Data Envelopment Analysis (Charnes et al., 1978, Charnes et al., 1985, Emrouznejad and Yang, 2017). All the aforementioned studies appraised international petroleum companies or petroleum companies in U.S., U.K. or China. Hence, despite its importance in the Canadian economy, to the best of our knowledge, there is no study that has implemented DEA models to analyze the efficiency of oil and gas companies in Canada or benchmark them.

[1] Corresponding author

In this paper, we close that gap by performing an efficiency analysis of the Canadian oil and gas industry firms at a specific period of time: the years 2012, 2013, 2014, and 2015. To measure the efficiency of oil and gas companies, we used previously developed CCR and BCC DEA models and the inputs and outputs are selected according to the literature. Our literature review has shown that previous DEA models in oil and gas industry were using inputs from three categories: financial information, labor, and available natural resources. In our study, we decided to use the following inputs: *number of employees, total assets, and capital expenditures*. Indeed, the first one is the most used to proxy labor, and the two remaining are chosen because of the capital intensive nature the industry. For outputs, we have selected *oil and gas productions*, which were the most used outputs in the literature.

We performed an empirical efficiency analysis of samples built from 55 Canadian oil and gas public firms, selected from the top hundred oil and gas producers listed in Canadian stock exchanges, ranked by *Alberta Oil - The Business Energy* magazine, for the years 2012 to 2015 and based on the availability of data. We have performed a windows analysis (Charnes et al., 1985) to compute the overall technical efficiency (OTE) and the pure technical efficiency (PTE) of the 55 firms for each of the four years 2012 to 2015. We were then able to make the following observations.

First, we have identified the benchmark firms of among the 55 companies in the sample. A total of fourteen (14) companies are CCR-efficient, with one (1) from 2012, three (3) from 2013, two (2) from 2014, and eight (8) from 2015. These firms form the efficiency frontier of our sample and are therefore the benchmark units that the inefficient companies have to target to improve their efficiency. One can note that none of the actual companies has been consistently efficient in the four years of study. All of these CCR-efficient companies are also BCC-efficient, and hence SE-efficient. We have also classified the efficient firms by using their super efficiencies. The super efficiency of an efficient company is defined here as the number of times it appears as a benchmark unit of an inefficient company. The 14 efficient companies, listed in decreasing super efficiencies order, *PMT2015, TGL2015, RMP2015, SGY2015, EPS2013, EPS2014, RMP2014, PRE2015, CDH2015, RRX2015, TGL2012, TGL2013*, *PEY2015,* and *VET2015*, represent the best practices of the industry. Note that a total of 21 companies are BCC-efficient, but not CCR and SE efficient.

Second, we have analyzed the annual efficiency scores of the sample and performed successive years pairwise mean comparisons t-tests, as well as ANOVA tests over the 4 years. From our observations, overall the Canadian oil and gas industry has a weak operating efficiency, and these inefficiencies can largely be traced back to the management of operations, rather than the scale of their activities. From a given year to the next, the OTE and PTE have been slowly improving with a statistically significant leap from 2014 to 2015.

Our **third** analysis looked at the impact of the size of the company and its efficiency. We have divided our companies into three classes: junior oil and gas companies, whose total assets are in the lowest one-third of the sample; major companies, with total assets in the highest one-third of the sample and the remaining companies are intermediate size companies. For each class, we computed the descriptive measures of the efficiency scores. Then, we have performed pairwise mean comparisons t-tests and ANOVA tests over the 3 classes. Again, the three classes of companies exhibit low efficiencies. Our results show however that intermediate oil and gas companies are the benchmark of the industry, when it comes to overall operating efficiencies and setting up the optimal scale of operations, while the junior companies excel in managing their operations. In other words, in order to operate efficiently, an oil and gas firm should operate at an

intermediate scale in terms of the total assets and manage their operations like a junior company. All of these results were statistically significant.

In a **final** analysis, we have assessed the relationship between the type of outputs and the efficiencies. Using once again descriptive statistics, mean comparisons t-tests and ANOVA, we were able to assert that pure oil producers have the edge and are the benchmark of the industry with respect to the three efficiency measures that we have calculated.

In summary, to the best of our knowledge, we have performed the first efficiency analysis of the Canadian Oil and gas industry. Our findings show that the industry has low efficiency, mainly due management of operations issues. We were able to benchmark the firms to identify best practice firms. We also found that size of the company has an impact of the efficiencies of the companies and this was statistically significant. As well, the overall technical, managerial and scale efficiencies of the firms in the industry are impacted by whether the company is a pure oil or oil and gas producers.

References

Canadian Association of Petroleum Producers (2016), "Crude oil forecast, markets, and transportation". http://www.capp.ca/canadian-oil-and-natural-gas.

Charnes, A., Cooper, W. W. & Rhodes, E. (1978). Measuring the efficiency of decision making unit. *European Journal of Operational Research*, 2 (6)**,** 429-444.

Charnes, A., Clark, C.T., Cooper, W.W. & Golany, B. 1985. A developmental study of data envelopment analysis in measuring the efficiency of maintenance units in the U.S. Air Forces. *Annals of Operations Research, 2 (1)*, 95-112.

Emrouznejad, A., & Yang, G. L. (2017). A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016. *Socio-Economic Planning Sciences*. Forthcoming. http://dx.doi.org/10.1016/j.seps.2017.01.008

Eller, S. L., Hartley, P. R., & Medlock, K. B. (2011). Empirical evidence on the operational efficiency of National Oil Companies. *Empirical Economics*, *40*(3), 623-643.

Jung, E. J., Kim, J. S., & Rhee, S. K. (2001). The measurement of corporate environmental performance and its application to the analysis of efficiency in oil industry. *Journal of Cleaner Production*, *9*(6), 551-563.

Kashani, H. A. (2005). Regulation and efficiency: an empirical analysis of the United Kingdom continental shelf petroleum industry. *Energy Policy*, *33*(7), 915-925.

Rabbani, A., Zamani, M., Yazdani-Chamzini, A., & Zavadskas, E. K. (2014). Proposing a new integrated model based on sustainability balanced scorecard (SBSC) and MCDM approaches by using linguistic variables for the performance evaluation of oil producing companies. *Expert Systems with Applications*, *41*(16), 7316-7327.

Song, M., Zhang, J., & Wang, S. (2015). Review of the network environmental efficiencies of listed petroleum enterprises in China. *Renewable and Sustainable Energy Reviews*, *43*(1), 65-71.

Sueyoshi, T. (2000). Stochastic DEA for restructure strategy: an application to a Japanese petroleum company. *Omega*, *28*(4), 385-398.

Sueyoshi, T., & Goto, M. (2012). Data envelopment analysis for environmental assessment: comparison between public and private ownership in petroleum industry. *European Journal of Operational Research*, *216*(3), 668-678.

Sueyoshi, T., & Goto, M. (2015). DEA environmental assessment in time horizon: Radial approach for Malmquist index measurement on petroleum companies. *Energy Economics, 51(1),* 329-345.

Sueyoshi, T., & Wang, D. (2014). Sustainability development for supply chain management in US petroleum industry by DEA environmental assessment. *Energy Economics*, *46*(1), 360-374.

Thompson, R. G., Dharmapala, P. S., Díaz, J., Gonzalez-Lima, M. D., & Thrall, R. M. (1996b). DEA multiplier analytic center sensitivity with an illustrative application to independent oil companies. *Annals of Operations Research*, *66*(2), 163-177.

Thompson, R. G., Dharmapala, P. S., Rothenberg, L. J., & Thrall, R. M. (1994). DEA ARs and CRs applied to worldwide major oil companies. *Journal of Productivity Analysis*, *5*(2), 181-203.

Thompson, R. G., Dharmapala, P. S., Rothenberg, L. J., & Thrall, R. M. (1996). DEA/AR efficiency and profitability of 14 major oil companies in US exploration and production. *Computers & operations research*, *23*(4), 357-373.

Thompson, R. G., Lee, E., & Thrall, R. M. (1992). DEA/AR-efficiency of US independent oil/gas producers over time. *Computers & Operations Research*, *19*(5), 377-391.

Victor, N. M. (2007). On measuring the performance of national oil companies (NOCs). *Program on Energy and Sustainable Development working papers, WP64, Stanford University*.

Wolf, Christian O. H. & Pollitt, Michael G. (2008). Privatising National Oil Companies: Assessing the Impact on Firm Performance. *Cambridge Judge Business School Working Paper No. 02/2008, University of Cambridge, UKS* (February 29, 2008). Available at SSRN: https://ssrn.com/abstract=1088327 or http://dx.doi.org/10.2139/ssrn.1088327.

Zhang, X., Huang, G. H., Lin, Q., & Yu, H. (2009). Petroleum-contaminated groundwater remediation systems design: A data envelopment analysis based approach. *Expert Systems with Applications*, *36*(3), 5666-5672.