USING DATA ENVELOPMENT ANALYSIS TO ANALYZE THE PERFORMANCE OF NORTH AMERICAN CLASS I FREIGHT RAILROADS

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ABSTRACT

With increased crude oil prices, railroad is emerging as a cheaper alternative to trucks and other less fuel efficient modes of transportation. As a result, with increase in crude oil price, while other modes of transportation have suffered economic slump, railroad industry is thriving with every company reporting an increase in revenue and profits. In this study, we analyze the performance of seven North American Class I freight railroads. In this paper, we illustrate the use of data envelopment analysis, an operations research technique, to analyze the financial performance of the U.S. railroad industry by benchmarking a set of financial ratios of a firm against its peers. Data envelopment analysis clearly brings out the firms that are operating more efficiently in comparison to other firms in the industry, and points out the areas in which poorly performing firms need to improve.

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I. INTRODUCTION

With increase in crude oil prices and the consequent increase in fuel costs for different modes of transportations, railroad industry is back in focus as a popular means of transportation for people as well as for goods. Freight trains, too, are moving into a new, more promising future. The nation needs an economical way to move its burgeoning volume of imports, and trains can do the job better than trucks. Trains use fuel more efficiently and avoid the costly delays caused by traffic. And of course they are also greener than smoke-belching 18-wheelers. This paper addresses the financial performance of seven North American Class I freight railroads.

The North American freight railroad industry comprises over 550 railroads with 173,000 miles of track, and earns about $54 billion in annual revenues[1]. Industry participants are segmented into classes, to which individual railroads are assigned based on revenues. This paper analyzes the seven largest railroads – those in Class I, with over $ $346.8 million in 2006 revenues each - which account for 93 percent of the total industry revenues. In addition, there are 33 regional railroads and over 510 local (shortline or switching and terminal) railroads.[2]

During the 1960's and 1970's, the railroad industry experienced substantial financial strain, including the loss of interstate passenger rail service to airlines and interstate shipments to trucks, and bankruptcies of many of the largest carriers. During the 1970's, government financial participation was required to keep the industry afloat.

Prior to 1980, the highly unprofitable industry was regulated by the Interstate Commerce Commission (ICC), which approved routes, rates, and many operating activities. In 1980, the Staggers Act substantially deregulated the industry, permitting railroads to contractually establish rates and routes directly with shippers. This has led to two significant trends during the last three decades – resurgence of industry financial health and profitability, resulting in the end of all public financial participation in the

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[1] Federal Railroad Administration. Freight Railroading. 2008. <"http://www.fra.dot.gov/us/content/4>
[2] Ibid

industry; and significant consolidation of the mature industry. In fact, since 1981, the number of Class I railroads has dropped from 40 to seven.

All Class I railroads are privately owned, meaning they must compete in the open marketplace for financing. They are capital - intensive companies – in fact, railroads spend more than $20 billion per year (or 37% of revenues) to maintain and expand their track and equipment.[3] This places them at a disadvantage with air and truck transport modes, whose infrastructure is largely funded by the public. Therefore, it is important that railroads provide sufficient returns to investors to ensure a flow of enough capital at a reasonable cost of capital. However, while railroad profits have improved substantially since deregulation, the industry has struggled to provide returns that exceed their cost of capital after reinvestment in track and equipment.

Several recent trends and events have provided increased scrutiny of the industry, and of its financial performance.

- Increased imports from Asia during the past 20 years have shifted and increased traffic flows of container traffic, especially east to west. In fact, Intermodal container freight recently became the largest category of freight moved by Class I's railroads.
- Recognizing the improved financial climate surrounding the industry, Warren Buffett announced during 2007 that his company, Berkshire Hathaway, had made substantial investments in three Class I railroads – Norfolk Southern, Union Pacific, and

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[3] Association of American Railroads. Overview of America's Freight Railroads. May 2008. <http://www.aar.org/~/media/AAR/BackgroundPapers/775.ashx>

Burlington Northern Santa Fe.[4] In keeping with his high profile in the investment community, other investors immediately turned their attention to the improving fortunes of the industry.

- In keeping with a trend to greater shareholder involvement in corporate governance, the private Children's Investment Fund (TCI), a significant holder of CSX stock, during October 2007 "… urged CSX, the railroad operator, to overhaul its management structure in an attempt to rein in spending and improve its financial performance."[5] To date, this has resulted in 2 TCI - sponsored members being added to the CSX Board, and significant pressure being placed on the company to increase its financial performance.
- Since rail is a very fuel-efficient mode of freight transportation, recent increases in crude oil prices have led to increased shipments and additional revenues for the industry.
- As a result of deregulation, some shippers now have access to only a single railroad for their shipments. As a result, there have been calls for re-regulation, especially to oversee service and rates to these "captive" shippers.

This paper seeks to utilize Data Envelopment Analysis to investigate the performance of the Class I railroad operators. The resulting data will be of interest to railroad operators, investors, capital suppliers, and the academic community.

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[4] Sorkin, Andrew Ross. "Buffett Discloses More Railroad Stakes." New York Times. 16 May 2007. <http://dealbook.blogs.nytimes.com/2007/05/16/buffett-discloses-more-railroad-stakes/?scp=2&sq=Buffett%20Union%20Pacific&st=cse>

[5] Activist Hedge Fund Presses CSX for Change, October 17, 2007 NYT http://www.nytimes.com/2007/10/17/business/17hedge.html?_r=1&scp=7&sq=csx%20childrens%20fund&st=cse&oref=slogin

Rest of the paper is organized along the following lines. In section II, we provide a review of previous studies on DEA applications in performance evaluation. Section III discusses the data and methodology used in this study. In section IV, we provide an empirical analysis of our results. Section V summarizes and concludes our study.

II. LITERATURE REVIEW

A number studies have been published on different aspects of financial statement analysis. We include only those studies that use data envelopment analysis in either financial statement analysis or analysis of financial performance of firms. Zhu (2000) uses data envelopment analysis to develop a multi-factor financial performance model that recognizes tradeoffs among various financial measures. Kao and Liu (2004) compute efficiency scores based on the data contained in the financial statements of Taiwanese banks. They use this data to make advanced predictions of the performances of 24 commercial banks in Taiwan. Pille and Paradi (2002) analyze the financial performance of Ontario credit unions. They develop models to detect weaknesses in Credit Unions in Ontario, Canada. Yasar and McCure (1996) use data envelopment analysis for measuring and assessing the financial performance for hospitals. They compute a financial performance index (FPI) as a measure of aggregate financial performance. They show that financial performance index across many financial ratios eases the comparison of an individual hospital with its peers. Feroz, Kim and Raab (2003) is the only study that directly talks about financial statement analysis using data envelopment analysis methodology. They show that data envelopment analysis can augment the traditional ratio analysis to a consistent and reliable measure of managerial or operational efficiency of a firm. Halkos and Salamouis (2004) explore the efficiency of Greek banks with the use of a number of suggested financial efficiency ratios for the time period 1997-1999. They show that data envelopment analysis can be used as either an alternative or complement to ratio analysis for the evaluation of an organization's performance.

With regard to the railroad industry, most of the studies have analyzed the productivity and efficiency of various aspects of the industry. Hoon and Chunyan (1994) analyzed the productive efficiency of the railway services in 19 Organization for Economic Cooperation and Development (OECD) countries. They report that railway systems with high dependence on public subsidies are less efficient than similar railways with less dependence on subsidies. Cowie and Riddington (1996) evaluate the efficiency of the European railways through the use of a production frontier approach. Yu and Lin (2008) uses a multi-activity network DEA model to simultaneously estimate passenger and freight technical efficiency, service effectiveness, and technical effectiveness for 20 selected railways for the year 2002.

In this paper, we extend previous studies by illustrating the use of DEA models to benchmark the performance of North American class I freight railroads in terms of financial performance. No previous study has benchmarked railroad firms in terms of financial performance.

III. DATA AND METHODOLOGY

The Data Envelopment Analysis (DEA) (Charnes et al., 1978) is a widely used optimization-based technique that measures the relative performance of decision making units that are characterized by a multiple objectives and/or multiple inputs structure.

Data envelopment analysis[6] is a technique used to assess the comparative efficiency of homogenous operating units such as schools, hospitals, utility companies, sales outlets, prisons, and military operations. More recently, it has been applied to banks (Haslem, Scheraga, & Bedingfield, 1999) and mutual funds (Haslem & Scheraga, 2003; Galagedera & Silvapulle, 2002; McMullen & Strong, 1998; Murthi, Choi, & Desai, 1997). It is a powerful technique for measuring performance because of its objectivity and ability to handle multiple inputs and outputs that can be measured in different units. The DEA approach does not require specification of any functional relationship between inputs and outputs, or a priori specification of weights of inputs and outputs. DEA provides gross efficiency scores based on the effect of controllable and uncontrollable factors.

The DEA methodology measures the performance efficiency of organization units called Decision-Making Units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs. The performance of DMUs is assessed in DEA using the concept of efficiency or productivity defined as a ratio of total outputs to total inputs. Efficiencies estimated using DEA are relative, that is, relative to the best performing DMU or DMUs (if multiple DMUs are the most efficient). The most efficient DMU is assigned an efficiency score of unity or 100 percent, and the performance of other DMUs vary between 0 and 100 percent relative to the best performance.

We used the financial data available from ***Hoovers Online*** for this study. We used ten financial ratios to evaluate seven North American class I freight railroads.

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[6] For mathematical details of the data envelopment analysis model, please see Zhu (2003)

Seven companies that we include in our study are: Burlington Northern Santa Fe, Canadian National Railway, Canadian Pacific Railways Limited, CSX, Kansas City Southern, Norfolk Southern, and Union Pacific. These are the seven largest railroads – those in Class I, with over $ $346.8 million in 2006 revenues each - which account for 93 percent of the total industry revenues. We benchmark the financial performance of these companies on the basis of the following financial variables:

- ***Average Collection Period*** **–** number of days on an average it takes for the company to receive payments owed in terms of receivables from its customers and clients.
- ***Cash flow per share*** - Cash Flow is calculated as Net Income - Preferred Dividends + Depreciation. It is divided by Shares Outstanding from the most recent balance sheet.
- ***Current Ratio*** - Current Ratio equals the Total Current Assets divided by Total Current Liabilities from the most recent balance sheet. This gives an indication of the financial soundness of the company by showing the degree to which short-term obligations are covered by short-term assets. A figure greater than 1 indicates the company's Total Current Assets are greater than its Total Current Liabilities.
- ***Quick Ratio*** - Quick Ratio equals Cash and Equivalents plus Receivables divided by Total Current Liabilities from the most recent balance sheet. Quick Ratio measures a company's short-term liquidity.
- ***Inventory Turnover Ratio*** - Inventory Turnover equals the Cost of Goods Sold divided by the Average Inventory from the most recent balance sheet and the

corresponding balance sheet a year ago. Inventory Turnover measures inventory management efficiency

- ***Long-Term Debt Per Share*** - Long-Term Debt Per Share equals Long-Term Debt divided by Shares Outstanding from the most recent balance sheet.
- ***Return on equity*** - Return on Equity equals the Net Income from Total Operations divided by Common Stock Equity from the most recent balance sheet. It measures the return on each dollar invested by the common shareholders in a company.
- ***Return on assets*** - Return on Assets equals the Net Income from Total Operations divided by the Total Assets from the most recent balance sheet. A measure of profitability, ROA measures the amount earned on each dollar invested in assets.
- ***Interest rate coverage ratio*** - Interest Coverage equals income before interest and taxes divided by the interest expense.

Table 1 illustrates the pooled data of the seven companies used for analysis.

< Insert Table 1 about here>

Data Envelopment Model Specifications for the Railroad Industry

Besides the mathematical and computational requirements of the DEA model, there are many other factors that affect the specifications of the DEA model. These factors relate to the choice of the DMUs for a given DEA application, selection of inputs and outputs, choice of a particular DEA model (e.g. CRS, VRS, etc.) for a given application, and choice of an appropriate sensitivity analysis procedure (Ramanathan, 2003). Due to DEA's non parametric nature, there is no clear specification search strategy. However, the results of the analysis depend on the inputs/outputs included in the DEA model. There are two main factors that influence the selection of DMUs – homogeneity and the number of DMUs. To successfully apply the DEA methodology, we should consider homogenous units that perform similar tasks, and accomplish similar objectives. In our study, the companies are homogenous as they are identified by ***Hoovers Online*** to be competitors. Furthermore, the number of DMUs is also an important consideration. In addition, the number of DMUs should be reasonable so as to capture high performance units, and sharply identify the relation between inputs and outputs. The selection of input and output variables is the most important aspect of performance analysis using DEA. In general, the inputs should reflect the level of resources used or a factor that should be minimized. The outputs reflect the level of the economic variable factor, and the degree to which an economic variable contributes to the overall strength (efficiency) of a company. There are some simple rules of thumb that guide the selection of inputs and outputs, and the number of participating DMUs[7].

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[7] The following are the guidelines for DMU model selection:

a. The number of DMUs is expected to be larger than the product of number of inputs and outputs (Darrat et. Al., 2002; Avkiran, 2001) to discriminate effectively between efficient and inefficient DMUs. The sample size should be at least 2 or 3 times larger than the sum of the number of inputs and outputs (Ramanathan, 2003).
b. The criteria for selection of inputs and outputs are also quite subjective. A DEA study should start with an exhaustive, mutual list of inputs and outputs that are considered relevant for the study. Screening inputs and outputs can be quite quantitative (e.g. statistical) or qualitative that are simply judgmental, use expert advice, or use methods such as analytical hierarchy process (Saaty, 1980). Typically inputs are the resources utilized by the DMUs or condition affecting the performance of DMUs. On the other hand, outputs are the benefits generated as a result of the operation of the DMUs, and records higher performance in terms of efficiency. Typically, we should restrict the total number of inputs and outputs to a reasonable level. As the number of inputs and outputs to a reasonable level. As the number of inputs and outputs increases, more number of DMUs get an efficiency rate of 1, as they become too specialized to be evaluated with respect to other units (Ramanathan, 2003).

To study the performance of the railroad industry, we consider eight factors to develop the DEA model: average collection period, long-term debt per share, cash flow per share, return on equity, return on assets, inventory turnover, quick ratio, and interest rate coverage.

Out of these ten factors, we specify average collection period and long-term debt per share as input, because for a given company the lower these variables are the better the performance of the company is. Similarly, higher cash flow per share, return on equity, return on assets, inventory turnover, quick ratio, and interest rate coverage imply a better-performing company. Thus, we consider these variables as output variables. Finally, the choice of the DEA model is also an important consideration. We should select the appropriate DEA model with options such as input maximizing or output minimizing, multiplier or envelopment, and constant or variable returns to scale. DEA applications that involve inflexible inputs or not fully under control inputs should use output-based formulations. On the contrary, an application with outputs that are an outcome of managerial goals, input-based DEA formulations are more appropriate. In addition, for an application that emphasizes inputs and outputs, we should use multiplier version. Similarly, for an application that considers relations among DMUs, envelopment models are more suitable. Furthermore, the characteristics of the application dictate the use of constant or variable returns to scale. If the performance of DMUs depends heavily on the scale of operation, constant returns to scale (CRS) is more applicable, otherwise variable returns to scale is a more appropriate assumption.

In our study, the comparative evaluation among the companies is an important consideration. Therefore, we select the envelopment models for our analysis. In addition, the outputs are an outcome of managerial goals. Therefore, input-based formulation is recommended for our study. The objective of the analysis is to suggest a benchmark for the railroad firms. Furthermore, to investigate the affect of scale of operations, if any, among the 7 companies, we consider both variable returns to scale and constant returns to scale DEA models. Also, the structure of the DEA model (in envelopment form) uses an equation and separate calculation for every input and output. Therefore, all the input and output variables can be used simultaneously and measured in their own units. In this study, we use the Input-Oriented Variables Return to Scale (VRS) to evaluate the efficiency of seven companies for the second quarter of 2008.

IV. EMPIRICAL ANALYSIS

Each of the railroad company is a homogenous unit, and we can apply the DEA methodology to assess the comparative performance of these companies. We analyze and compute the efficiency of these companies using the financial statements for the for the second quarter of 2008. Table 2 illustrates the efficiency scores for seven companies. Further, we also study the peers (model companies) for inefficient companies.

<Insert Table 2 about here>

Table 2 shows the relative performance of the railroad companies benchmarked against each other. Table 2 also shows that five out of seven companies were ranked as efficient based on the financials for the second quarter of 2008, and two companies were inefficient companies. Burlington Northern Santa Fe, Canadian National, Canadian Pacific, CSX Corp, and Union Pacific are 100% efficient. On the other hand Kansas City Southern and Norfolk Southern are inefficient. Figure 1 shows the efficiency frontier graph of the pooled company data. The 100% efficient companies (blue dots) are on the efficiency frontier, where as the inefficient companies (red dots) are inside the efficiency frontier. The DEA Analyzer calculates the level of inefficiency by measuring the distance between the efficiency frontier and the inefficient companies. Therefore, a financial analyst can use this efficiency frontier to assess the relative efficiency of the firm in the industry. The DEA model compares the average collection period, long-term debt per share, cash flow per share, return on equity, return on assets, inventory turnover, quick ratio, and interest rate coverage.

<Insert Figure 1 about here>

We present the score in percentage value varying between 0% and 100%. We find that the input efficiency of Burlington Northern Santa Fe, Canadian National, Canadian Pacific, CSX Corp, and Union Pacific is 100%. On the other hand, the input efficiency of the remaining companies is: Kansas City Southern (27%), and Norfolk Southern (81%). This means that the observed levels of cash flow per share, return on equity, return on assets, inventory turnover, quick ratio, and interest rate coverage for Kansas City Southern can be achieved with 27% of the current levels of average collection period and long-term debt per share,. The same rationale applies to Norfolk Southern. Table 3 illustrates the efficiency scores and the corresponding ranking of the pooled companies in the year 2008. The average score is 87%, with five companies having efficiency levels above average while the remaining two are below the average level. Four 100% efficient companies turned out to be the best practices companies within the pooled database of the Decision Support System.

<Insert Table 3 about here>

The best practices companies: Burlington Northern Santa Fe, Canadian National, CSX Corp, and Union Pacific are 100% efficient. As Kansas City Southern and Norfolk Southern are inefficient; the next step is to identify the efficient peer group or companies whose operating practices can serve as a benchmark to improve the performance of these companies.

Table 4 illustrates the peer group for the inefficient companies.

<Insert Table 4 about here>

As shown in the Table 4, Canadian National and Union Pacific serve as peer for Kansas City Southern. In addition, Kansas City Southern is more comparable to Union Pacific (weight 62%) and less comparable to its more distant peer Canadian National (38%).Thus, Kansas City Southern should scale up its cash flow per share, return on equity, return on assets, inventory turnover, quick ratio, and interest rate coverage.. Similarly, Norfolk Southern has CSX Corp(50%) as the closest peer that it should emulate and Union Pacific (25%) as the distant peer company that can also be investigated. Further, Union Pacific has Canadian National (17%) as its far-distant peer and Burlington Northern Santa Fe (8%) as its furthest peer. Finally, , Union Pacific and Canadian National are the most efficient company among the given pool of the companies in the DSS, as not only are Union Pacific and Canadian National 100% efficient, they also serve as the role model for all other companies. Similarly, CSX Corp is the next most efficient company among the group of companies. CSX Corp serves as the immediate peer for Norfolk Southern. The efficient peer companies have a similar mix of input-output levels to that of the corresponding inefficient company, but at more absolute levels. The efficient companies generally have higher output levels relative to the company in question. The features of efficient peer companies make them very useful as role models that inefficient companies can emulate to improve their performance. Furthermore, Union Pacific and Canadian National are the immediate efficient peers for the inefficient companies, so its frequency of use as an efficient-peer, expressed as a percentage of the number of pareto-inefficient companies, is 100%. Burlington Northern Santa Fe and CSX Corp serve as an immediate peer for one company. Thus, we have enhanced confidence that Burlington Northern Santa Fe and CSX Corp are genuinely well performing companies as they outperform all the other companies. Furthermore, these companies are more likely to be a better role model for less efficient companies to emulate as their operating practices and environment match the majority of the other companies quite closely. Table 5 displays the benchmarking factor and the hit percentage of efficient company.

<Insert Table 5 about here>

After calculating the efficiency of a company using DEA, and identifying the efficient peers, the next step in DEA analysis is feasible expansion of the output or contraction of the input levels of the company within the possible set of input-output levels. The DEA efficiency measure tells us whether or not a given company can improve its performance relative to the set of companies to which it is being compared. Therefore, after minimizing the input efficiency, the next stage involves calculating the optimal set of slack values with an assurance that input efficiency will not decrease at the expense of slack values of the input and output factors. Once efficiency has been minimized, the model does seek the maximum sum of the input and output slacks. If any of these values is positive at the optimal solution to the DEA model that implies that the corresponding output of the company (DMU) can improve further after its output levels have been raised by the efficiency factor, without the need for additional input. If the efficiency is 100% and the slack variables are zero, then the output levels of a company cannot be expanded jointly or individually without raising its input level. Further, its input level cannot be lowered given its output levels. Thus, the companies are pareto-efficient with technical output efficiency of 1. If the company is 100% efficient but one slack value is positive at the optimal solution then the DEA model has identified a point on the efficiency frontier that offers the same level on one of the outputs as company A in question, but it offers in excess of the company A on the output corresponding to the positive slack. Thus, company A is not Pareto-efficient, but with radial efficiency of 1 as its output cannot be expanded jointly. Finally, if the company A is not efficient (<100%) or the efficiency factor is less than 1, then the company in question is not Pareto-efficient and efficiency factor is the maximum factor by which both its observed input levels can be reduced without the changing its output. If at the optimal solution, we have not only input efficiency < 1, but also some positive slack, then the output of company A corresponding to the positive slack can be raised by more than the factor output efficiency, without the need for additional input. The potential additional output at company A is not reflected in its efficiency measure because the additional output does not apply across all output dimensions. Table 6 illustrates the slack values identified in the next stage of the DEA analysis. The slack variables for 100% efficient companies are zero. Therefore, Burlington Northern Santa Fe, Canadian National, Canadian Pacific, CSX Corp, and Union Pacific are Pareto-efficient as the DEA model has been unable to identify some feasible production point which can improve on some other input or output level. On the other hand, for Kansas City Southern, there is further scope for increasing cash flow per share by .27, return on equity by .06 units, return on assets by .03 units, inventory turnover by 10.41 units, quick ratio by .06 units, and interest coverage by 5.37 units. Kansas City Southern can follow Canadian National and Union Pacific as its role model and emulate their policies. Similarly, Norfolk Southern can increase its return on equity by .01 units, return on assets by .01 units, quick ratio by .12 units, and interest rate coverage by .66 units. Table 6 illustrates the slack values of the relevant factors for inefficient companies.

<Insert Table 6 about here>

The next step in our analysis was to perform sensitivity analysis of the DEA model. DEA is an extreme point technique because the efficiency frontier is formed by actual performance of best-performing DMUs (Ramanathan 2003). Furthermore, as DEA is a non-parametric technique, statistical hypothesis tests are difficult. It is possible for a DMU to obtain a value of utility by simply improving its performance in terms of only one particular output ignoring others. One way of checking the sensitivity of DEA efficiency of a DMU is by omitting one or more inputs or outputs. Thus, we used 26 different models to calculate efficiency of the railroad companies. Table 7 summarizes the results of our analysis. Table 8 displays the average efficiency, the standard deviation of the efficiencies, and median efficiency level for each country. Table 9 lists all the companies and their rankings based on average efficiency.

<Insert Table 7 about here>

<Insert Table 8 about here>

<Insert Table 9 about here>

As expected, Canadian National and Union Pacific are the most efficient, followed closely by Union Pacific, Canadian Pacific, and CSX Corp. Norfolk Southern and Kansas City Southern are the most inefficient company.

V. SUMMARY AND CONCLUSIONS

With the increase in crude oil prices, railroad industry around the world is undergoing a major transformation. While other modes of transportation have suffered economic slump due to higher crude oil prices, railroad industry is thriving with every company reporting an increase in revenue and profits. In this study, we analyze the performance of seven North American Class I freight railroads. In this paper, we illustrate the use of data envelopment analysis, an operations research technique, to analyze the financial performance of the U.S. railroad industry by benchmarking a set of financial ratios of a firm against its peers. DEA employs relative efficiency, a concept enabling comparison of companies with a pool of known efficient companies. The DEA model compares a firm with the pool of efficient companies by creating an *efficiency frontier* of good firms—a tolerance boundary created by establishing the efficiency of firms in terms of several sets of financial ratios. Companies lying beyond this boundary can improve one of the input values without worsening the others. We find that Burlington Northern Santa Fe, Canadian National, Canadian Pacific, CSX Corp, and Union Pacificare are 100% efficient. On the other hand Norfolk Southern and Kansas City Southern are inefficient. We also illustrate the areas in which inefficient companies are lacking behind efficient firms.

We also provide an insight into the benefits of DEA methodology in analyzing financial statements of firms. The decision support system stores the company's historical data, competitive firm's data, and other industry specific data, and uses the DEA methodology to analyze a firm's performance. Moreover, DEA modeling does not require prescription of the functional forms between inputs and outputs. DEA uses techniques such as mathematical programming that can handle a large number of variables and constraints. As DEA does not impose a limit on the number of input and output variables to be used in calculating the desired evaluation measures, it's easier for loan officers to deal with complex problems and other considerations they are likely to confront.

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Table 1: Pooled Data Set of North American Class I Freight Railroad Companies for Year 2008

Company	Average Collection Period	Long Term Debt per Share	Cash Flow per Share	Return on Equity	Return on Assets	Inventory Turnover	Quick Ratio	Interest Coverage Ratio
Burlington Northern Santa Fe (BNI)	24.96	24.35	10.51	0.168	0.054	12.5	0.5	6.63
Canadian National (CNI)	20.24	11.27	3.08	0.234	0.099	23.5	0.6	9.95
Canadian Pacific (CP)	47.41	29.02	8.84	0.219	0.083	11.4	0.7	6.33
CSX Corp (CSX)	49.54	18.14	6.02	0.165	0.058	28.3	1.2	5.67
Kansas City Southern (KSU)	88.44	16.29	4.97	0.113	0.039	6.4	0.6	2.97
Norfolk Southern (NSC)	45.41	16	6.01	0.154	0.058	22.3	0.8	6.24
Union Pacific (UNP)	25.91	0.1475	6.56	0.129	0.052	12.7	0.7	7.35

Table 2: DEA Efficiency Scores for the Railroad Companies.

Company	Efficiency
Burlington Northern Santa Fe (BNI)	100%
Canadian National (CNI)	100%
Canadian Pacific (CP)	100%
CSX Corp (CSX)	100%
Kansas City Southern (KSU)	27%
Norfolk Southern (NSC)	81%
Union Pacific (UNP)	100%

A company with 100% score is considered the most efficient and a company with less than 100% score is considered inefficient. Efficiency scores is based on average collection period, long-term debt per share, cash flow per share, return on equity, return on assets, inventory turnover, quick ratio, and interest rate coverage.

Figure 1: Efficiency Frontier for the Benchmarked Companies.

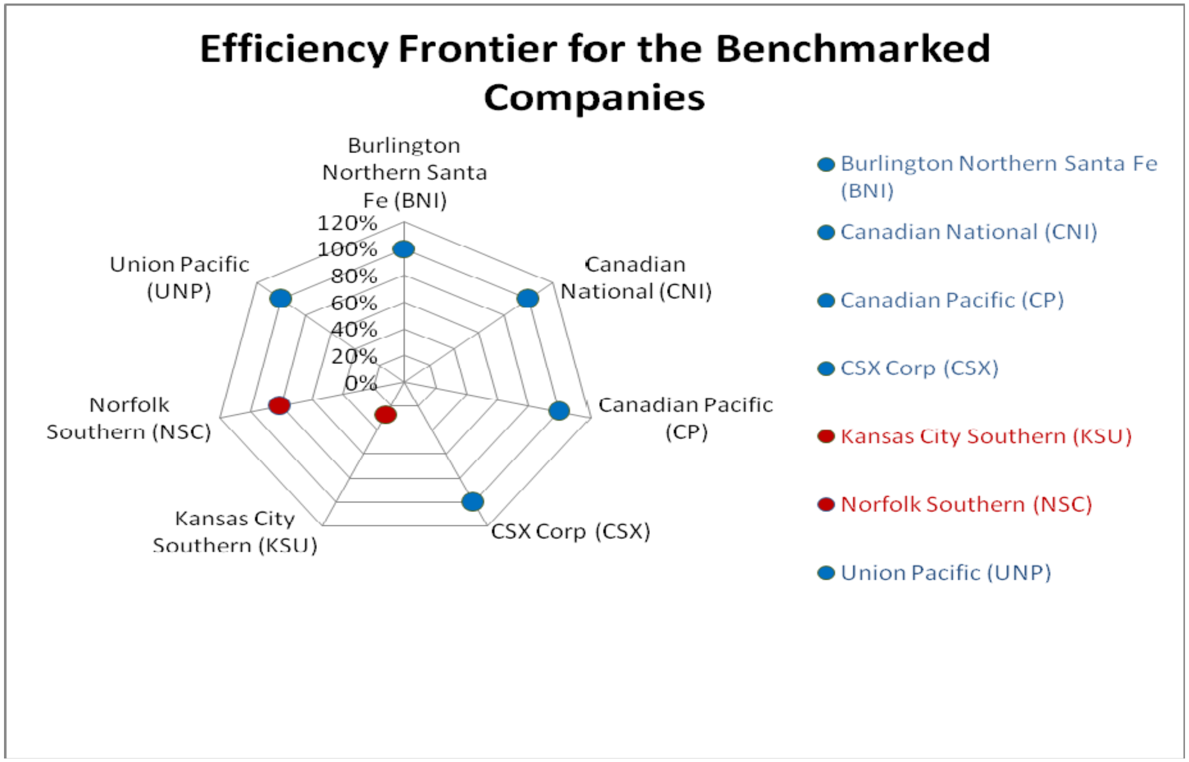

Table 3: Efficiency Score and Ranking of the 7 Companies for 2008.
Ranking of individual company is based on the DEA efficiency scores from Table 3. Highest ranking is given to a company with the efficiency score of 100.

Company	efficiency	Ranking
Union Pacific (UNP)	100%	1
CSX Corp (CSX)	100%	1
Canadian National (CNI)	100%	1
Burlington Northern Santa Fe (BNI)	100%	1
Canadian Pacific (CP)	100%	1
Norfolk Southern (NSC)	81%	2
Kansas City Southern (KSU)	27%	3
Average	87%	

Table 4: Peer Companies and their weights in percentage
This table shows those companies that can serve as a benchmark for companies with DEA efficiency score of less than 100.

Company	Burlington Northern Santa Fe (BNI)	Canadian National (CNI)	CSX Corp (CSX)	Union Pacific (UNP)
Kansas City Southern (KSU)	0%	38%	0%	62%
Norfolk Southern (NSC)	8%	17%	50%	25%

Table 5: Benchmarking Factor and Hit Rate for Pareto Efficient Companies

Company	Benchmarking Factor	Hit rate
Burlington Northern Santa Fe (BNI)	1	100%
Canadian National (CNI)	2	50%
CSX Corp (CSX)	1	100%
Union Pacific (UNP)	2	50%

Table 6: Slack Variables for Inefficient Companies (efficiency < 100%) (2008)
Table shows the adjustment needed in each of the seven economic variables for an inefficient company to become efficient.

Company	Cash Flow per Share	Return on Equity	Return on Assets	Inventory Turnover	Quick Ratio	Interest Coverage Ratio
Kansas City Southern (KSU)	0.27	0.06	0.03	10.41	0.06	5.37
Norfolk Southern (NSC)	0.00	0.01	0.01	0.00	0.12	0.66

Table 7: DEA Models and their corresponding efficiencies

Company	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Burlington Northern Santa Fe (BNI)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canadian National (CNI)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canadian Pacific (CP)	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.53
CSX Corp (CSX)	1.00	0.45	0.45	0.45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.48
Kansas City Southern (KSU)	1.00	0.24	0.24	0.24	0.24	0.24	0.24	1.00	1.00	1.00	1.00	0.27
Norfolk Southern (NSC)	0.72	0.49	0.49	0.49	0.69	0.69	0.72	0.72	0.72	0.81	0.81	0.52
Union Pacific (UNP)	1.00	0.87	0.87	0.87	0.87	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Company	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21	Model 22	Model 23	Model 24
Burlington Northern Santa Fe (BNI)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canadian National (CNI)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canadian Pacific (CP)	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00
CSX Corp (CSX)	0.48	0.48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.45	0.45
Kansas City Southern (KSU)	0.27	0.27	0.27	1.00	1.00	0.27	0.27	0.27	0.27	0.27	0.24	0.24
Norfolk Southern (NSC)	0.52	0.52	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.49	0.49
Union Pacific (UNP)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.87

Company	Model 25	Model 26	Average
Burlington Northern Santa Fe (BNI)	1.00	1.00	100%
Canadian National (CNI)	1.00	1.00	100%

Canadian Pacific (CP)	1.00	1.00	93%
CSX Corp (CSX)	0.45	1.00	81%
Kansas City Southern (KSU)	0.24	0.24	46%
Norfolk Southern (NSC)	0.49	0.69	67%
Union Pacific (UNP)	0.87	0.87	96%

Table 8: Average Percentage Efficiency of all companies

Company	Average	Standard Deviation	Median
Burlington Northern Santa Fe (BNI)	100%	8.85E-12	100%
Canadian National (CNI)	100%	5.33E-11	100%
Canadian Pacific (CP)	93%	0.17784	100%
CSX Corp (CSX)	81%	0.263713	100%
Kansas City Southern (KSU)	46%	0.337206	27%
Norfolk Southern (NSC)	67%	0.136688	72%
Union Pacific (UNP)	96%	0.062841	100%

Table 9: Company Rankings based on Efficiency

Company	Average	Ranking
Canadian National (CNI)	100%	1
Burlington Northern Santa Fe (BNI)	100%	1
Union Pacific (UNP)	96%	2
Canadian Pacific (CP)	93%	3
CSX Corp (CSX)	81%	4
Norfolk Southern (NSC)	67%	5
Kansas City Southern (KSU)	46%	6