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THE EFFICIENCY OF THE MAJOR OILS & GAS PRODUCERS USING DEA METHODOLOGY

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ABSTRACT

Until 2015, worldwide oil demand is forecasted to increase 1.3% per year, and production growth will increase 0.8% per year. To maintain competitiveness and to avoid the replacement of oil with another energy source, oil producers must improve the production efficiency of fluids. This paper aims to analyse the transportation efficiency of major hydrocarbons companies by considering their production, transportation and financial aspects. The Data Envelopment Analysis (DEA) model was used for analysis, and the annual data were obtained from the companies' financial and sustainability reports from 2006 to 2010. Tables are used to classify the companies by production efficiency. As a result, we found that even considering different variables as input and output, the major company in the world is the most efficient company as well, but this relation is not observed in others companies.

Keywords: *DEA; Oil & Gas; Efficiency; Logistics*

1. INTRODUCTION

Energy is a vital resource for societies. Without commercial energy (electricity, natural gas, and crude oil, with its refined products and coal), societies, as they are known today, would be in decline. However, in recent years, the future of renewable energy sources has been increasingly discussed.

In particular, crude oil production is unsustainable in the long term, and even considering the sources yet to be discovered, the increase in supply will be insufficient with the development of countries such as China, India, Iran and Saudi Arabia (Almeida and Silva 2009).

The worldwide economy is forecasted to increase by 3% per year until 2015, resulting in an increase of 1.3% per year in oil production. However, oil production is forecasted to grow only 0.8% per year, 0.5% per year less than required. Given this prediction, the demand forecasted for 2030 is 106.4 M barrels per day (Mb/d), but oil production is forecasted to be 80 Mb/d (Aleklett, et al. 2010).

In this context, increasing the efficiency of fluid production is crucial to ensure that companies remain competitive in a market in which the product tends to be scarce, the prices tend to increase, and new energy sources tend to gain increasing market share as the main energy source.

The objective of this paper is to analyse the efficiency of major companies in the oil and gas market considering the relationship between oil production, the transport of fluids and the financial aspects. To do this efficiency analysis, it was used the Data Envelopment Analysis (DEA) methodology to classify the companies.

1.1. Motivation of this study

Some individuals are more productive than others, some businesses are small and operate in a profitable niche market that others overlook, some large companies are more profitable than others, and some utilities offer better services than others. In each case, performance may improve or worsen over time. Short-term success may be associated with long-term failure, while short-term failure can lead to death or even precede long-term success (Fried, Lovell and Schmidt 2008). This fact also applies to the oil and gas market, particularly given the highly production levels of oil and natural gas in the forthcoming years. Thus, we can infer that enterprises' production efficiency will be pivotal to the success of their operations.

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Other factors may aggravate the future of the oil and gas market, such as the need for hydrocarbon exploration at increasing depths, pre-salt exploration, and oil exploration in alternative environments, such as the oil sands (Aleklett, et al. 2010). Also, the expected increased development of the world economy, driven by emerging countries and crises in developed countries; and the development of alternative energy sources, given that hydrocarbons are non-renewable energy sources and may one day be depleted.

These factors will strongly affect the oil and gas market and necessitate that companies increase their efficiency and assess exploratory criterion with long-term strategic planning to prepare for a scenario in which reserves and the availability of hydrocarbons will decline worldwide.

2. THE CURRENT MARKET

Currently, the oil and gas market is highly segmented with global companies positioned at each production stage. In this context, we emphasise the major oil-producing companies with annual revenues of tens of thousands of dollars and high numbers of workers, which may surpass 100 000 employees worldwide in some cases.

A feature of the global industry that underscores this market's importance and its development is the global energy matrix, which is dependent on the energy generated by oil and is shown in Table 1.

Table 1 - World Energy Production

	1973	2009
Oil	46%	33%
Coal	24%	27%
Natural gas	16%	21%
Biofuel	11%	10%
Hydraulics	2%	2%
Nuclear	1%	6%
Other	0%	1%

SOURCE: Adapted from EIA, 2011

Firms in this market appear to be in stable high positions in comparative rankings of companies worldwide, as calculated by business magazines and financial institutes.

The FT500 report in the Financial Times ranks the 500 largest companies worldwide based on market value (Financial Times 2011).

In 2011, 500 companies in the industry, sector "Oil & Gas Producers" had the second highest representation (46 companies), second only to the Bank sector (75 companies).

Table 2 - Major Sectors World

Rank	Companies	Marked Value	Number of enterprises
1	Banks	27%	30%
2	Oil & gas producers	24%	19%
3	Pharmaceuticals & biotechnology	9%	8%
4	Technology hardware & equipment	8%	8%
5	Minning	7%	7%
6	Software & computer services	6%	5%
7	Mobile telecommunications	5%	6%
8	Automobiles & parts	5%	6%
9	General retailers	5%	6%
10	Fixed line telecommunications	4%	5%

SOURCE: Adapted from (Financial Times 2011)

Table 2 summarises the top 10 sectors in the FT500. With respect to market value, oil and gas producers are the second most valuable market worldwide, with 24% (approximately $4 trillion) of the total financial value of the 10 major sectors. The numbers of companies for each industry on the list are identical. Oil and gas producers and banks vie for leadership. Interestingly, among the 10 largest sectors of the world, banks have 10% more companies listed than oil and gas producers, but with respect to market value, they are only 3% more valuable than the latter, which, although outnumbered, are the most valuable companies.

2.1 Future Challenges

The oil industry faces an immense challenge to maintain its current levels of activity in the world economy.
In the short and the medium terms, the replacement of global oil reserves and the approach of peak production are the most worrisome factors. Geopolitical events around the world have prompted a discussion of economic embargos, sanctions and commercial locks in several countries, including Venezuela, Russia and Iran and Iraq (Ngoasong and Michael 2014).

Peak oil production has been heavily researched and remains the topic of several studies that estimate that the decline in world oil production will begin in the first three decades of the 21st century (Wood et al, 2004; Witz, 2007; (Campbell and Lahérrere 1998); (Aleklett, et al. 2010); (Almeida and Silva 2009); (Höök, Hirsch and Aleklett 2009), an event that would be followed by an increase in price, thus reducing the competitiveness of petroleum compared to other energy sources (Almeida and Silva 2009).

This fact includes historical evidence concerning oil that indicates that the exhaustion of cycles associated with natural resources does not occur from the exhaustion of the resource itself (or a lack of access to it) but when the competitive advantages associated with each cycle disappear, as when coal replaced wood as the main energy source during the Industrial Revolution and when oil replaced coal in the early 20th century after the invention of combustion engine power. In these cases, the replacement followed not the lack of availability of firewood or charcoal but the exhaustion of economic advantages (Witze 2007). In other words, the end of the "Age of Oil" will depend on whether another energy source offers more advantages in terms of price, the availability of reserves and the future impact on the environment and not on the exhaustion of the reserves.

All of these threats to the oil industry can also be considered opportunities for the renewal and the development of companies in the oil and gas market. Large companies such as Shell, Exxon, BP and Petrobras have already taken action to avoid the end of the "oil era" by changing their philosophy from company oil to firm energy. These companies will invest more heavily in alternative energy sources, thus diversifying their product portfolios. This transition will last until alternative sources are more economically viable compared with oil, at which time the sources that were once alternatives will become mainstream, and oil will be used for specific applications (Szklo, Schaeffer and Mariano 2005).

Hydrocarbons can be extracted for reserves (i.e., produced) in many ways, depending on the environment where the reserve is located. However, independent of the environment, the utilisation of pipes is crucial for production. If the reserve is onshore, then pipes must be used to transport it to separation facilities from the time the hydrocarbon is extracted. If the reserve is located offshore, then pipes called flow lines and risers will be used to transport the fluid from the seabed to production units. Finally, for unusual forms of production, pipes are necessary to transport the fluids to refinery facilities.

For this paper, the production of hydrocarbons is considered the capacity of a company to transport fluids to the processing unit so it is possible to establish a relationship between the companies' productivity level and their efficiency in transporting fluids through pipes. Data Envelopment Analysis (DEA) methods is usually used in Oil & Gas analysis (e. g. Oil & Gas Disclosure data reported (primarily) by the Arthur Andersen Company for the years 1980-1991 (Thompson, et al. 1996).

3. DATA ENVELOPMENT ANALYSIS (DEA)

Proposed by (Banker, Charnes and Cooper 1984), the BCC model differs from previous models by considering that returns can be scale variables, with the relationship between input and output replaced by non-linear behaviour. This replacement occurs by substituting the axiom of proportionality between inputs and outputs with the convexity axiom (Angulo Meza, Biondi Neto, et al. 2005). This model is also known as VRS, Variable Return to Scale, with a mathematical formulation oriented to inputs, as shown in Equation (1).

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Mathematically, the convexity of the boundary is considered by adding a restriction to the linear model of the envelope.

$$Min\ h_0 \quad (1)$$

Subject to:

$$h_0 x_{i0} - \sum_{k=1}^{n} x_{ik}\lambda_k \geq 0, \forall i$$
$$-y_{j0} + \sum_{k=1}^{n} x_{jk}\lambda_k \geq 0, \forall j$$
$$\sum_{k=1}^{n} \lambda_k = 1$$
$$\lambda_k \geq 0, \forall k$$

3.1 The Inverted Frontier

The inverted frontier is a method that aims to sharpen the distinction between efficient DMUs, considering the high number of efficient DMUs typically generated by the model (Tschaffon and Angulo-Meza 2014).

This type of boundary is based on reversing the inputs and outputs to create a boundary comprising units with the worst management practices, i.e., border inefficient, as proposed by (Entani, Maeda and Tanaka 2002) .

DEA can be considered an exemplary model because it rewards DMUs with the best practices, based on the border efficiency standard. The inverted frontier allows the analysis of the worst performing DMUs.

Combining these two indices, it is possible to more accurately classify units as efficient or inefficient, thus preventing a DMU from being evaluated only for its more favourable results, without requiring the assignment of weights to subjective criteria ((Angulo Meza, Biondi Neto, et al. 2005, Pimenta 2005).

Thus, this problem can be analysed in a more sophisticated manner by a review of a DMU's inefficiency or by specialising a DMU based on its strengths so that it does not perform poorly on other tasks. The inverted frontier also allows the identification of a DMU considered "effective false" or a DMU with an efficient frontier that is considered inefficient and inverted on the border by default, thus generating a false efficiency (Soares de Mello, Macedo and Pimenta 2003).

The inverted efficiency is used to calculate the efficiency composite described in Equation (2), which is the arithmetic average standard efficiency in relation to the original boundary and the reversed boundary of relative inefficiency. This added efficiency index allows the ordering of the DMUs of the model.

$$\text{Composite Efficiency} = \frac{\text{Standard Efficiency} + (1 - \text{Inverted Efficiency})}{2} \quad (2)$$

To obtain an index for which efficient units have a value of 1, the normalisation is performed for efficiently composed units to divide their values for most or all efficiency measures composed. Thus, for a DMU to have a high efficiency, it must have a high degree of relevance to the optimistic border and low degree of relevance to the pessimistic border (Tschaffon and Angulo-Meza 2014).

The software used for analysis was SIAD (Angulo Meza, Biondi Neto, et al. 2005), which was developed to yield a wide range of results for the DEA, including the efficiency of each DMU and the weights, benchmarks and composed efficiency.

3.2 The identification of DMUs

To correctly apply the DEA model, the evaluated units acting on homogeneous processes, i.e., performing the same tasks with the same objectives and working under similar market conditions, must consider the same variables at each process, varying only in relation to the intensity or magnitude of production.

Following the concept of homogeneity, the group of DMUs was chosen to consist of major oil producing companies present in the qualifying lists presented in table 3

Table 3 - Major oil producing companies in 2010:

General Ranking	Oil and Gas ranking	Company	Country	Sales	Profit	Market Value
2	2	ExxonMobil	United States	$341.6B	$30.5B	$417.2B
13	3	Petrobrás	Brazil	$128.5B	$21.2B	$247.4
18	4	BP	United Kingdom	$300.5B	-$3.7B	$136.8B
19	5	Royal Dutch Shell	Netherlands	$373,3B	$20.4B	$228,1B
25	6	Chevron	United States	$189.6B	$19B	$215.9B
34	8	Total	France	$188.1B	$14.2B	$143.2B
53	10	ENI	Italy	$132.3	$8.4B	$98.5B

Source: (Financial Times 2011)

With respect to size and market positioning, Table 3 shows each company's global value and its position relative to other companies in 2000 (Overall Ranking) and within the Oil & Gas segment (Ranking Oil & Gas), according to the FORBES classification of the 2000 largest publicly traded companies in the world in February 2012. This classification is based on information available in companies' financial summaries and uses a methodology that separately assesses each company's volume of sales (Sales), profit (Profits), fixed assets (Assets) and market value (Market Value) to generate a score for each category. These scores are consolidated using the journal's internal metric to generate the list.

Despite the tendency of companies that are "oil-producing" to consider "producing energy" to encompass forms of renewable energy, these segments remain small in relation to hydrocarbon production. The company's main objective remains production, the predominant energy source worldwide.

Another important consideration is that the activities of enterprises are typically divided into three groups: downstream, upstream and chemicals. The first group relates to the entire operation of extracting hydrocarbons (crude oil, bitumen or gas); the second corresponds to the conversion of hydrocarbons; and the third represents indirectly derived products such as plastics, rubbers and other polymers. This division is a classification of activities within the same chain, with the overall outcome, downstream dictated by the performance of the principal activity.

Regarding the selection of DMUs, it was decided that the units should be accounted for companies and global operations, for two reasons. The first concerns access to financial data because these companies are required to provide information to the public about their operations, production levels, profitability and investment spending. The second relates to the standardisation of the data for the North American market, which requires the financial reports of companies to conform to certain standards such that all the data are communicated in a similar manner. An example is Form 20-F, created by the Securities and Exchange Commission (English, Security and Exchange Commission - SEC) and required for any publicly traded company that is not American and wishes to conduct financial activities in the United States.

Following the concept of homogeneity, the group of DMUs was composed of the major worldwide hydrocarbon producers, based on papers negotiated on the open market and the classifications of global magazines such as Fortune, Forbes and The Financial Times (Financial Times 2011). Only companies in the open market were considered because of the comparative ease of gathering information. So, the companies: PetroChina (General Ranking – 1 and Oil and Gas Ranking – 1), Gazprom (General Ranking – 33 and Oil and Gas Ranking – 7) and Sinopec (General Ranking – 36 and Oil and Gas Ranking – 9) weren´t selected in this study.

To correctly apply the DEA model, the only companies that were evaluated had homogeneous processes and competed in the same market with the same objective, under the same conditions with the same process variables and differed only by their size and level of production.

We chose to classify each Company_year as a DMU to enable assessment of the efficiency and the evolution of the efficiency ratio over time. The input-output data were analyzed year-by-year by use of DEA (see e.g. (Thompson, et al. 1996)). The DEA BCC ratio model was applied to each selected decision making unit (DMUo, o = 1,2,..., n). The data for the analysis was gathered from the financial and sustainability reports of the 7 major oil producers from 2006 to 2010.

3.3 Inputs and Outputs Determination

Determining the inputs and outputs is a critical phase of the study because these variables are the basis of the efficiency evaluation. Inputs may be defined as the basic resources or production factors that are available in limited quantities and have values larger than zero and that peaks as the utilization is increased f its utilisation (Thompson, et al. 1996).

Selecting inadequate variables may yield an inaccurate result regarding the evaluated group, so only the most important inputs and outputs were included in the model. The variables of this paper were chosen from the variables considered in similar papers, based on their applicability to the proposed analysis and the availability of information.

As inputs, Kassai (2002) used the net income and the number of employees, (Thompson, et al. 1997) considered the capital employed and the number of employees, and Thompson et al. (1996) considered the total costs incurred and the proven crude oil (Mbbls) and natural gas (MMCF) reserves of the previous year. As outputs, Kassai (2002) used the actual value, the added value and the investment in assets; (Thompson, et al. 1997) considered the expected earnings; and (Thompson, et al. 1996) considered the additions made to crude oil (Mbbls) and natural gas (MMCF) reserves by exploring the crude oil (Mbbls) and natural gas (MMCF) production for sale from their respective proven reserves.

For this analysis, the inputs were the investments in Exploration and Production (EP) (x_1) in US$ Billions, the investments in Research and Development (RD) (x_2) in US$ Millions, the number of employees (x_3) in thousands and the volume of spills (x_4) in BOE. The outputs were the annual production (y_1) in millions of BOE, the net income (y_2) in US$ Billions, in the current year. The data domain is presented in Table 4 for 2006. Similar data domains were developed for 2006,...,2010 (see Appendix I).

Table 4 - Input-output data for 7 Majors Oil Producing Companies: 2006

DMUs	**Inputs**				**Outputs**	
Company	x1	x2	x3	x4	x1	x2
BP	22.00	0.40	97	13,838	393	22.03
Chevron	16.61	0.47	55.88	6,099	267	17.14
ENI SPA	6.90	0.29	73.57	6,150	1.77	3.79
Exxon	16.23	0.73	82.1	7,000	4.24	39.50
Petrobrás	8.70	0.90	62.27	1,842	2.30	14.73
Shell	17.51	0.95	92.85	19,391	2.38	11.40
Total	11.93	0.75	95.07	15,906	2.35	11.61

Importantly, the output related to the volume of spills (x_4) in the current year is a negative result of the production process and does not contribute to process efficiency thus, it is considered an undesirable output. Because this variable will be treated distinctly, the Multiplicative Inverse approach will be used, which inverts the value of undesirable outputs and subsequently treats them as standard outputs (Tschaffon and Angulo-Meza 2014).

3.4 DEA Model to be used

The correlation of each variable of the group of DMUs was determined using a graphical analysis of the gathered data with a two-axis chart.

Nine analyses were conducted using all possible combinations of inputs and outputs in order to establish a relationship between the variables of the model and the DMUs that would compose the efficient frontier, based on the constant return scale (CRS) and the variable return scale (VRS). This analysis was used to determine the appropriate DEA model type, a linear graphical analysis of all variables revealed nonlinear relations between the outputs and inputs, thus indicating that the BCC model was best oriented to the outputs.

The following graphical analyses show a low level of linear correlation between the chosen variables. The largest values were found for the correlations in Figure 1 - "Daily Production X Investment in EP"(0,38), Figure 2 - "Number of Spills X Investment in EP"(0,19) and Figure 3 - "Net Income X Investment in RD"(0,1).

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Figure 1: Correlation Analysis - Daily Production X Investment in EP (0,38)

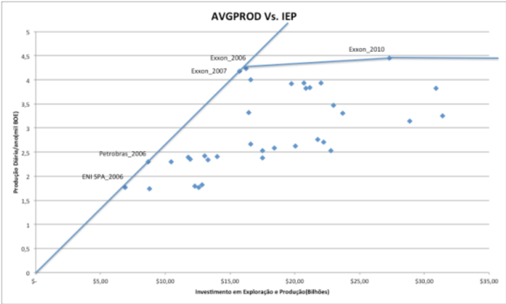


Figure 2: Correlation Analysis - Spills X Investment in EP (0,19)

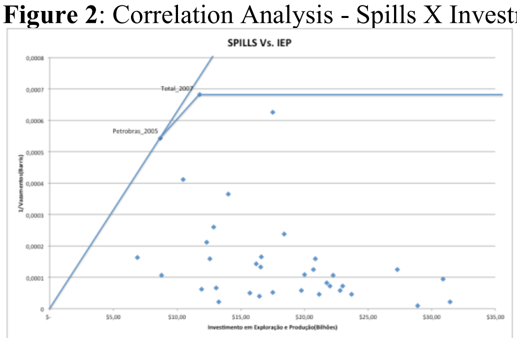
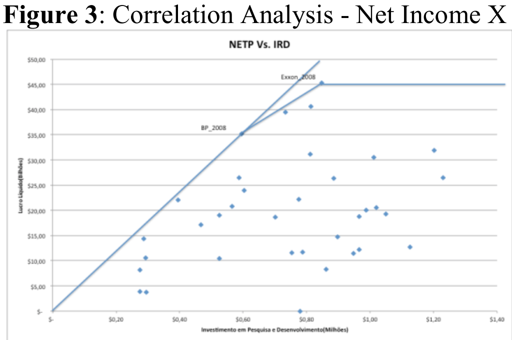


Figure 3: Correlation Analysis - Net Income X Investment in RD (0,1)



These low correlation levels strongly indicate that the relationship of the variable is not linear; thus, a variable scale would be more applicable to this case study. Consequently, the chosen model was BCC oriented to the outputs, and the variable spills during the year were considered an undesirable output, and it was adjusted based on the Multiplicative Inverse model.

4. RESULTS OF DEA EFFICIENCY ANALYSIS APPLICATION

The analysis of the standard BCC model oriented to outputs of the 35 DMUs evaluated in total (7 DMUs/y for 5 y), showed 17 were found to be DEA with an efficiency of 100%(standard frontier) and 13 were found to be DEA-inefficient (inverted frontier); see Table 5. Two companies remained efficient for additional years and 2006 witnessed the greatest number of efficient companies (5)

Table 5 - Majors efficiency measure by year and DMU, DEA-BCC

DMU	2006		2007		2008		2009		2010			
	Stand	Inv	Stand	Inv	Stand	Inv	Stand	Inv	Stand	Inv	#Ef	#Inv
BP	1	0,687	0,934	0,704	0,933	0,656	1,000	0,536	0,926	0,838	2	0
Chevron	1	0,781	0,910	0,909	0,833	1,000	0,926	0,921	0,980	0,888	1	1
ENI SPA	1	0,985	1,000	1,000	0,907	0,993	1,000	1,000	0,886	1,000	3	2
Exxon	1	0,519	1,000	0,536	0,943	0,623	0,933	0,676	1,000	0,657	3	0
Petrobrás	1	0,977	0,831	1,000	0,668	0,984	0,638	0,907	0,617	0,962	1	1
Shell	0,797	1,000	0,782	1,000	0,730	1,000	0,707	0,990	0,754	0,838	0	3
Total	0,747	0,969	0,767	0,972	0,664	1,000	0,698	0,990	0,558	1,000	0	1
#Ef and #Inv	5	1	2	3	0	3	2	1	1	2		

Regarding the inverted frontier, 16 DMUs were identified as not efficient. Also, the efficiency analysis shows that the inverted frontier 5 DMUs were considered "falsely efficient." These DMUs were 100% efficient in the two approaches (Standard and Inverted), thus indicating a high level of efficiency in their strengths and a high level of inefficiency in their weaknesses.

Considering the high level of efficient DMUs, an analysis of composite efficiency was performed with the aim of classifying all DMUs, shown on Table 6. The DMU EXXON_2006 was the most efficient DMU, which was confirmed by a comparison between the data of this DMU and the average results of the group. This comparison indicated that with the same levels of inputs, this unit generated considerably more outputs than did the others.

Table 6 - Overall Rating of DMUs

Company	Year	DMU	Standard	Inverted	Composed	Composed*
Exxon	2006	20	1	0,518619	0,74069	1
BP	2009	2	1	0,536057	0,731971	0,988229
Exxon	2007	19	1	0,536458	0,731771	0,987958
Exxon	2010	16	1	0,657176	0,671412	0,906468
Exxon	2008	18	0,943076	0,622787	0,660144	0,891256
BP	2006	5	1	0,68728	0,65636	0,886146
BP	2008	3	0,932802	0,655698	0,638552	0,862104
Exxon	2009	17	0,932803	0,675982	0,628411	0,848412
BP	2007	4	0,934362	0,70395	0,615206	0,830584
Chevron	2006	10	1	0,781495	0,609252	0,822547
Chevron	2010	6	0,979732	0,888129	0,545801	0,736882
BP	2010	1	0,926156	0,838293	0,543932	0,734357
Petrobrás	2006	25	1	0,976788	0,511606	0,690715
ENI SPA	2006	15	1	0,985417	0,507291	0,68489
Chevron	2009	7	0,925954	0,920751	0,502601	0,678558
Chevron	2007	9	0,910122	0,908717	0,500702	0,675994
ENI SPA	2009	12	1	1	0,5	0,675046
ENI SPA	2007	14	1	1	0,5	0,675046
Shell	2010	26	0,753712	0,838433	0,457639	0,617855
ENI SPA	2008	13	0,907417	0,993042	0,457187	0,617245
ENI SPA	2010	11	0,885797	1	0,442899	0,597954
Chevron	2008	8	0,832506	1	0,416253	0,56198
Petrobrás	2007	24	0,830959	1	0,415479	0,560935
Shell	2006	30	0,797108	1	0,398554	0,538085
Total	2007	34	0,767441	0,972405	0,397518	0,536686
Shell	2007	29	0,781658	1	0,390829	0,527655
Total	2006	35	0,746558	0,968851	0,388853	0,524988
Petrobrás	2009	22	0,638191	0,906569	0,365811	0,493879
Shell	2008	28	0,73038	1	0,36519	0,49304
Shell	2009	27	0,706544	0,990222	0,358161	0,48355
Total	2009	32	0,697822	0,990165	0,353828	0,477701
Petrobrás	2008	23	0,668416	0,984338	0,342039	0,461785
Total	2008	33	0,664429	1	0,332214	0,44852
Petrobrás	2010	21	0,617407	0,961538	0,327934	0,442742
Total	2010	31	0,558048	1	0,279024	0,376708

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***NORMALISED VALUE OF COMPOSED EFFICIENCY**

In summary, the development of the model showed that the most efficient company was EXXON, with 100% efficiency in 2006, 2007, 2008 and 2009. The year 2006 witnessed the greatest number of efficient DMUs, i.e., 5 companies.

The DMU Exxon_2006 stands out for its high level of production and net income. With 4,237 Mboe / day, this company enters second largest production group rated, behind Exxon_2010 with 4,447 Mboe / day and above the group average (2,935 Mboe / day). The difference is the net income, where Exxon_2006 reached the value of 39.5 billion compared to 19.59 billion dollars of group average. Investment levels of DMU were 17.9 and 0.73 billion dollars in E & P and R & D respectively, remaining in the group average. Other factor that remained in the middle of the group was the number of employees and the amount of spilled oil was lower than the average. Table 7 summarizes this information.

Table 7 – Variables analysis of Exxon_2006

	Exxon_2006	Group Average	Variation (%)
Annual production in millions of BOE	4,237	2,936	44
Net income in US$ Billions	$39,50	$19,59	102
Investments in EP in US$ Billions	$16,23	$17,94	-10
Investments in RD in US$ Billions	$0,73	$0,74	-
Number of employees in thousands	82,1	82,48	-
Volume of spills in thousands of BOE	7	15	-43

A possible explanation for the high number of efficient DMUs in 2006 is the value of the dollar, which was relatively high in 2005 and 2006, and the increase of crude oil spot prices thus impacting the results of enterprises in 2006. In 2007 and 2008, the value of the American dollar was low and negatively impacted the results of the enterprises, but 2008 is the second year with high number of efficient DMUs and it can be explained with the increase of crude oil in 37.38%, see Table 8. In 2010, the reduce of crude oil price associated with a sequence of three years of lost of the American dollar (15.78%), presents the lowest number of DMUs efficient (only 2).

Table 8 – Annual average values for the WTI crude oil spot prices, in USD/barrel, and USD/EUR from 2005 to 2010

	2005	2006	2007	2008	2009	2010
Crude oil Spot Price	56,64	66,05	72,34	99,67	61,95	79,48
Variation %		16,61%	9,52%	37,78%	-37,84%	28,30%
USD/EUR	0,805	0,797	0,731	0,683	0,719	0,756
Variation %		-0,99%	-8,33%	-6,47%	5,19%	5,13%

(From the EIA website: http://www.eia.doe.gov),
(ENERGY INFORMATION ADMINISTRATION,USA 2014)

5. CONCLUSION

~~To measure the efficiency of the transport of hydrocarbons by pipes,~~ This paper presents the efficiency analysis of the production and financial aspects of 7 major worldwide hydrocarbons producers based on DEA methodology that considered the variables related to its productivity.

The analysis verified a high level of efficiency for all DMUs. A total of 17 of the 35 DMUs were considered efficient in the standard analysis, and 16 of them were inefficient. Because 6 DMUs were classified as both efficient and non-efficient, they were considered "falsely efficient" and were excluded from the final results, thus reducing the number of efficient DMUs to 11. This high efficiency level may be justified by the fact that because hydrocarbons are negotiated as commodities, a high level of production efficiency is necessary for the companies to remain competitive in the market.

The most efficient company in terms of production levels was EXXON, which achieved 100% efficiency in 2006, 2007, 2008 and 2009. The greatest number of efficient companies occurred in 2006 (5).

Finally, it is important to notice that the major company EXXON presents the higher efficiency in DEA Model is the first company FT Global Ranking ((Financial Times 2011), even when we use different inputs and data outputs such as spills. This result proves the consistency of DEA analysis. On the other hand, the company BP showed better efficiency in the use of its resources, despite being in an inferior position in the ranking than other companies like Petrobrás.

The DEA model was adequate for this application because of its general characteristics and its use of few specific data. However, the results of the model should be used carefully because they are valid only for the evaluated group and the selected variables. The DEA methodology should be an element of an integrated management and decision system.

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