UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ENGENHARIA MECÂNICA
E INSTITUTO DE GEOCIÊNCIAS
PROGRAMA DE PÓS-GRADUAÇÃO EM
CIÊNCIAS E ENGENHARIA DE PETRÓLEO

MONICA REBELO RODRIGUEZ

Análise de Competição em Licitações Brasileiras de Áreas de Exploração e Produção de Petróleo

Este exemplar corresponde à redação final da tese defendida por **Monica Rebelo Rodriguez** pela Comissão julgadora em **06/12/2010**.

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Orientador

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Análise de Competição em Licitações Brasileiras de Áreas de Exploração e Produção de Petróleo

Autora: Monica Rebelo Rodriguez
Orientador: Prof. Dr. Osvair Vidal Trevisan
Co-orientador: Dr. Boris Asrilhant

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TESE DE DOUTORADO

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A Banca Examinadora composta pelos membros abaixo aprovou esta tese:

Prof. Dr. Osvair Vidal Trevisan
Instituição DEP/FEM/UNICAMP

Prof. Dr. Helder Queiroz Júnior
Instituição UFRJ/IE

Prof. Dr. Denis José Schiozer
Instituição DEP/FEM/UNICAMP

Prof. Dr. José Alberto Bucheb
Instituição PETROBRAS

Prof. Dr. Gabriel Alves da Costa Lima
Instituição DEP/FEM/UNICAMP

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Quem com perspicácia declarar sua
limitação está muito perto da perfeição.

Johann W. Goethe

RESUMO

RODRIGUEZ, Monica Rebelo, Análise de Competição em Licitações Brasileiras de Áreas de Exploração e Produção de Petróleo. Departamento de Engenharia de Petróleo: Faculdade de Engenharia Mecânica, Universidade Estadual de Campinas, 2010. 185 p. Tese de Doutorado.

Há 10 anos da quebra do monopólio para a exploração e produção (E&P) de petróleo no Brasil o mercado se mostrou estável, competitivo e gerando resultados positivos que atraem o interesse das companhias nacionais e estrangeiras a investir no setor de “upstream”. O processo de cessão de direitos e obrigações sobre as áreas de E&P é conduzido pela Agência Nacional de Petróleo, Gás Natural e Bio-combustíveis (ANP) por meio de licitação pública, com regras bem definidas, onde o vencedor assina um contrato de concessão com a ANP. Esta pesquisa apresenta e analisa o histórico destas licitações para áreas de exploração e produção e áreas inativas com acumulações marginais, dentro do cenário econômico brasileiro e do potencial exploratório do país, e compara o desempenho das empresas no Brasil e no Golfo do México Americano, segundo os investimentos realizados para aquisição dessas áreas. Apresenta, ainda, um modelo estocástico para estimava do valor dos blocos desenvolvido a partir das ofertas realizadas para áreas da Bacia de Campos em licitações pretéritas. Para analisar o nível de competição esperado para essas áreas, este estudo descreve também o desenvolvimento de um sistema especialista com a ferramenta Exsys Corvid®, baseado no julgamento de 36 especialistas da indústria do petróleo que trabalham em 20 companhias de pequeno, médio e grande porte. A aplicação desta metodologia permite que estas companhias estimem o nível de competição (alto, moderado, ou baixo) para áreas da Bacia de Campos. Conhecendo o valor das áreas e a estimativa do nível de competição, é possível subsidiar o processo decisório na elaboração de estratégias de oferta que permitam uma melhor alocação financeira dos recursos e a gestão ótima do portfólio exploratório pretendido pela companhia.

Palavras-Chave

Licitação pública de áreas de petróleo, exploração e produção de petróleo, competição, jogos, leilões, riscos e incertezas, valoração econômica, sistema especialista

ABSTRACT

RODRIGUEZ, Monica Rebelo, Análise de Competição em Licitações Brasileiras de Áreas de Exploração e Produção de Petróleo. Departamento de Engenharia de Petróleo: Faculdade de Engenharia Mecânica, Universidade Estadual de Campinas, 2010. 185 p. Tese de Doutorado.

After 10 years of the ending of petroleum exploration and production (E&P) monopoly in Brazil, the market for those activities has shown to be stable and competitive, providing positive results which attracted both national and international investment for the upstream oil and gas sector. The regulatory agency promotes public licensing of E&P areas through a competitive sealed bid auction, whose rules are clear and known in advance by the companies. This research describes and evaluates the historical data for these E&P licensing, as well as for tenders of marginal oilfield accumulations, under the Brazilian economic scenario and the geologic potential of the country. It also compares oil companies performance regarding investment made in acquiring areas in Brazil to those in US-Gulf of Mexico. A stochastic model for block-value estimation is presented and applied to previous data from Campos Basin licensed areas. In order to estimate the level of competition expected for those areas, an expert system was built using Exsys Corvid®, based on the knowledge captured from 36 specialists in Brazilian public licensing working for 20 oil companies. The proposed methodology is applied to the case of Campos Basin areas and showed to properly estimate the levels of competition expected (high, moderate or low) in the bid. By knowing the block-value and the expected level of competition, decision makers are better prepared for formulating bidding strategies that can result in better resources allocation and yield a better exploration portfolio management.

Key Words

Petroleum exploration and production, petroleum public licensing, competition, games, auction, risk and uncertainties, economic evaluation, expert system

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1. INTRODUÇÃO

1.1. Motivação

Na indústria brasileira do petróleo, bem como em vários países do mundo em que o estado é o proprietário dos recursos minerais existentes no subsolo, a transfer6encia de direitos e obrigações para explorar e produzir petróleo se dá por meio de licitações públicas de áreas pré-determinadas, e segundo regras pré-estabelecidas pela agência reguladora.

As companhias de petróleo qualificadas para participar desses processos licitatórios competem entre si pela aquisição dessas áreas para compor / recompor seu portfólio exploratório ou explotatório. Portanto, para vencerem a competição entre si, essas companhias devem apresentar a oferta mais competitiva, cuja elaboração se baseia em dois aspectos críticos: a valoração técnico-econômica da área e a análise da competição esperada para a área de interesse.

Cada companhia faz sua estimativa de valor da área e compromete uma fração deste valor como oferta na licitação. A estimativa desta fração ótima é dada por modelos matemáticos, amplamente divulgados na literatura, que visam determinar a oferta ótima capaz de maximizar os investimentos da companhia. Esses modelos adotam como premissa, dentre outras, que exista competição pela área. Entretanto, não são conhecidos na literatura modelos que permitam realizar esta análise de competição considerando a percepção dos decisores. Sabendo que a análise de competição é um fator que pode modificar consideravelmente a oferta que a companhia apresentará para uma área, esta pesquisa se dedicou ao desenvolvimento de ferramentas para o cálculo da oferta ótima e estimativa do nível de competição esperado nas licitações brasileiras.

1.2. Objetivos

A presente pesquisa objetiva desenvolver um método de estimativa do nível de competição esperado em uma determinada licitação pública brasileira para áreas de exploração e produção de petróleo (E&P), localizadas em uma bacia sedimentar marítima com sistema petrolífero ativo.

Sua contribuição para a indústria do petróleo, dentre outras, é auxiliar os decisores nos processos de elaboração de estratégias de oferta mais competitivas que maximizem os investimentos e/ou aumentem a chance das empresas adquirirem áreas de E&P.

1.3. Estrutura do Trabalho

Para se alcançar o objetivo pretendido, esse trabalho contou com uma extensa pesquisa bibliográfica sobre licitações brasileiras de áreas de exploração e produção de petróleo (E&P), sobre modelos e processos de licitação no mundo, e ouviu a opinião de especialistas com experiência em leilões no Brasil e no mundo. Todas as observações aqui apresentadas consideram os conceitos da teoria dos leilões, da teoria dos jogos e de como se desenha um modelo de licitação que atenda as necessidades do governo e da indústria.

O desenvolvimento da pesquisa e seus resultados são apresentados na forma de artigos técnicos publicados em congressos e revistas nacionais e internacionais, compondo os capítulos subsequentes, exceto o capítulo 6, ainda não publicado, cujo texto será submetido à apreciação da revista Resources Policy. A organização desses artigos (capítulos) segue a sequência da pesquisa e não sua ordem cronológica de publicação, permitindo assim, se ter um entendimento da evolução do trabalho

O capítulo 2 apresenta o artigo publicado na revista Terrae, v. 6. no.1, em 2009, e discorre sobre como a agência reguladora brasileira (ANP) formatou o processo de licitação de áreas de E&P após o fim do monopólio estatal exercido pela Petrobras. Inicialmente, é mostrado o cenário de preço do petróleo mundial, em queda a partir da década de 80, e os resultados de sucesso exploratório alcançados simultaneamente pela Petrobras com a descoberta de campos gigantes de óleo na Bacia de Campos, que motivaram empresas estrangeiras a participarem das licitações instituídas quando da sanção da Lei 9478/97 pelo governo. A idéia central deste capítulo é mostrar que o modelo adotado pela ANP, em função dos resultados das licitações, é considerado sucesso dentro dos conceitos teóricos que analisam o número de participantes no processo (competidores), a quantidade de área adquirida e o montante de bônus arrecadado pelo governo.

Após seis anos licitando com sucesso as áreas exploratórias, a ANP ofereceu ao mercado áreas inativas com acumulação marginais de petróleo sob um modelo muito semelhante ao já consagrado. O capítulo 3 apresenta as informações sobre este modelo e os resultados das duas licitações realizadas até então, mostrando que devido ao caráter de baixos volumes recuperáveis, o número e o perfil das companhias que competem por essas áreas difere daquelas que se qualificam para as licitações exploratórias. Em geral, são companhias brasileiras de pequeno porte que competem pelas áreas, preferencialmente consorciadas entre si, e que não têm perfil de atuação conhecido no segmento “upstream” da cadeia do petróleo. O objetivo dessa seção, cujo artigo foi publicado na Revista Brasileira de Geociências, v. 38, no. 2 em 2008, além de apresentar os dados compilados destas licitações, é mostrar que a análise de competição é um estudo a ser feito para qualquer processo decisório de aquisição de área via licitação pública. Entretanto, as áreas inativas com acumulações marginais não foram alvo deste estudo devido à ausência de um número de dados estatisticamente significativo para a aplicação dos métodos de valoração e competição aqui propostos.

Assim sendo, tais métodos foram desenvolvidos para as licitações de áreas exploratórias da Bacia de Campos, por esta ter sido ofertada em oito das dez licitações promovidas pela ANP, existindo, portanto, uma massa crítica de dados que permitiram estudar os processos decisórios de aquisição de áreas. A tomada de decisão sobre qual a oferta mais competitiva a apresentar precisa considerar o valor ótimo da oferta a ser comprometida como bônus de assinatura, o montante de programa de trabalho exploratório (PEM) e o nível de competição esperado para cada área. O capítulo 4 mostra que a busca por métodos que maximizem as ofertas apresentadas pelas companhias é objeto de estudo de vários autores, conforme indicado na literatura deste artigo publicado na AAPG Bulletin, v. 92, no. 10 em 2008. Dentro dos conceitos de eficiência alocativa, maximização de receitas e multidimensionalidade das informações e das propostas foi desenvolvido um método, baseado na simulação estocástica utilizando o método de Monte Carlo, para calcular a oferta ótima a partir das informações públicas (simétricas) existentes. Os resultados simulados são comparados aos bônus efetivamente realizados e a análise das estratégias adotadas pelas companhias, permite o decisor identificar como é possível elaborar uma estratégia de oferta competitiva utilizando diferentes valores da fração do valor monetário esperado (VME) da área.

A partir deste ponto da pesquisa duas questões suscitaram interesse em se investigar:

a) a primeira se refere aos valores de oferta que as companhias de petróleo estão oferecendo para as áreas da Bacia de Campos. Partindo da premissa da licitação competitiva selada, ou seja, que tais companhias não conhecem os valores que seus competidores irão oferecer pela área, nem quais são estas áreas de interesse, nem quantos e quais são estes competidores, foi testada a hipótese de que as empresas que participam de uma licitação brasileira realizam investimentos para aquisição de áreas similares aos realizados para áreas no Golfo do México Americano;

b) a segunda diz respeito ao processo decisório em si que requer uma análise de competição robusta para que a oferta mais competitiva seja vencedora, sem entretanto, deixar um montante de dinheiro desnecessário sobre a mesa ou que permita a companhia não ser vítima da maldição do vencedor (pagamento de bônus muito elevados que não retornarão os investimentos realizados).

O capítulo 5 aborda o teste de hipótese supracitado, tendo sido escolhido o Golfo do México Americano (US-GOM) por ter suas áreas licitadas, segundo um modelo com dinâmica de oferta semelhante às licitações brasileiras, por mais de 40 anos, apresentando áreas com resultados de sucesso exploratório, campos em produção com infraestrutura de escoamento, e características geológicas para acumulação de hidrocarboneto, similares as da Bacia de Campos (BC). A análise comparativa entre as ofertas do US-GOM e da BC considerou os valores de bônus e PEM e teve seus resultados publicados sob o no. SPE 113696 dos anais do 2008 SPE Europec / EAGE Annual Conf. and Exhibition. A análise foi conduzida para ofertas por áreas de águas rasas e profundas, onde se observou que as empresas internacionais adquirem as áreas da BC desembolsando valores “upfront” comparáveis aos bônus pagos por áreas no US-GOM, porém comprometendo valores adicionais a título de PEM como pagamento de longo termo.

No capítulo 6 é apresentada a metodologia desenvolvida para auxiliar os decisores no processo de estimativa de competição que suporta a escolha da melhor estratégia de oferta. Esta seção, estruturada sob a forma de artigo técnico ainda não foi publicada, mas seu conteúdo foi submetido à apreciação do editor da revista Resources Policy. Com o intuito de identificar como os decisores estimam a competição, alguns métodos de pesquisa operacional baseados em análise mutliatributo foram investigados (matriz de decisão e processo analítico hierárquico) com o suporte acadêmico do Prof. Dr. Michael Walls na Economic and Business Division da Colorado School of Mines. Porém, tais métodos, apesar de lidar com a preferência dos decisores, não incorporam processos cognitivos como o julgamento de cada decisor (raciocínio lógico construído a partir de suas experiências e conhecimento). Métodos como sistema especialista, ramo da inteligência artificial, capturam tais julgamentos, sendo capaz de auxiliar as tomadas de decisão a partir da construção de uma base de conhecimento e da formulação de regras que representam a lógica racional dos decisores. A construção do sistema especialista se deu a partir da captura do conhecimento de 36 representantes da indústria do petróleo familiarizados com os processos de licitação no Brasil. Profissionais de empresas de pequeno, médio e grande porte foram convidados a responder um questionário inédito desenvolvido especificamente para abordar a competição por áreas da Bacia de Campos, o qual permitiu quantificar a percepção com relação a formação de parcerias e outros. Transformando este conhecimento em variáveis, regras e blocos lógicos com a plataforma Exsys Corvid®, foi possível estimar o nível de competição esperado para cenários variáveis do tipo de áreas ofertadas, do número e perfil de companhias participantes e quanto ao tipo e proveniência das informações que circulam durante o período de licitação e que podem impactar a análise de competição.

Toda a metodologia desenvolvida nesse trabalho se voltou para as licitações brasileiras de áreas de exploração e produção sob o modelo de concessão adotado pela ANP. Entretanto, motivada pelo novo marco regulatório que determina a assunção do modelo de Partilha de Produção (PSC) para licitar áreas exploratórias da camada do pré-sal, esta pesquisa capturou o julgamento dos especialistas quanto ao possível impacto que este modelo e suas regras poderiam causar na competição por estas áreas. Os resultados são apresentados e discutidos ainda no capítulo 6.

Por fim, o capítulo 7 resume as principais conclusões desta pesquisa e elenca algumas sugestões para trabalhos futuros.

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2. AN OVERVIEW OF BRAZILIAN PETROLEUM EXPLORATION LEASE AUCTIONS

An Overview of Brazilian Petroleum Exploration Lease Auctions

Monica Rebelo Rodriguez
PETROBRAS, Science and Petroleum Engineering Graduate Program – FEM/IG – UNICAMP
monicarr@petrobras.com.br
Saul B. Suslick
UNICAMP, Institute of Geosciences and Center of Petroleum Studies

Abstract

The concession process for oil and gas exploration through competitive bidding marks a significant step for Brazil's petroleum sector after 1997, which created an attractive setting for oil industry investments. Its geological potential, as proven by the results achieved through the discovery of giant oilfields, stimulated oil companies to participate in auctions hosted by the Brazilian National Petroleum Agency. Using a classical competitive first-price sealed bid model, this process grants companies the rights to exploration under a concession contract signed with the government's representative. A number of eight licensing rounds, performed yearly, guaranteed about 443,840 km² of exploration area for 141 oil companies who spent over R$ 3.84 billions as bonuses, which could be considered as a indicator of the success of the Brazilian bidding process. This paper presents an overview of the main aspects and results of Brazilian petroleum exploration bidding which is a specific experience of change from a monopoly to an open market entry for E&P investments. A review of exploration activities before the opening of the petroleum sector is also included to explain the impacts creating by the new market settings.

Keywords *Petroleum exploration, auctions, risk.*

Introduction

Until 1997, upstream activities in Brazil had been conducted exclusively by a state-owned company, PETROBRAS[1], when Petroleum Law 9.478/97 was approved, ending a 42-year monopoly of oil and gas exploration and production. Since 1998, the Brazilian petroleum regulatory agency has been hosting yearly licensing rounds for leasing acreage for petroleum exploration rights under a concession regime. The adopted model is competitive sealed bid auctions, in which the winner is the oil company presenting not only a higher cash bonus, but also committing an expressive exploration program and a percentage of local content in services and operations to be applied in both the exploratory and production development phases.

The bidding scheme favors government's expectation to maximize the chances of a fair market value for the right to drill for and to produce oil and gas on public lands. In an oil and gas lease setting, auctions can serve as an allocation mechanism and as resource rent taxation. An auction provides the

1 Petrobras ownership has a significant participation of the private sector (ADR, Bovespa). The government holds approximately 32.2% of the capital and BNDES 7.6%.

government both with better information about a company's perception of the value of a resource tract and with the potential of considerable higher future revenues from its licensing.

Campos Basin outcomes push the oil companies to heavily invest in Brazil through the acquisition of exploration rights since the first licensing round, believing that Brazil is the new "Eldorado" for petroleum exploration discoveries (Moraes Jr. et al., 2004). The oil and gas production of Campos Basin presently corresponds to over 80% of Brazilian domestic production that recently reached 1.8 million bbl/d, making the country self-sufficient in domestic oil supply.

Oil companies are also envisaging a promising new frontier known as the "pre-salt play" recently drilled in deep water Santos Basin. Their enthusiasm for the geological potential for hydrocarbon generation and for finding giant oil and gas fields in this setting lead the companies to compete strongly in the last licensing round, increasing the cash bonus value of the areas to figures never seen before in Brazilian rounds. Since 1999, eight licensing rounds have been held in Brazil, in which more than 3,000 blocks[2] were released and over 140 oil companies spent approximately R$3.8 billion.

The goal of this paper is to give an overview of the whole process of Brazilian auctions including their modeling aspects, strategies and results, in addition to a review of exploration activities before the opening of the petroleum sector.

This paper is organized in two main sections: The Opening of the Brazilian Petroleum Sector and Petroleum Auctions Rules and Strategies. In the first part subjects such as the monopoly period, the Brazilian geological setting and the role of the Brazilian National Petroleum Agency will be addressed. In the second part the Brazilian bidding process, strategies, rules and results as well as the dynamic of competing or cooperating in bidding systems will be presented. The final section presents general remarks and conclusions.

The Opening of the Brazilian Petroleum Sector

For over 40 years, PETROBRAS had the rights and obligations to carry out petroleum exploration, production and marketing under the aegis of the petroleum state monopoly.

The Brazilian Constitution of 1934 and 1937 defined that all mineral resources belong to the state and any exploration of natural resources should take place through a concession regime law. A Mining Code was enacted in 1934, formally defining the state monopoly of petroleum. Regulatory agencies such as Conselho Nacional do Petróleo (CNP) and Departamento Nacional de Combustíveis (DNC) were created to regulate and to conduct all related activities (Ribeiro, 2005). In 1953, PETROBRAS was created as a state-owned company, and remained so until to 1995, when constitutional amendment 09/95 established the end of the petroleum monopoly held by PETROBRAS. Two years later, Petroleum Law 9.478/97 established the main principles and guidelines of national energy policy, creating both the Agência Nacional de Petróleo, Gás Natural e Biocombustíveis (ANP) and the Conselho Nacional de Política Energética (CNPE) as reported in Bucheb (2007).

The Monopoly Period

The boom of the oil industry around the world motivated the start of petroleum activities in Brazil. After the Second World War, the imbalance between demand and supply of oil products enhanced progressively, stimulating countries to perform more activities to find petroleum resources in their own territories to avoid an increasing dependence on fuel or crude oil imports.

At that time, there were two opposite development views in Brazilian energy and political scenarios. The country has a business sector with powerful international economic groups interested in both the refining and distribution sectors of the oil industry, as well as a strong nationalistic appeal derived from the popular historical campaign - "O Petróleo é Nosso" – seeking to guarantee the country's oil supply.

Arguments against the nationalistic movement were the uncertainties related to the existence of an active petroleum system in Brazilian sedimentary basins, and the limited domestic technological capability for petroleum exploration and production. Arguments in favor were the high level of credibility of the Conselho Nacional do Petróleo – CNP – and its strong political influence.

2 In Brazilian licensing rounds, the term blocks has the same meaning as area used traditionally elsewhere.

Created in 1938 by Decree 395/38, CNP played the role of an embryonic regulatory agency auditing and giving permits for petroleum exploration activities up to 1990, when it was closed. Two events should be highlighted during CNP management: the first oil deposit discovered in Lobato city (Bahia), in 1939, and the first commercial oil pool – the Candeias Field – with 350 MM bbl of oil in place, discovered in 1941 at Recôncavo Baiano Basin, which is still productive today. During this period, the Brazilian government decided, in 1953, to create a national oil company with Law 2004 – PETROBRAS – which would be in charge of the entire process of finding, producing and marketing oil and gas resources. In 1954, CNP transferred all its legacy of onshore oil deposits as well as its recognized technical consulting team to PETROBRAS (Mendonça et al., 2004).

PETROBRAS also inherited from CNP a 15 MM bbl reserve, a daily production of 2,700 bbl, and a goal to supply the challenging target of 137,000 bbl/d national demand. In 1960, CNP was incorporated into The Mining and Energy Ministery (MME), when the domestic daily production reached 43,300 bbl/d, but consumption bypassed 200,000 bbl/d. The first oil crises broke out in 1973 (the OPEC Embargo), raising oil price from US$ 2/bbl to US$ 14/bbl, when Brazil's 170,000.00 bbl/d oil production was coming from three different sedimentary basins: Recôncavo Baiano, Sergipe-Alagoas and Espírito Santo. The second oil shock (Iranian Revolution and Iran – Iraq War) blew up six years later when oil prices reached up to US$ 85/bbl. That year, 1979, the growing demand for oil was 1,133,000 bbl/d - pushed the government to establish an oil production goal of 500,000 bbl/d to be reached by 1985[3]. During this period, the federal government decided to implement a national program to produce ethanol from sugarcane as a gasoline substitute. This decision was motivated by the extreme burden placed on the nation's external trade balance by high oil import prices and was aimed at reducing petroleum imports despite the fact that the program required substantial additional investments and high subsidies (Moreira and Esparta, 2006).

When the petroleum state monopoly carried out by PETROBRAS ended in 1995, the oil price was US$ 17/bbl, oil production was 807,000 bbl/d and oil consumption was 1,498,000 bbl/d, but the anticipated self-sufficiency[4] in oil supply came only by the end of 2005. At that point, PETROBRAS was producing over 90% of the 1,800,000 bbl/d consumption in a scenario of high oil prices (US$54/bbl) forecasting continuous price volatility. Figure 1 presents the evolution of Brazilian oil production in million barrels, from 1950 to the present, and the petroleum price ($brent/bbl).

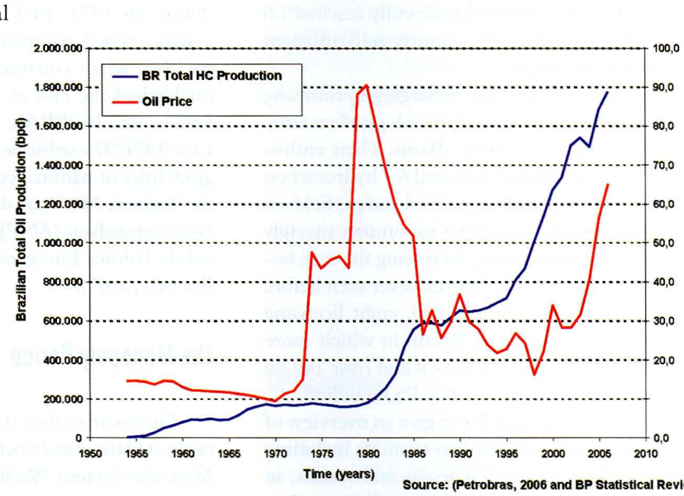


Figure 1 – The evolution of oil prices per barrel (actual values) and PETROBRAS petroleum production from 1950 to 2006. Oil prices reported are: 1861-1944 US Average, 1945-1983 Arabian Light posted at Ras Tanura, and from 1984-2005 Brent dated

3 All figures related to oil prices, oil production and consumption were obtained from *Platts* and Statistical Review Full Report Workbook, 2006.

4 The scenario of full self-sufficiency adopted by the government was equilibrium of 3 or more consecutive months between supply and demand during one year. In 2005, the country's total oil production accounted for self-sufficiency. In 2006, PETROBRAS reached oil self-sufficiency, with about 70% of its production coming from deep and ultradeep waters (Petrobras, 2006).

The Brazilian Geological Setting Attracted New Players

In addition to the successful results of Recôncavo Baiano Basin, by the end of 1960 PETROBRAS' exploration manager (Walter Link) reported that if PETROBRAS would like to stay in the petroleum exploration activities in a position to compete in the international oil scene, it should direct its attention to foreign countries as analogs in which the chances of finding oil and gas deposits were better than in Brazil (Campos, 2001).

In 1961, the PETROBRAS team indicated different techniques and models to evaluate Brazilian sedimentary basins. The results achieved through this approach proved that Brazil had a strong potential for petroleum with important oilfield discoveries such as Carmópolis (1.15 billion bbl of oil in place in the Sergipe-Alagoas onshore basin) and Miranga (600 MM bbl of oil in place in the Recôncavo basin).

Seismic acquisition and aeromagnetic surveys were performed in the Brazilian Continental Shelf at the beginning of the 60's at the same time as some advances in petroleum exploration technologies became available. In the early 70's, more than 53 wells were drilled in basins such as Foz do Amazonas, Potiguar, Campos and Santos offshore and Espírito Santo onshore basins.

Garoupa Field, an offshore oil deposit discovered in 1974, was the first expressive commercial find in shallow water Campos basin, the play drilled was Albian carbonates structured as a roll-over due to the fault system generated as consequence of the movement of Aptian salt domes. Following this trend of high-energy carbonates, a number of oilfields were mapped and discovered. Tertiary sandstone oil reservoirs were found as a secondary exploration target at water depths lower than 400 m (Mendonça et al., 2004). Other relevant plays in shallow water Campos basin were the Upper Cretaceous sandstones and the Lacustrine limestones of the rift sequence.

In 1976, exploration activities on the continental shelf of the Brazilian Equatorial Coast uncovered some Cretaceous oilfields with moderate volumes in both Potiguar and Ceará basin. The onshore portion of Espírito Santo basin had impressive results with oil production at 2,500 bbl/d from sandstone Eocene turbidites. Notwithstanding, Potiguar, Sergipe-Alagoas and Recôncavo basins also had good results for both oil and gas prospecting.

Extensive interpretation work focused on geological and seismic amplitude anomaly modeling revealed favorable reservoirs with good permeability and porosity and features such as bright spots – a gas sandstone pool - leading to the discovery of Piranema gas field located in the Amazon Cone.

Paraná Paleozoic basin was a very poorly sampled basin due to the existence of basaltic sills close to the surface and intruding low velocity layers. These sills interfere with seismic acquisition, generating noise and low resolution, and are hard to interpret in addition to having higher drilling costs. But, after some gas finds and considering the strategic location of Paraná basin in the heart of the southeast consumer market, the exploration work continued up to the discovery in 1997 of Barra Bonita Field, a 17 km^2 commercial gas accumulation (Campos et al., 1998).

By the end of the 70's, PETROBRAS had taken a 3D seismic capture of Campos basin, improving the quality of the geophysical data. Using seismic amplitudes and sequence stratigraphy concepts as direct hydrocarbon identification (DHI), the PETROBRAS team devoted attention to the sediment package deposited over the continental shelf by-pass zones. At the beginning of the 80's, all of the fields found in Campos basin proved the existence of an active petroleum system and the most prolific trend for petroleum exploration in Brazil. Oil reserves in 1983 were equivalent to 4 billion bbl and oil in place volume reached 30 billion boe.

Solimões basin, a Paleozoic basin, was drilled in this period with successful results for both gas (Juruá Field – Carboniferous sandstone) and high quality oil (Urucu Field – Devonian fluvial/eolic sandstone producing around 58,000 bbl/d).

In the middle of 1989, onshore Potiguar basin produced higher volumes of oil and gas compared to the mature basins of Recôncavo and Sergipe-Alagoas. Features such as those observed in carbonate reservoirs of shallow water Campos Basin were found in shallow water Santos Basin. The discoveries of high-energy carbonate fields filled with condensate opened a new frontier for this basin.

Although petroleum exploration in Brazil revealed a widespread variety of geological settings for oil and gas located around the country, what definitely attracted the attention of the international oil industry were the deep-water Campos basin exploration results achieved in the 80's and 90's.

The advances in technology and its fast development for both seismic acquisition and drilling in water depths over 400 m allowed geoscientists to explore new offshore frontiers. Campos Basin, with its proven active petroleum system in shallow waters, was a natural candidate for the application of these technologies. In the 80s, in water depths over 400 m, a set of canyons dividing the platform were identified. A detailed investigation of this geological model lead to the discovery of the giant Marlim Field, a depositional fan system with 6 billion bbl of original oil in place. A series of tertiary turbidite sandstones were mapped in that decade, resulting in the discovery of other giant oilfields such as Albacora Field (4.5 billion bbl of oil in place) and Barracuda (2.7 billion bbl of oil in place). Information about general geological and geophysical features, reservoir characteristics, and development and production projects can be found in Assis et al. (1998) and Luchesi and Gontijo (1998).

In 1996, right before the opening of the petroleum sector to foreign oil companies, Roncador oilfield was discovered at a depth of approximately 1,500 m with 9 billion bbl of original oil in place. The evaluation wells drilled in Roncador lead PETROBRAS to a new record: the drilling in water depths over 1,800 m (Assayag, 1997). In 2001, for the second time, the Offshore Technology Conference (OTC), a recognized petroleum institution, awarded PETROBRAS a quality prize for its performance. As the offshore drilling technology reached 2,000 m water depth, new geological settings were mapped and a new giant oilfield (Jubarte Field) was discovered in the northern sector of Campos basin, opening a new perspective for exploration activities (Da Silva et al., 2004).

All these positive indicators push international oil companies to participate in Brazilian licensing rounds, and from 2000 to 2006, they made successful discoveries in Campos basin, with more than six economically successful oil deposits in this region, for example: Argonauta, Ostra, Abalone and Nautilus Oilfields (Shell / PETROBRAS / ExxonMobil); Polvo Field (Devon / SK); Papa Terra Field (PETROBRAS / ChevronTexaco / Nexen); and Chinook Oilfield (EnCana / Kerr McGee)[5].

The evolution of these discoveries, recorded by volumes of equivalent oil, can be seen in Figure 2 showing that technology and geological modeling improvements guide exploratory activities to results

5 The Consortium names presented in this paragraph reflect the name of the companies that were the concessionaire of the fields in year 2005. From year 2006 to 2007 ANP assigned the rights of Chinook Field to Anadarko and Hydro, Nexen withdrew from Papa Terra Field, and the assignment of Argonauta, Ostra, Abalone and Nautilus Oilfields from ExxonMobil to ONGC is still under analysis.

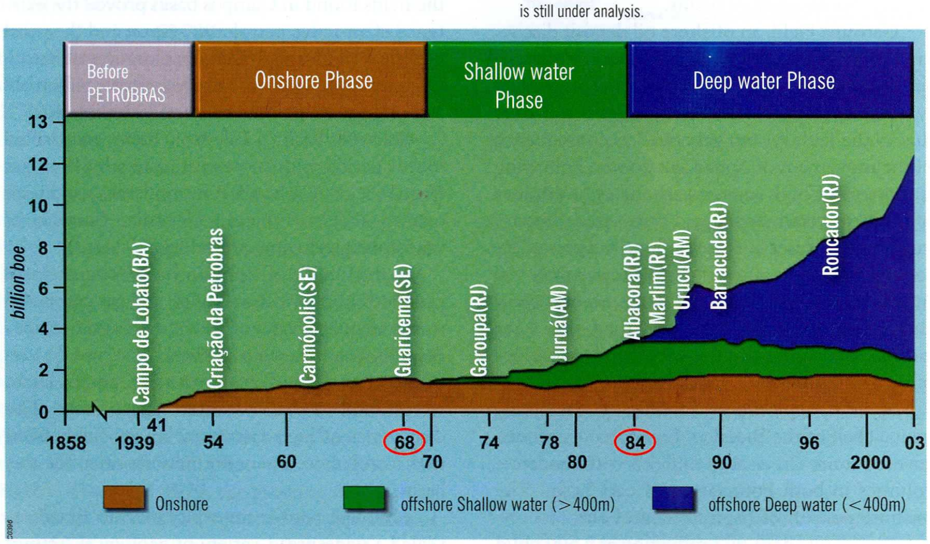


Figure 2 – The evolution of exploratory activities along the years and the resulting volumes of equivalent oil produced from onshore basins through deep water offshore basins

that range from 1.5 billion boe onshore volumes to a 12 billion boe deep water offshore reserves.

Recent exploration outcomes in deep water Santos Basin are creating the perspective of a new frontier, in terms of geological setting, that could revolutionize the exploration history of the country. In basins like Santos, which is prolific but mature, deeper and subtler opportunities should be pursued. Often these plays rely on new petroleum systems and/or preservation of deep porosity, as stated by Rudolph (2007). Oil companies are focusing their interest to pre-salt horizons located below a 2,000 m thick salt layer, which may enclose high volumes of hydrocarbon due to the size of the area mapped in the 3D seismic data. These perspectives stimulate PETROBRAS to pursue high risk/high reward potential plays in remote or challenging settings. Exploration in these frontier areas is being enabled by both a return to fundamentals and the next generation of basin concepts and modeling capabilities. Recent discoveries in such pre-salt structures confirm a new frontier for exploration and production activities. A competitive climate is driving up the cost of opportunity capture, creating a "winner's curse" scenario, as it is shown by the results of the unfinished Brazilian 8th auction.

The Role of the National Petroleum Agency

As previously discussed, Brazil's National Congress has created Petroleum Law 9.478/97 and two institutions: the regulatory agencies ANP and CNPE. These organizations report to the Mining and Energy Ministry and to the Government. Although ANP has important activities relating to auditing, contracting and regulating all segments related to petroleum economic activities, this paper concentrates more the role of ANP in promoting petroleum lease auctions.

One of ANP main targets is to define the rules allowing the set up and the maintenance of a competitive market that is beneficial for Brazilian economic development. Based upon the government taxation system created by the Petroleum Law and using the international petroleum price as a reference, ANP chose the auction process and designed a model for Brazilian acreage licensing rounds for the purpose of enhancing domestic oil and gas reserves and attracting national and international oil companies (ANP, 2007).

Before hosting the first licensing round, which required a selection of areas to be offered and preparation of a data package with technical information of those areas, ANP had to manage all existing geological and geophysical data acquired during the last 50 years as a result of the exploration and production activities carried out by PETROBRAS.

According with the new regulations established by Petroleum Law 9.478/97, for all existing oil and gas fields under production or in a development phase, PETROBRAS had a three-month deadline to submit a production development project for ANP approval in order to receive the concession rights.

Regarding all exploration activities in progress, and considering that Brazil has around 160,000 km2 of sedimentary basins (Fig. 3), PETROBRAS had to elect areas to keep exploring and others to return to ANP. In 1998, according to Article 33 of the Petroleum Law, PETROBRAS and ANP signed 397 concession contracts, with 115 exploration areas, 51 development areas and 231 production fields. This event is known as "Licensing Round Zero" (Furtado, 2004). Figure 3 shows that even after licensing acreage for eight consecutive years, ANP still has almost 97% of potential areas to be offered through auction, i.e., only 3% of total sedimentary covertures are under concession rights.

It is ANP's role to host the Brazilian licensing rounds. The announcement of a new auction in Brazil is made through a road show performed worldwide to attract companies' interest. ANP also develops all rules, contracts and procedures that companies should follow to participate in the leasing, as well as the minimum bonus for each area under offer and the selection of areas. The bidding model structured by ANP will be detailed in the next topics.

Auction dynamics and success depends on the number of participants interested in investing in the country. ANP adopted the practice of getting companies' feedback through public hearings, so the concession contract clauses and regulations could better reflect companies' international experience and expectations in petroleum exploration, production and commercialization in the Brazilian market. An important issue that motivates companies to keep investing in acreage acquisition is the assurance for companies to export the petroleum

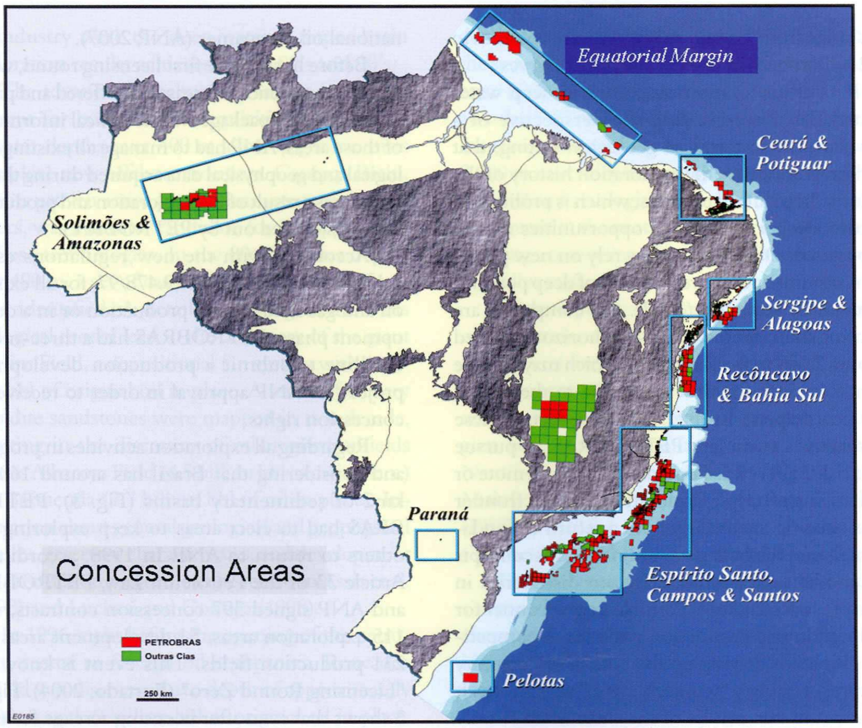


Figure 3 – Brazilian map showing all sedimentary basins in light yellow and the acreage under concession contracts since 1998. PETROBRAS' areas are the red blocks (solo or in joint ventures) and other companies' areas are green blocks (solo or in joint ventures)

produced[6] and the attractiveness of petroleum basins for giant oil and gas resources (ANP, 2007).

Since 1999, the regulatory agency has hosted eight licensing rounds. The eighth was interrupted and the ninth is scheduled for November, 2007.

What are the Rules and Strategies of a Petroleum Auction?

In order to exploit natural resources efficiently, government agencies can choose, among several approaches, a model to assign exploration rights for the companies that guarantee a performance in accordance with the best practices of the industry. Focusing on the petroleum industry, there are two main processes for allocating petroleum leases: informal, such as direct negotiation, and administrative, such as auctions.

The informal process has some constraints such as lack of transparency, specific preferences, corruption and its tendency to be more vulnerable to expropriation, which reduces both competition among the companies and government revenues.

On the other hand, an auction requires rules clearly established before the start-up process, giving transparency benefits for both bidders and auctioneers, mitigating potential corruption and encouraging competition through a fair process (Cramtom, 2005). The bidding process is a mechanism that has been widely used by different countries to distribute their oil exploration acreages optimally. The auctioneer is concerned with the long-term health and growth of his business, not with maximizing his expected revenue from a single auction. These are accomplished by balancing sellers (government) and buyers (companies) targets, i.e., it should have

6 The Petroleum Law states that only in a *force majeure scenario*, such as a strong disruption between supply and demand, are the companies temporarily obliged to sell the oil and gas in domestic market.

high enough prices to keep sellers consigning assets for sale and it should have low prices to keep bidders voluntarily attending in sufficient numbers (Rothkopf and Harstad, 1994).

Another characteristic of the auction model is that it discloses information: how valuable the bidders believe the lease to be, and which bidder values it most. This information isconsidered a competitive advantage, since the bidders do not know a priori the actual value of the oil blocks. Knowing your competitors and the likelihood of their bids carries equal importance when compared to a good estimation of the actual value of the block offered, avoiding participants bidding less of their estimated values, a normal practice considering uncertainties in valuation and covering their potential losses in case of exploration failure.

These features push ANP into an auction model. The Brazilian leasing mechanism elected by ANP to assign petroleum exploration rights is a common value auction based on a competitive first-price sealed bid method.

The Brazilian Bidding Process

A well-designed auction model should consider five main aspects: pre-qualification, guarantees, reservation prices, auction form and biddable factor, such as working program, royalty, profit share and cash bonus (Cramtom, 2005). ANP built the Brazilian bidding model considering some of these aspects.

The main bidding processes are the following (Figure. 4):

• Announcement – ANP announces a licensing round and releases the areas to be offered with a minimum cash bonus value per area (similar to a reservation price). The areas are selected according to government strategies for the country's development, such as improving exploration activities in new frontier basins or in a specific gas province etc.

• Qualification - companies are requested to prove technical, legal and financial assurance, as well as indicate their intention to be operator or non-operator for onshore, offshore shallow or offshore deep-water areas. This qualification step assures both ANP and potential partners that a skilled company is able to carry out all commitments required by the regulatory agency.

• Technical data package – companies receive a data package with geological and geophysical data from the sedimentary basins on offer they wish to bid for, after confirming participation by paying a fee. This data package contain information such as 2D and 3D seismic data, well logging registers, geochemical analyses, aeromagnetic and aero-gravimetric measurements, cuttings, maps, petrophysical analyses, thin section petrography, among others;

• Bidding offer according to established rules and schedules - companies' qualified are only able to present offers solo or in joint ventures for the areas for which they bought the data package. The winning proposal is the one that has higher points considering the total amount committed as bonus, working program and local content.

• Concession contract signature - executed between ANP and an affiliate or Brazilian company (solo or in consortium), requires a cash bonus payment and a bank guarantee letter to prove companies' financial capability to perform the working program committed in the offerings. It is valid for up to 27 years, in case the exploration area turns into a production field.

The biddable factors to define the winning proposal per area leased are: cash bonus, minimum exploration working program (PEM) and local content (CL).

• Cash bonus – means the sum of cash money companies offer to have the rights to explore the area. ANP defines a minimum bonus value and companies may bid as much as they wish. In general, the respective literature says that they bid around 30% of the expected monetary value (VME) estimated for the area, and may reach 100% or even more (Furtado and Suslick, 2003);

PEM – means the amount of exploration activities companies will carry out in the area. It is a commitment assumed by companies when presenting their offers and reflects how companies see the potential of the area. The more aggressive the PEM is, the higher the value of the area is for the bidder.

CL – the local content is a percentage of both the exploration phase and development and production phase. It is a commitment the companies assume to use national services and equipment envisioning the growth of Brazilian industry.

Historically the bidding processes have been updated to attend both government's and companies' expectations. There were four main modifica-

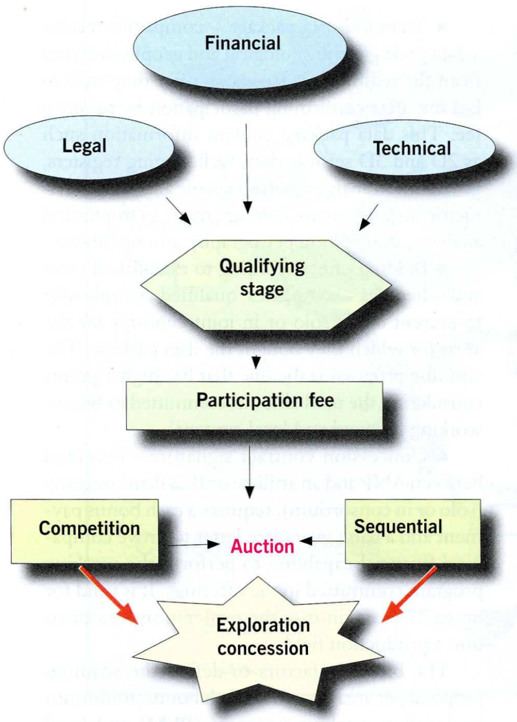


Figure 4 – Schematic of the main steps o the bidding process as modeled by ANP. The first step is the technical, financial and legal qualification stage, followed by the payment of a participation fee to bid in the sequential and competitive auction to become a concessionaire of an exploration area

tions introduced after the fifth licensing round: a) the auction itself, b) area size, c) PEM, and d) the formula to define the winning proposal.

The auction – the competitive first-price sealed bid was performed sequentially up to licensing round 4, becoming simultaneous after the fifth round. That means that the areas were being offered one by one in a previously known sequence.

Area size – from licensing rounds 1 to 4, the size of the areas released varied and their geographical coordinates were pre-defined by ANP. After the fifth licensing round, ANP applied a cell-model method defining a standard area size and creating the sector concept (distributed into onshore and offshore shallow, deep and ultra-deep water). Each area of a specific sector has, generally, the same size, except for areas that come from previous partial relinquishment by companies;

- PEM – from licensing round 1 to 4 ANP usually defined the value of the obligatory exploration program per area; it was not a biddable factor. After licensing round 5, companies were allowed to offer the value of the exploration program they wished to perform in the area of interest;

Winning proposal – before licensing round 5, cash bonus accounted for 80% of the formula to calculate the points and CL for 20%. Currently, the winning proposal is the one presenting a higher number of points summed from a weighted computation of the cash bonus, PEM and CL, according to equation 1. This new form creates an impact in the block assessment and disbursement committed in the auction process that will be detailed further.

$$\text{Winning proposal} = 40\%\ \text{Bonus} + 40\%\ \text{PEM} + 20\%\ \text{CL} \quad \text{(Eq. 1)}$$

In Brazil, royalty is not a biddable factor being applied to areas under production with a fixed percentage, varying only if the fields are located onshore (5%) or offshore (10%). The fiscal system for petroleum production includes, in addition to royalties, a special participation tax (PE). This tax protects the government from underpayment by companies who discover large volumes of hydrocarbon. It has a progressive rate, varying from 10% to 40%, depending on the volume produced, the water depth, which the field is located, the net production revenue and the time of production. Area rental is also a fee paid by companies that increases as the area becomes more attractive and companies pass from exploration to development and production phases (ANP, 2007).

Competition and Cooperation in a Bidding Process

A primary advantage of an auction is its tendency to assign the areas to those companies best able to use them, which is accomplished by competition among bidders. Those companies with the highest estimates of value for the areas likely are willing to bid higher and hence tend to win the areas (Cramtom, 2005)

Assuming that all companies participating in a petroleum lease round are serious, have knowledge of exploration and production activities, are qualified to participate in a specific tender and actually wish to acquire acreage according to their strategies and budgets, one of the divergence points among competitors may be the degree of information each company has.

Taking into account the uncertainties that exist in assessing an area to be leased, it is reasonable to consider that information has a fundamental role. If the information is available to all companies (public information), there is a symmetry among competitors. On the other hand, if some companies are performing exploration and production activities in the surrounding area, these companies will have more information than is publicly available (private information), spawning an asymmetry among bidders. Therefore, assessing a piece of information that is not public, a competitor is obtaining competitive advantage (Tavares, 2000). The information gives companies a better knowledge of the area's geological potential, allowing the decision to be made to participate in the lease and how aggressive the offer should be.

Iledare et al. (2004) stated that companies form a consortium with other likely bidders to pool resources or obtain the private information, and empirical data accumulated suggested a positive correlation between the numbers of joint ventures, bidders and bids. Tavares (op. cit.) emphasizes that companies combining expertise and technology reduce uncertainties and increase the value estimated for the area, possibly by decreasing the premium required to win the bid and discouraging small companies from competing. The referred author also concluded that generally, joint ventures are more aggressive and tend to win the auctions over companies bidding solo, however they usually left more money on the table. By definition, the difference between the amount of money the winner paid for the area and the second higher offer is called "money left on the table".

Usually the degree of competition in lease auction markets is evaluated by two attributes: the number of bids and the number of bidders per lease. Lohrenz (1991) observed that in any auction model, the government makes substantial gains in net expected values with more competitors, which are further incremented when bidding aggressively. Capen et al. (1971) noticed that the winner tends to be the bidder or consortium who overestimates reserve potential, which paid more for the area to avoid competitors, consequently suffering the winner's curse. Just for a quick review, the winner's curse is "successful bidders", at the time they win the game, which did not have an economic outcome in the exploration and production of the area leased.

The cooperation process, for a time, allows the homogeneity of technical and strategic companies' knowledge, promoting important learning in companies' behavior, improving competition analyses for future auctions.

The Brazilian Bidding Dynamic and Results

The first approach companies qualified had to participate in licensing rounds 1 to 4 was to build partnerships with PETROBRAS for reasons such as its unquestionable knowledge of Brazilian sedimentary basins and its possession of all available production flow systems. On the other hand, from PETROBRAS' point of view, the new rules and timetable imposed by the regulation directly affected its strategies to perform all related work to explore, evaluate and produce in the areas retained before the opening of the petroleum sector. The opportunity to share critical resources became attractive and the cooperative bidding strategy overcame the solo competition strategy (Fig. 5). Round 0 had a specific dynamic and reasons, previously presented in this paper, to achieve the results shown on Figure 5 as it may not be considered an effective auction related to the procedures adopted by ANP for leasing acreage.

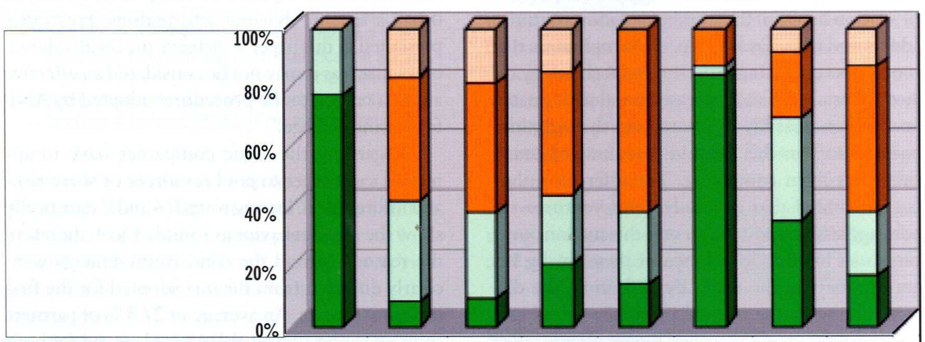
Regarding the tactic companies have to approach each other to pool resources or share risks and information, leasing rounds 6 and 7 statistically show the same behavior as rounds 1 to 4, therefore the reasons behind the consortium strategy were clearly different from the one adopted for the first licensing rounds. An average of 27.5 % of partnerships engaging PETROBRAS is observed for both groups, rounds 1 – 4 and rounds 6 and 7 (Fig. 5). In these two mentioned rounds, companies were more confident in ANP rules, in the Brazilian fiscal system, and in the geological potential of the basins, considering the positive exploration results of some blocks acquired by companies in the prior rounds. Consequently, the strategy of forming joint ventures seemed to be more devoted to avoid competition or pooling investments due to scarce resources, than to share information. Increasing oil price scenarios stimulated companies to put large volumes of oil production on the market from the year 2005 on (Rodriguez et al., 2006). Partnerships were interesting because: (a) the increasing demand on limited resources (drilling rigs, FPSO etc.), which reached high daily rates in the oil market, pushing companies to pool capital, and (b) bidding as a consortium companies could enhance their chances to win the most valuable area of the auction, which could result in future reserve replacement.

Special attention should be dedicated to 2003, when ANP announced the fifth licensing round. Several changes occurred in the Brazilian fiscal system and in the regulatory scenario, directly affecting oil exploration and production as well as the bidding process. New bid rules and the unexpressive commercial results of blocks acquired in preceding leases led the companies to reduce their investments in the acquisition of new exploration areas in the fifth licensing round. This effect can be seen in Table 1, row ´Round 5´, in which there were just 12 companies qualified and only half of them presented offers. It is important to highlight that PETROBRAS itself acquired almost 90% of the acreage released in the fifth round (Figs. 5 and 6).

Table 1 gives an idea on the dynamic of companies' participation per licensing round in Brazil, varying significantly in numbers from the qualification process until the final offer. In general, 63% of the companies qualified did not actually present offers, an exception made for licensing round 6 which had 87.5% of the companies participating in the auction. Notice that round 8 was interrupted by ANP, meaning that all related data presented in this paper is partial and refers only to the blocks released until the bidding suspension. There is no concession contract signed between the winners and ANP for these blocks until December, 2007.

The signature bonus in Real currency and the area (km^2) per lease are presented in Table 1, however according to ANP regulations, is shouldn't be assumed that there is a direct correlation between the total amount of money paid as cash bonus and the total acreage acquired per lease.

Acreage acquisition depends on how companies deal with cash bonus, PEM and CL to present the best offer for a specific area of interest. As the formula to obtain the offer value considers weights for these variables (eq.1) there is a range of possibilities for companies to compose their bids. Furtado et al. (2008) present a methodology considering the use



	Round 0 (1998)	Round 1 (1999)	Round 2 (2000)	Round 3 (2001)	Round 4 (2002)	Round 5 (2003)	Round 6 (2004)	Round 7 (2005)
Companies´Partnerships	0	2	4	5	0	0	12	33
Companies´ Blocks	0	5	9	14	13	13	35	122
Petrobras´ Partnerships	26	4	6	8	5	3	52	54
Petrobras´ Blocks	89	1	2	7	3	85	55	42

Source: Moraes Jr et al. (2004)

Figure 5 – Brazilian licensing rounds 1 to 7: results for cooperation and competition strategies. Number of blocks acquired split into 4 categories: PETROBRAS bidding alone (dark green), PETROBRAS bidding in partnership (light green), companies bidding alone (dark orange) and companies bidding in partnership with companies other than PETROBRAS (light orange)

Table 1 – Number of oil companies qualified by ANP, presenting offers and the winners per licensing round in Brazil from 1999 to 2006, as well as the total amount paid as signature bonus and the total area acquired. Notice that Round 8 is a partial result as the leasing was suspended by ANP. *Source: Brazil Rounds (ANP, 2007)*

	Oil Companies			Signature Bonus (R$)	Area (km²)
	Qualified	Presenting Offers	Winners		
Round 1	38	13	11	321.656.637,00	54.660
Round 2	44	27	16	468.259.069,00	48.079
Round 3	42	26	22	594.944.023,00	48.629
Round 4	29	17	14	92.377.971,00	24.351
Round 5	12	6	6	27.448.493,00	21.947
Round 6	24	21	19	665.196.028,00	39.657
Round 7	46	32	30	1.085.802.800,00	194.631
Round 8	43	27	23	587.372.561,00	11.887

of PEM as a long-term payment, in addition to the signature bonus which is an upfront payment, to receive the exploration rights in the Brazilian bidding system. Furtado (*op.cit.*) stated that in licensing rounds 6 and 7, companies' strategies to make the most competitive offer were to split the money into cash bonus and PEM as these variables have the same weight on the winning equation (eq.1). Instead of leaving money on the table as a cash bonus, as it does not bring any benefit to the winner (Tavares, 2000), companies committed large work programs to be performed during the entire exploration phase. This attitude is advantageous for the government agency that receives, besides the cash money, an assured amount of geological and geophysical data that will be released as public information in future licensing rounds.

The rules of the game impose companies to

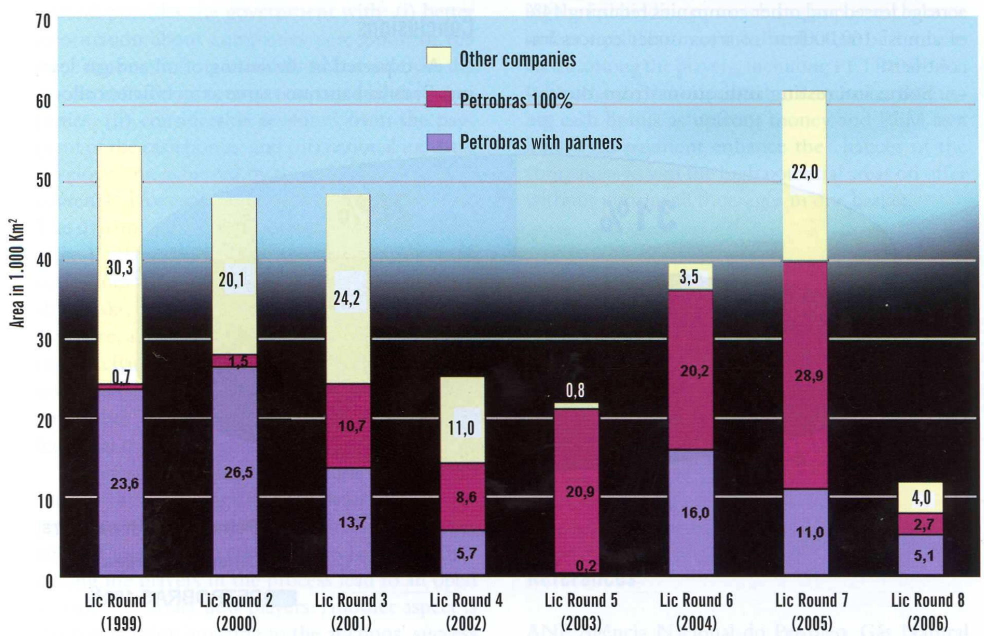


Figure 6 – Total acreage leased per licensing rounds. The colors refer to areas acquired by PETROBRAS solo (purple), companies solo or in partnerships among themselves (light yellow), and PETROBRAS with partners (blue). The data presented for licensing round 7 excludes the onshore blocks released for Solimões and São Francisco onshore basins which accounts for acreage around 130,000km²

partially relinquish 50% of the area after the first exploration period and 25% of the remaining area at the end of the second exploration period. The consecutive relinquishment impacted PETROBRAS' portfolio. There were 89 blocks under PETROBRAS concession in Round 0 (fig. 5), forcing the company decision on low acreage acquisition during rounds 1 through 4 (fig. 6). As relinquishment advances, PETROBRAS' strategy reverses to area acquisition focusing on rebuilding its exploration portfolio (fig. 6). On average, ANP leases 50,000 km^2 a year, except for rounds 4 and 5. Companies have a statistical pattern in terms of acreage acquisition, because they acquired almost the same acreage amount, around 22,000 km^2. As per reasons mentioned above, companies were not bidding alone or in partnership among themselves in licensing rounds 5 and 6, due to the risk perceived in investing in Brazil

Despite PETROBRAS participating in all licensing rounds, assuming from time to time very aggressive behavior, Figure 7 shows an actual equilibrium of acreage distribution in Brazil with PETROBRAS participating in 56% of the total acreage leased and other companies retaining 44% of almost 160,000km^2 of areas under concession contracts.

Some interesting indications from the dynamics of the petroleum auctions can be traced to the high amount of money distributed by the oil industry, which reflects their strategy based upon their records in discovering petroleum fields. For example, foreign companies that create affiliates to participate in Brazilian licensing rounds usually play the game worldwide according to their strategies. Some focus on oil findings, others gas discoveries, there are companies willing to participate in the whole petroleum chain from upstream to downstream sectors, others prefer the international market. Figure 8 present a table with names and origin of different companies that participated in Brazilian auctions along the 8 licensing rounds. This is not a complete list. Some companies are still performing exploration work and others already develop and produce oil and gas, while others are undergoing mergers, and some that completely divested from performing exploration work. In 2007, there were 33 Brazilian companies and 24 affiliate players developing exploration and production activities in Brazil.

Conclusions

As expected in the setting of oil and gas leasing, Brazilian auctions serve as an efficient alloca-

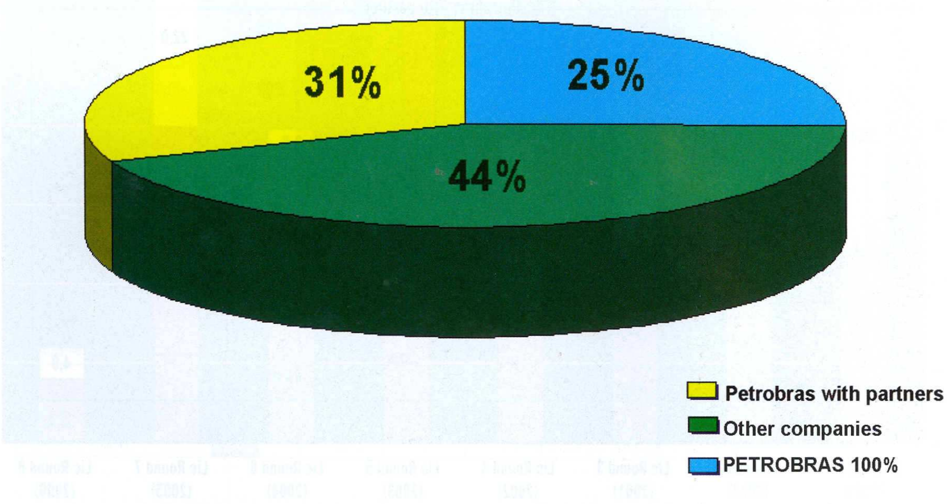


Figure 7 – Percentage of acreage distribution among companies. PETROBRAS alone retains 25% of the total acreage conceded by ANP. The other companies retain 44% of acreage and PETROBRAS with partners hold 31%, showing equilibrium in area distribution among the companies

Example of Oil Companies in Petroleum Activities in Brazil

Exploration		Development & Production
Amerada Hess (UK)	Koch (CAN)	ChevronTexaco (US)
Encana (CAN)	Devon (US)	Repsol (ESP)
Shell (NLD)	KerrMcGee (US)	Shell (NLD)
ExxonMobil (US)	Aurizônia (BR)	El Paso (US)
Statoil (NOR)	Maersk Oil (DNK)	Queiroz Galvão (BR)
ChevronTexaco (US)	BG (UK)	Inpex (JPN)
TOTAL (FR)	ENI (ITA)	Devon (US)
Wintershall (GER)	ONGC (IND)	Anadarko (US)
Norse (NOR)	Starfish (BR)	SK (KOR)
Petrogal (POR)	Partex (POR)	Hydro (NOR)

Figure 8 – A sample of companies playing the auctioning game in Brazil. Notice that some companies already have economic results from their exploration activities and are in the column of development and production. This is a picture of Brazilian players, but not definitive, because of the intrinsic and complex game of the oil industry with potential mergers, acquisitions of companies, as well as companies' international strategies which are dynamic and almost unpredictable and push companies to play around the world

tion mechanism and as resource rent taxation. As modeled by ANP, Brazilian first-price sealed bid auction provides the government with: (i) better information about companies perception of the value of a resource tract, which is obtained from the amount of work program committed by the companies; (ii) considerable revenues from the payment of the cash bonus; and (iii) national industry development, achieved by the percentage of local content bid for exploration and production phases. The dynamic of the eight licensing rounds played since 1999 has shown high interaction among the companies that can be seen as: (i) cooperating to share risks, reduce uncertainties, decrease financial exposure, and frighten competition, thus enhancing the chances for a joint venture to win the auction; and (ii) competing in order to avoid disclosing companies' risk aversion, the know-how of their technical team and economic criteria.

The results generated by the bidding rounds are fundamental in the Brazilian regulatory scheme for petroleum exploration and production. The creation of clear rules and the high level of confidence among the players in the process lead to an open scenario to attract new players. Another aspect is the competition attesting to the auctions' success as well as the governmental rents (tax, fees, and participations) that gives opportunities for various stakeholders (municipalities, states, R&D developments, environment sectors etc.) to benefit for the oil and gas activities. Some adjustments made during the last bidding process bring important balance and an equilibrium of the distribution of the areas leased among the players, including PETROBRAS. In this sense, it is important to emphasize that using cash bonus as upfront money and PEM as a long-term payment enhance the chances of the companies to win the high potential areas on offer without putting all their eggs in one basket.

Acknowledgments

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3. OS PROCESSOS DE LICITAÇÃO DE ÁREAS EXPLORATÓRIAS E ÁREAS INATIVAS COM ACUMULAÇÕES MARGINAIS

Os processos de licitação de áreas exploratórias e áreas inativas com acumulações marginais no Brasil

***Monica R. Rodriguez*[1]*, Olavo Colela Jr.*[1] *& Saul B. Suslick*[2]**

Resumo Em conseqüência da mudança no ambiente regulatório da indústria de petróleo e gás natural no Brasil foram realizadas nove rodadas de licitações de áreas exploratórias e duas rodadas para licitar áreas inativas com acumulações marginais. O modelo de licitação pública adotado pela agência reguladora para conceder às companhias de petróleo os direitos de lavra das referidas áreas baseia-se em leilões competitivos selados pela primeira maior oferta. De acordo com os conceitos da teoria dos leilões, o presente trabalho objetiva analisar os requisitos para adquirir os direitos de exploração e produção comercial e as variáveis de ofertas como bônus e obrigações mínimas para avaliação do potencial de produção de hidrocarbonetos. Este trabalho discute também os resultados dos leilões de áreas inativas e exploratórias em termos de competitividade, revelação de informação e analisa alguns impactos desses resultados no cenário brasileiro de petróleo. Observa-se que, mesmo com algumas diferenças nas regras do processo licitatório, os onze leilões da ANP obtiveram sucesso e possibilitaram a criação de um ambiente competitivo no setor de exploração e produção no Brasil. Esse sucesso pode ser traduzido em parte pela participação de 71 empresas nacionais e internacionais, algumas delas já atuantes em outros segmentos da indústria do petróleo, e outras formadas a partir da flexibilização do monopólio exercido pela PETROBRAS e a criação de novas oportunidades para exploração e produção de petróleo.

Palavras-chave: Exploração de petróleo, leilão, oportunidades geológicas no Brasil.

Abstract *The brazilian bidding process for licensing exploration and mature petroleum areas.* According to the regulatory changes in Brazilian oil and gas industry, nine leasing sales for exploration areas and two licensing rounds for inactive areas with marginal oil pools were promoted since 1997. The licensing model elected by the regulatory agency to concede petroleum exploration rights for these areas is a competitive first-price sealed bid auction. This paper uses auction theory concepts to analyze rules, requirements for participation and acquisition, biddable factors such as signature bonus and minimum commitments for hydrocarbon potential production evaluation. This paper presents the results obtained with both exploration and inactive areas leasing systems, regarding competitiveness, information disclosure and analyze some impacts of these results in the Brazilian petroleum scenario. Besides the differences on the auction rules, the eleven licensing rounds promoted by ANP were a successful initiative by creating a competitive environment on the Brazilian exploration and production industry with more than 60 national and international companies and the creation of the new prospects for E&P activity in Brazil.

Keywords: Petroleum exploration, auctions, Brazilian geological opportunities.

INTRODUÇÃO Até 1997 as atividades de exploração e produção de petróleo no Brasil foram conduzidas exclusivamente pela companhia estatal PETROBRAS[1], quando a Lei do Petróleo 9.478/97 foi aprovada encerrando um monopólio de mais de 40 anos exercido pela estatal. A União, detentora dos recursos minerais do subsolo, concede às empresas brasileiras o direito de explorar o petróleo sob o regime de concessão que também permite a livre comercialização da produção petrolífera. O mecanismo de transferência de direitos entre governo e empresa se dá através de licitações públicas promovidas anualmente pela agência reguladora de petróleo desde 1999, data do primeiro leilão.

Um modelo de licitação deve favorecer a expectativa do governo de maximizar as chances de obter um preço justo de mercado para conceder os direitos de prospectar e produzir óleo e gás em território nacional. Do ponto de vista do governo, os leilões de área para exploração e produção de petróleo servem como um mecanismo de alocação de recursos, sob uma perspectiva competitiva e equilibrada entre os participantes, bem como uma fonte de renda futura (*royalties*, taxas de aluguel de área) e uma forma de obter a percepção das companhias sobre o valor da área em oferta.

O modelo de licitação pública adotado pela Agência Nacional de Petróleo, Gás Natural e Biocom-

1- Petróleo Brasileiro S.A., Rio de Janeiro (RJ), Brasil. E-mails: monicarr@petrobras.com.br, olavo.colela@petrobras.com.br
2- Unicamp, Instituto de Geociências – Unicamp e CEPETRO, Campinas (SP), Brasil. E-mail: suslick@ige.unicamp.br

[1] Atualmente a Petrobras conta com uma participação significativa do setor privado (ADR's, Bovespa), detendo o governo aproximadamente 32,2% do capital e o BNDES 7,6%.

bustíveis (ANP) é o leilão competitivo selado de primeiro-preço na qual o vencedor é a empresa/consórcio que apresentar a maior oferta. Para as áreas exploratórias a ANP adotou como critério para definir a oferta vencedora o maior número de pontos contabilizados a partir de três variáveis: o bônus de assinatura, o programa exploratório mínimo (PEM), e o conteúdo local (CL) - percentual de aquisições de bens e serviços nas fases de exploração e produção. Para as áreas inativas com acumulações marginais o critério é o mesmo, porém com valores mínimos e percentuais distintos tanto para o bônus de assinatura, como para o programa de trabalho inicial (PTI), e para o conteúdo local (CL) - percentual de investimentos locais nas fases de avaliação e produção (ANP 2008).

Com esse mecanismo a ANP visa alcançar os objetivos do governo de maximizar suas receitas, atender as expectativas da indústria proporcionando um preço justo pela aquisição da área de interesse, bem como aumentar a aquisição de informações (geológicas, geofísicas e de produção). Após um período de confidencialidade essas informações estarão disponíveis às companhias interessadas em participar de futuros leilões, permitindo que as mesmas façam uma melhor valoração das áreas, conferindo confiabilidade ao processo licitatório brasileiro.

Cerca de dez anos antes da quebra do monopólio, ou seja, em meados da década de 80, a PETROBRAS realizou uma série de descobertas de campos de petróleo gigantes na Bacia de Campos-RJ. Esses resultados atraíram o interesse da indústria internacional que, após a abertura do setor petróleo, passou a adquirir áreas para exploração de petróleo por meio dos leilões promovidos pela ANP. A crescente estabilidade econômica do Brasil, a redução do risco-país e o aumento contínuo dos preços do petróleo foram fatores cruciais na decisão do governo e da ANP em oferecer ao mercado blocos exploratórios com potencial de descobertas de novas jazidas e áreas inativas com acumulações marginais com vistas à revitalização de campos cuja produção não era considerada economicamente viável, até então. Os mecanismos de licitação adotados pela ANP para licitar essas áreas se mostraram eficientes atraindo o interesse de companhias internacionais estatais, independentes, *majors* e *super-majors*, além de pequenas companhias nacionais que participaram de forma competitiva nos leilões.

Desde 1999, a ANP já realizou nove leilões de áreas exploratórias onde 490.000 km^2 foram arrematados por um valor próximo aos R$6,0 bilhões desembolsados por aproximadamente 165 companhias. Os leilões de áreas inativas com acumulações marginais apresentam números bem mais modestos, sendo que apenas duas licitações foram promovidas com um total de 83 companhias apresentando ofertas, 27 áreas inativas arrematadas e R$14,0 milhões arrecadados a título de bônus de assinatura (ANP 2008).

O objetivo deste trabalho é fornecer ao leitor uma compreensão geral dos processos de licitação de áreas para exploração e produção e de áreas inativas com acumulações marginais de petróleo no Brasil, adotados pela agência reguladora desde a quebra do monopólio exercido pela PETROBRAS, incluindo as estratégias e os resultados alcançados.

Esse artigo está organizado em cinco sessões principais. Na primeira sessão são apresentados um breve histórico sobre a abertura do setor petróleo. A segunda sessão apresenta um panorama da evolução do cenário exploratório no Brasil, enquanto as oportunidades de exploração e produção são apresentados na terceira sessão. Em seguida são descritos os diferentes tipos de modelos utilizados para licitar essas áreas e os conseqüentes resultados e as conclusões na quarta sessão e, na última sessão são apresentados os resultados e as discussões dos processos de licitações.

ABERTURA DO SETOR PETRÓLEO Por mais de 40 anos a PETROBRAS teve os direitos e as obrigações de promover a exploração, produção e comercialização do petróleo brasileiro sob a bandeira do monopólio estatal.

A Constituição Brasileira definiu que os recursos minerais em subsuperfície pertencem ao Estado (1937) e que a prospecção desses recursos deveria se dar sob um regime de concessão (1934). A promulgação do Código de Minas em 1934 formalizou o monopólio estatal do petróleo e, em 1938 foi criado o Conselho Nacional do Petróleo (CNP) para regular e conduzir todas as atividades relacionadas (Fig. 1). As atribuições do CNP, extinto em 1990, passaram a ser realizadas pelo Departamento Nacional de Combustíveis (DNC), segundo Ribeiro (2005). Em 1953, foi criada a companhia estatal PETROBRAS para exercer o monopólio do petróleo, extinto 42 anos depois pela Emenda Constitucional 09/95. Passados dois anos a Lei 9.478/97, conhecida como a Lei do Petróleo, estabeleceu os princípios e as diretrizes da política energética nacional, criando a Agência Nacional de Petróleo, Gás Natural e Biocombustíveis (ANP) e o Conselho Nacional de Política Energética (CNPE), como reportado por Bucheb (2007).

As atividades de exploração de petróleo no Brasil foram motivadas pelas descobertas realizadas pela indústria do petróleo em todo o mundo. Após a Segunda Guerra Mundial, o desequilíbrio entre demanda e oferta de óleo e seus derivados aumentou progressivamente, estimulando os países a prospectar petróleo em seus territórios a fim de evitar a crescente dependência de importação desses produtos.

Nas décadas de 40 e 50, o cenário político e energético brasileiro apresentava duas perspectivas de desenvolvimento opostas. O país possuía um setor de negócios representado por grupos econômicos internacionais fortalecidos e interessados nos setores de refino e distribuição, e por um forte apelo nacionalista oriundo da histórica campanha popular intitulada – "O Petróleo é Nosso" – que defendia a garantia do suprimento do petróleo ao país.

Argumentos contra o movimento nacionalista eram as incertezas relacionadas a existência de um

Constituição de 1934: regime dominial	Constituição de 1937: fechamento aos capitais estrangeiros	Inserção de dispositivos específicos para atividades de E&P no Código de Minas	Criação do CNP	Novo Código de Minas	Código do Petróleo	Constituição de 1946: reabertura aos capitais estrangeiros	Lei 2004: regime de monopólio e criação da Petrobras	Constituição de1988: Inserção do monopólio no contexto constitucional e vedação de qualquer contrato de risco	Emenda constitucional no 9 – “flexibilização” do monopólio	Lei 9.428 regime de concessão para as atividades de E&P
⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓
1934	1937	1938	1939	1940	1941	1946	1953	1988	1995	1997

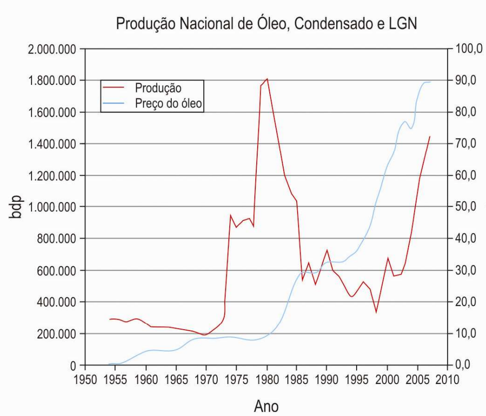
Fonte: adaptado de Pedroso & Abdounur (2007).

Figura 1 - Resumo dos principais marcos regulatórios da atividade de exploração e produção de petróleo e gás natural no Brasil.

sistema petrolífero ativo nas bacias sedimentares brasileiras, e a limitada capacidade tecnológica doméstica para explorar e produzir petróleo. No entanto, os argumentos favoráveis eram o alto nível de credibilidade do Conselho Nacional do Petróleo – CNP – e a sua forte influência política. Criado em 1938 pelo Decreto Lei 395/38, o CNP tinha um papel embrionário de uma agência reguladora fiscalizando e licenciando as atividades de exploração de petróleo até 1990, ano em que foi extinto (Machado 1989).

Durante a gestão do CNP dois eventos devem ser ressaltados: a primeira acumulação de óleo descoberta na cidade de Lobato (Bahia), em 1939, e a primeira acumulação de óleo comercial – o Campo de Candeias com um volume de 350 MM bbl de óleo *in situ*, descoberto em 1941 na Bacia do Recôncavo Baiano, e ainda em produção. Em 1953, o governo brasileiro decidiu criar a companhia estatal de petróleo pela Lei 2004 – PETROBRAS – responsável por prospectar, produzir e comercializar os recursos naturais de óleo e gás natural. Em 1954, o CNP transferiu para a PETROBRAS todo seu legado de acumulações de óleo terrestres, além do seu reconhecido acervo técnico de consultores (Mendonça *et al.* 2004).

A PETROBRAS herdou do CNP uma reserva de 15 MM bbl, uma produção diária de 2.700 bbl, e o desafio de suprir uma demanda nacional de 137.000 bbl/d. Em 1960, o CNP foi incorporado ao Ministério de Minas e Energia (MME), quando a produção doméstica atingiu 43.300 bbl/d, mas o consumo ultrapassava os 200.000 bbl/d. A primeira crise do petróleo ocorreu em 1973 (embargo da OPEC) implicando no aumento do preço do petróleo de US$ 2/bbl para US$ 14/bbl. Nesse momento o Brasil já contava com a produção diária de 170.000 bbl extraídos das bacias do Recôncavo Baiano, de Sergipe-Alagoas e do Espírito Santo. O segundo choque do petróleo aconteceu seis anos depois (Revolução iraniana e a Guerra Irã-Iraque) elevando os preços do petróleo para valores superiores a US$ 85/bbl (Fig. 2). Ainda em 1979, a crescente demanda de óleo que atingiu 1,13 milhão bbl/d, levou o governo a estabelecer uma meta de produção de 500.000 bbl/d a ser alcançada até o final de 1985[2]. Durante esse período o governo federal decidiu implementar um programa nacional para produzir etanol a partir da cana de açúcar como um substituto para a gasolina. Essa decisão foi



Fonte: BP Statistical Review (2007) e PETROBRAS

Figura 2 - A evolução dos preços de petróleo por barril (valores reais) e a produção de petróleo da PETROBRAS de 1950 a 2006. Base de cálculo do preço do petróleo: 1953-1983 árabe leve (Ras Tanura), e de 1984-2006 Brent *datado.*

[2] Todos os números relativos aos preços, produção e consumo de petróleo foram obtidos do Platts and Statistical Review Full Report Workbook 2006.

motivada pelo desequilíbrio da balança comercial devido aos elevados preços das importações de petróleo, apesar de o programa requerer investimentos substanciais e elevados subsídios (Moreira & Esparta 2006).

Quando o monopólio estatal do petróleo exercido pela PETROBRAS terminou em 1995, o preço do petróleo era de US$ 17/bbl, a produção brasileira atingia 807.000 bbl/d e o consumo de petróleo equivalia a 1.498.000 bbl/d, porém a auto-suficiência em petróleo veio a ser alcançada no final de 2005. Nessa época, a PETROBRAS produzia mais de 90% do consumo de 1.800.000 bbl/d e o cenário de preços era crescente com o petróleo do tipo B*rent* a valer US$54/bbl e uma elevada previsão de volatilidade. A figura 2 apresenta a evolução do preço do petróleo e da produção de petróleo no Brasil em milhões de barris, desde dos anos 50 até os dias atuais.

Com a promulgação da Lei 9.478/97 ficou definido que todos os campos de óleo e gás em produção ou em desenvolvimento da produção gerenciados pela PETROBRAS deveriam ter um projeto de desenvolvimento da produção a ser aprovado pela ANP, para que então fossem outorgados à PETROBRAS os direitos de concessão. O resultado foi a concessão à estatal, de 282 campos em produção ou desenvolvimento, sendo que foi assegurado por 27 anos o direito de explotação sobre cada campo que se encontrasse em produção na data de início de vigência da lei, conhecida como Rodada Zero.

A EVOLUÇÃO DO CENÁRIO EXPLORATÓRIO NO BRASIL Apesar do sucesso exploratório na bacia do Recôncavo Baiano, no final de 1960 o gerente de exploração da PETROBRAS, Walter Link, reportou que se a PETROBRAS desejasse continuar nas atividades exploratórias de petróleo e competir no cenário internacional, deveria se dedicar aos países estrangeiros que apresentassem melhores oportunidades de encontrar óleo e gás do que o Brasil (Campos 2001).

Entretanto, em 1961 o grupo da PETROBRAS indicou diferentes *plays* e modelos para avaliar as bacias sedimentares brasileiras, o que resultou na descoberta dos campos de Carmópolis (1,15 bilhão de bbl de óleo *in situ*, em Sergipe-Alagoas) e Miranga (600 MM bbl de óleo *in situ*, no Recôncavo), provando que o Brasil possui um forte potencial para a prospecção de petróleo.

Com os avanços tecnológicos, levantamentos sísmicos e aeromagnéticos foram realizados na plataforma continental brasileira. O campo de Garoupa, descoberto em 1974, foi a primeira acumulação de óleo comercial em águas rasas da bacia de Campos. Seguindo o *trend* dessa descoberta, a exploração objetivou as rochas carbonáticas Albianas estruturadas em forma de casco de tartarugas (*roll-over*) devido às falhas lístricas resultantes da movimentação halocinética dos domos de sal Aptianos. Um número significativo de campos de petróleo foi descoberto em carbonatos de alta energia desse sistema petrolífero, bem como em arenitos Terciários e do Cretáceo Superior, e nas coquinas lacustres da seqüência *rift*, na porção de águas rasas da bacia de Campos (Mendonça *et al.* 2004). Feições estruturais e petrofísicas similares aos reservatórios carbonáticos de águas rasas da bacia de Campos foram mapeadas pela PETROBRAS nos carbonatos de alta energia (*grainstones oolíticos*) depositados em águas rasas da bacia de Santos. A presença de gás, condensado e óleo de alto grau API (superior a 36º) abriu uma nova fronteira exploratória nessa bacia sedimentar. Cabe lembrar que esta região foi avaliada por companhias estrangeiras sob a égide dos Contratos de Risco firmados em meados da década de 70, porém que não resultaram em nenhuma descoberta comercial, exceto o campo de Merluza descoberto pela empresa Pecten, do Grupo Shell, nessa bacia.

Uma primeira experiência na licitação de áreas exploratórias foi realizada através da assinatura desses Contratos de Risco que duraram 11 anos (1977 a 1988), período no qual 32 das maiores companhias petrolíferas do mundo aqui estiveram e dispuseram de 84% das áreas sedimentares. A diferença essencial entre os Contratos de Risco e as licitações brasileiras da ANP é que nos contratos a propriedade do petróleo sempre permaneceu sob o controle da União, por se tratar de um contrato de prestação de serviços. Nessa época, as companhias estrangeiras tomaram conhecimento da potencialidade da geologia do Brasil a partir das informações técnicas que a PETROBRAS reuniu sobre os blocos definidos nos 84% de área sedimentar. No total foram assinados 243 Contratos de Risco, dos quais 156 com 32 empresas estrangeiras e 87 com 11 empresas brasileiras. Os baixos valores de investimentos realizados pelas companhias estrangeiras (US$ 1,8 bilhão em exploração e US$ 400 milhões em desenvolvimento) quando comparados aos da PETROBRAS (US$ 20 bilhões), não permitiram uma boa amostragem das bacias brasileiras que, aliado a falta de resposta das mesmas, levou as empresas ao baixo sucesso exploratório. Além do campo de Merluza na bacia de Santos, apenas quatro campos foram descobertos na bacia Potiguar pela empresa Azevedo & Travassos: Serra Vermelha, Redonda, Noroeste do Morro do Rosado e Ponta do Mel (Santos *et al.* inédito).

Ainda na década de 70 as atividades de exploração na plataforma continental da margem equatorial brasileira apontaram volumes moderados de óleo em reservatórios do Cretáceo nas bacias Potiguar e Ceará, bem como nas porções terrestres das bacias Potiguar, Sergipe-Alagoas e Recôncavo. Na porção terrestre da bacia do Espírito Santo os resultados foram positivos alcançando a produção diária de 2.500 bbl de óleo extraídos dos arenitos turbidíticos Eocênicos. Em meados de 1989, a porção terrestre da bacia Potiguar produzia elevados volumes de óleo e gás em comparação aos volumes das bacias maduras do Recôncavo e de Sergipe-Alagoas.

Mendonça *et al.* (2004) destacaram que os extensivos trabalhos de interpretação, focando o modelo geológico e os estudos de anomalia de amplitude sísmica, revelaram reservatórios favoráveis com boas condições permo-porosas e feições do tipo *bright spots* – uma acumulação de arenito com gás, que levou a descoberta do campo de gás de Pirapema na bacia do Cone do Amazonas.

A bacia Paleozóica do Paraná foi pobremente amostrada devido a camada de basalto existente próxima a superfície que se intrude por camadas de baixa velocidade sísmica. Esses *sills* interferiam na aquisição sísmica gerando ruídos de baixa resolução e difíceis de ser interpretados, bem como oneravam os custos operacionais dado a sua resistência à perfuração. Entretanto, em 1997 a existência de indícios de gás aliada a localização estratégica dessa bacia – no coração do mercado consumidor do sudeste do Brasil – é que a intensificação dos trabalhos exploratórios resultou na descoberta do campo de Barra Bonita – uma acumulação comercial de gás de 17 km^2 (Campos *et al.* 1998). A bacia Paleozóica do Solimões, por sua vez, apresentou melhores resultados exploratórios para gás (campo de Juruá – arenito Carbonífero) e para óleo leve (campo de Urucu – arenitos eólico/fluvial do Devoniano produtores de 58.000 bbl/d).

Apesar da exploração de petróleo no Brasil ter revelado uma variedade de cenários geológicos para prospecção de óleo e gás natural em diferentes tipos de bacias sedimentares, o que definitivamente atraiu o interesse da indústria internacional do petróleo foram os resultados encontrados em áreas de águas profundas da bacia de Campos nas décadas de 80 e 90. Em 1983, os volumes *in situ* eram de 30 bilhões de boe e a reserva equivalia a 4 bilhões de bbl de óleo.

Os campos de petróleo descobertos na porção de águas rasas da bacia de Campos provaram a existência de um sistema petrolífero ativo e mostrou ser esta a região exploratória mais promissora. Na década de 80, os avanços tecnológicos tanto na aquisição sísmica quanto na perfuração de poços em laminas d'água superiores a 400 m, permitiram a exploração de novas fronteiras em bacias marítimas. A interpretação dos dados sísmicos levantados em águas profundas da bacia de Campos identificou um conjunto de *canyons* submarinos cortando a plataforma continental. O detalhamento do modelo geológico levou a descoberta de acumulações gigantes de petróleo como o campo de Marlim – um sistema deposicional em forma de leque com um volume original de 6 bilhões de bbl de óleo *in situ*. Arenitos turbidíticos foram então mapeados, resultando nos campos gigantes de Albacora (4,5 bilhões de bbl de óleo *in situ*) e Barracuda (2,7 bilhões de bbl de óleo *in situ*). Informações sobre as feições geológicas e geofísicas, sobre as características dos reservatórios, e sobre os projetos de desenvolvimento e produção desses campos podem ser obtidas em Assis *et al.* (1998) e Luchesi & Gontijo (1998).

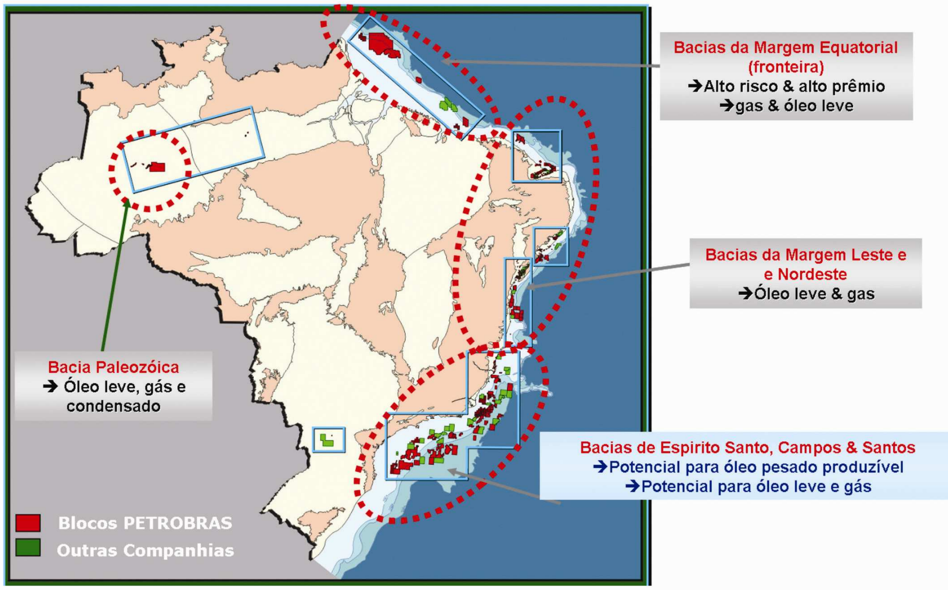
Os progressos exploratórios da PETROBRAS levaram a descoberta do campo de Roncador, em 1996, a 1.500 m de lâmina d'água com um volume original de óleo *in situ* de 9 bilhões de bbl. A necessidade de avaliação desse campo com a perfuração de poços em lâminas d'água cada vez mais profundas garantiu à PETROBRAS um novo recorde de perfuração a 1.800 m (Assayag 1997). Esse desempenho foi reconhecido internacionalmente pela Offshore Technology Conference (OTC), que em 2001 premiou pela segunda vez a PETROBRAS pela qualidade do seu desempenho - o primeiro prêmio foi conferido em 1992 pelo recorde de perfuração no campo de Marlim. Com a perfuração de poços ultrapassando os 2.000 m de lâmina d'água, novos contextos geológicos foram mapeados, como por exemplo, aqueles localizados no setor norte da bacia de Campos que levou a descoberta do campo gigante de óleo, Jubarte, abrindo novas perspectivas exploratórias no Brasil (Da Silva *et al.* 2004).

Todos esses resultados positivos da década de 90 estimularam as companhias internacionais a participar dos leilões brasileiros a partir de 1999. Desde então, tais companhias obtiveram seus primeiros resultados de sucesso, levando-os a declarar a comercialidade de seis acumulações de óleo na bacia de Campos, a saber: Argonauta, Ostra, Abalone e Nautilus (Shell / PETROBRAS / ExxonMobil), Polvo (Devon / SK), Papa Terra (PETROBRAS / ChevronTexaco / Nexen), Peregrino (EnCana / Kerr McGee)[3].

A figura 3 mostra a evolução das fases de exploração e suas conseqüentes descobertas com os volumes de óleo equivalente. Esse gráfico mostra que a contribuição dos avanços tecnológicos e do aperfeiçoamento dos modelos geológicos nas atividades de exploração possibilitou o aumento das reservas de óleo e gás do país de 1,5 bilhão de boe (volumes contidos em bacias terrestres) para valores superiores a 12 bilhões de boe (volumes que contabilizam as bacias terrestres e marítimas de águas rasas e profundas).

Os recentes resultados exploratórios obtidos nos blocos localizados em águas profundas da bacia de Santos sugerem uma nova província petrolífera que pode revolucionar a história da exploração no país. Em bacias como a de Santos, novas oportunidades devem ser investigadas na identificação de reservatórios mais profundos. Frequentemente esses *plays* dependem de sistemas petrolíferos novos, bem como de preservação do sistema permo-poroso (Rudolph & Halbouty 2007). As companhias de petróleo estão focando seus interesses para os horizontes do pré-sal localizados abaixo de uma camada de sal com 2000 m de espessura, que pode acumular elevados volumes de hidrocarbonetos devido ao tamanho da área mapeada com a sísmica 3D. Essas perspectivas estimularam a PETROBRAS a investigar

[3] As denominações dos consórcios apresentados nesse parágrafo refletem o nome das companhias concessionárias desses campos em 2005. Em 2007, a ANP transferiu os direitos do campo de Peregrino para as companhias Anadarko e Hydro, atualmente 100% em posse da companhia StatoilHydro, a empresa Nexen se retirou do campo de Papa Terra, e os campos de Argonauta, Ostra, Abalone e Nautilus foram vendidos pela ExxonMobil para a estatal indiana ONGC.



Fonte: PETROBRAS

Figura 3 - A evolução das atividades exploratórias ao longo dos anos e os volumes de óleo equivalente produzidos nas diferentes fases de exploração de petróleo nas bacias sedimentares brasileiras.

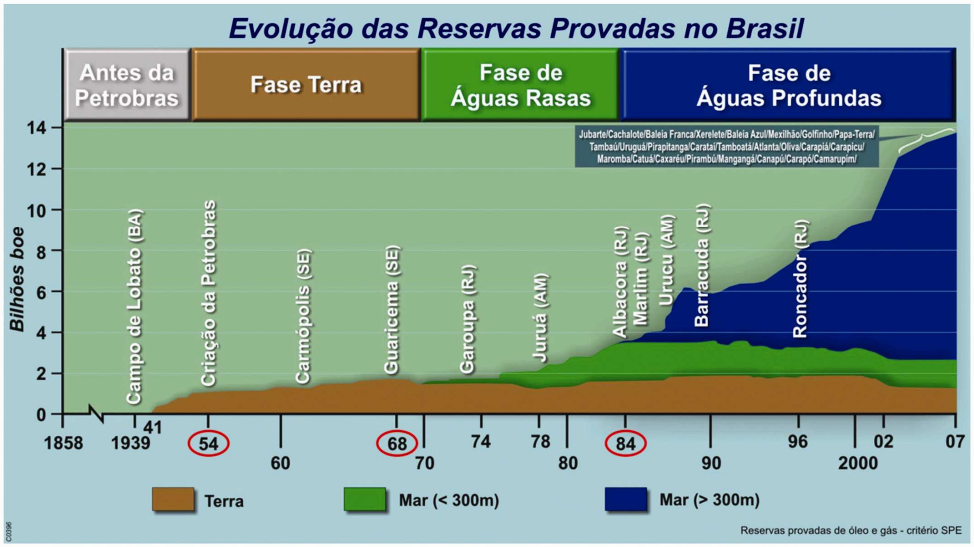
plays de alto risco e alto prêmio em áreas geológicas remotas com base nos novos conceitos de modelos de bacias. O campo de Tupi, descoberto em 2007 em lâmina d'água superior a 2000 m e com volumes entre 5 e 8 bilhões boe, é o mais recente resultado dessas pesquisas no pré-sal, ainda que apresente elevado desafio tecnológico, econômico e logístico (Berman 2008).

OPORTUNIDADES DE EXPLORAÇÃO E PRODUÇÃO Os países desenvolvidos, de um modo geral, são dependentes de importação de petróleo, tendo em vista que as suas produções domésticas não atendem ao próprio consumo. Essa dependência é suprida por paises com elevado risco político, principalmente aqueles localizados no Oriente Médio. Sendo assim, o Brasil se mostrou uma alternativa para a prospecção de novas jazidas, principalmente quando foram realizadas as descobertas significativas na Bacia de Campos na década de 80. A extensa costa marítima brasileira oferece, até o presente, boas perspectivas exploratórias para óleo leve e pesado e para gás natural, mesmo nas bacias consideradas de nova fronteira onde o alto risco exploratório está associado ao alto prêmio geológico. As bacias sedimentares terrestres, inclusive as paleozóicas, também apresentam potencial exploratório para prospecção de hidrocarbonetos (Fig. 4).

Apesar do Brasil apresentar uma cobertura sedimentar (terrestre e marítima) de cerca de 6,4 milhões de km^2, apenas 5,2% desse total (330.318 km^2) se encontra sob a concessão de empresas de petróleo para exploração e produção de hidrocarbonetos (PETROBRAS 2008).

O Brasil tem sido alvo de significativos investimentos na atividade de E&P, em sua maior parte pela PETROBRAS na busca de novas descobertas e, sobretudo no desenvolvimento da produção de seus campos marítimos nas bacias de Campos, Santos e Espírito Santo. Além disso, deve-se destacar que os leilões realizados a partir de 1999 possibilitaram o ingresso de diversas empresas no mercado de petróleo brasileiro, que segundo a ANP (2008), já atingem 60 concessionárias, sendo 15 dessas operadoras de campos em produção.

Mais recentemente, foram divulgadas descobertas com grande potencial de produção de petróleo e gás natural, provenientes de reservatórios carbonáticos localizados nas camadas pré-sal em bacias marítimas. O volume dessas descobertas e sua localização podem significar uma mudança do paradigma vigente na atividade de E&P no Brasil. Caso sejam confirmadas as expectativas, o país, que sempre foi um importador de petróleo e gás natural e que recentemente atingiu uma produção de petróleo que garante seu próprio consumo, pode vir a se tornar um exportador na próxima década. Essa mudança no ambiente de negócio se tornou tão evidente que o Conselho Nacional de Política Energética, por meio da Resolução CNPE nº 6, de 8 de novembro de 2007, determinou a retirada de 41 blocos exploratórios da 9ª Rodada e no seu Art. 4º, "Determinar ao Ministério de Minas e



Fonte: PETROBRAS

Figura 4 - Mapa das bacias sedimentares brasileiras mostrando o potencial exploratório das principais províncias petrolíferas.

Energia que avalie, no prazo mais curto possível, as mudanças necessárias no marco legal que contemplem um novo paradigma de exploração e produção de petróleo e gás natural, aberto pela descoberta da nova província petrolífera, respeitando os contratos em vigor".

Um dos indicativos que estimulou a redação dessa resolução do CNPE e a decisão de retirada dos blocos foi o forte clima competitivo observado na 8ª Rodada, onde oito companhias de petróleo ofertaram elevados valores monetários (R$560 milhões) para adquirir dez blocos na bacia de Santos. Com a suspensão da 8ª Rodada os contratos de concessão desses blocos arrematados não foram assinados. Tais contratos apresentam cláusulas que conferem às concessionárias o direito de exportar sua produção, salvo em caso de força maior onde devem preferencialmente abastecer o mercado nacional. Essa forte competição está aumentando a captura do custo de oportunidade criando um cenário conhecido por "maldição do vencedor", ou seja, os investimentos significativos realizados com a aquisição e exploração da área podem não resultar em retorno econômico para o concessionário.

Assim, não está decidido o que será alterado na legislação vigente, porém o final do Art. 4º, anteriormente citado, indica que não se pretende nem reeditar o monopólio da PETROBRAS nem promover a renegociação de contratos. É razoável imaginar um aumento das participações governamentais nos campos com produção extraordinária, seja pela via dos tributos ou na retenção de parte da produção no País. Qualquer revisão do marco regulatório que seja adotada, desde que guarde uma racionalidade econômica, em conjunto com a confirmação das expectativas de volumes descobertos, o Brasil continuará a oferecer boas oportunidades de negócio na industria do petróleo e gás natural.

O SISTEMA DE LEILÕES DA ANP Visando explorar os recursos naturais de forma eficiente, as agências do governo podem optar entre várias formas de transferir os direitos de exploração para companhias que podem garantir uma atuação de acordo com as melhores práticas da indústria. Segundo Cramton (2007), existem dois métodos, a saber:

• Métodos informais - negociação direta entre governo e companhia que pode implicar na falta de transparência do processo, em preferências específicas, na corrupção e em maior vulnerabilidade a expropriação, reduzindo a competição entre as companhias e as receitas apuradas pelo governo;

• Métodos administrativos - os leilões que estabelecem regras claras antes do início do processo trazem benefícios ao governo e aos participantes, mitigando a potencial corrupção e encorajando a competição.

O leilão é um mecanismo que tem sido amplamente utilizado em diferentes países para distribuir de forma ótima as áreas exploratórias. O governo se preocupa com o crescimento prolongado do negócio e não com a maximização da receita esperada a partir de um único leilão. Para manter a dinâmica dos negócios, o leilão deve balancear os interesses do governo (vendedor) e das companhias (comprador). Isso ocorre quando há preços altos o suficiente para que o vendedor continue colocando as áreas exploratórias à venda, e quando há preços baixos o suficiente para que as companhias participem de forma numerosa e voluntária (Rothkopf & Harstad 1994).

Outra característica de um modelo de leilão é que ele revela informação, ou seja, qual o valor da área licitada para as diferentes empresas participantes, e qual companhia a avaliou melhor. Essas informações são consideradas uma vantagem competitiva, pois as companhias não conhecem *a priori*, o real valor da área em oferta.

Por essas razões a ANP adotou o modelo de leilão competitivo selado pelo primeiro-preço tanto para as áreas exploratórias quanto para as áreas inativas com acumulações marginais. As principais etapas desse processo (Fig. 5) são:

• Anúncio – a ANP, ao anunciar uma rodada de licitação, revela as áreas selecionadas para oferta e seu preço mínimo. As áreas são selecionadas de acordo com a estratégia do governo para o desenvolvimento do país, como por exemplo, aumentar as atividades exploratórias em bacias de nova fronteira ou em uma específica província de gás, etc.

• Qualificação – as companhias interessadas em participar dos leilões devem comprovar sua capacidade técnica, financeira e jurídica de realizar tarefas de exploração de petróleo. Essa etapa de qualificação garante tanto para a ANP quanto para potenciais parceiros que uma companhia habilitada possui competência para executar todos os compromissos adquiridos com a agência reguladora. As companhias também devem manifestar seu interesse em ser operadoras de áreas terrestres (tipo C ou D), marítimas de águas rasas (tipo B) ou profundas (tipo A) – necessário comprovar mínima qualificação técnica e de patrimônio líquido;

• Pacote de Dados Técnicos – as companhias que manifestaram interesse pagam uma taxa de participação que lhes dá direito a obter um pacote de dados geológicos e geofísicos dos setores das bacias sedimentares selecionadas. Esse pacote contém informações de domínio público existentes sobre a área até a data em questão, tais como dados de sísmica, poços e de métodos potenciais (magnetometria e gravimetria). Para as áreas inativas, o pacote de dados possui ainda mapas de localização e infra-estrutura, relatórios, e dados de produção;

• Apresentação de Oferta – de acordo com regras e cronograma pré-estabelecidos, as companhias qualificadas estão aptas a apresentar ofertas sozinhas ou em consórcios para as áreas na qual manifestaram interesse. A proposta vencedora é aquela que apresenta a maior pontuação obtida considerando o total comprometido em bônus de assinatura, programa de trabalho e conteúdo local;

• Assinatura do Contrato de Concessão – a assinatura dos contratos de concessão entre a ANP e as companhias nacionais ou as afiliadas brasileiras de companhias estrangeiras, requer o pagamento do dinheiro referente ao bônus de assinatura ofertado e a apresentação de uma carta de garantia financeira para assegurar a realização do programa de trabalho compromissado nas

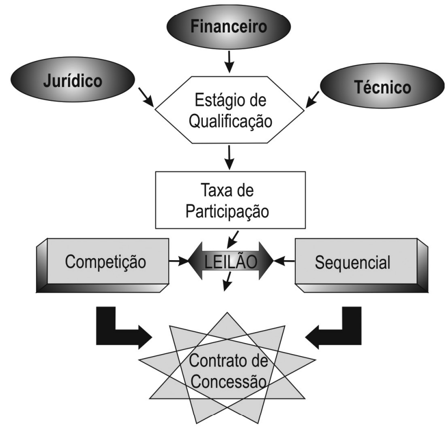


Figura 5 - Modelo esquemático das principais etapas do processo de licitação utilizado pela ANP.

ofertas. Os contratos para as áreas exploratórias têm a duração de 27 anos, caso haja declaração de descoberta economicamente viável, e podem ser renovados com a aprovação da ANP, caso a companhia deseje continuar com as atividades de produção de hidrocarbonetos. Para as áreas inativas com acumulações marginais, caso em 2 anos de avaliação seja declarado a comercialidade da área, a provisão do contrato de concessão é de 15 anos para a explotação da jazida (reabilitação e produção).

Nos leilões promovidos pela ANP, os fatores de oferta que definem a proposta vencedora tanto para as áreas exploratórias quanto para as áreas inativas com acumulações marginais são:

• Bônus de assinatura – significa o montante em dinheiro ofertado pelas companhias para obter o direito de realizar atividades de exploração das áreas em oferta. A ANP define o valor mínimo do bônus, sem entretanto, estipular um valor máximo. Esse valor é estimado de acordo com a localização e o potencial geológico da área, por exemplo, para as áreas inativas com cumulações marginais varia de R$1.000,00 a R$4.500,00 e nas áreas exploratórias pode alcançar cifras superiores a R$200.000.000,00 (ANP 2008).

• Programa de trabalho – significa a quantidade de trabalho para explorar ou produzir petróleo comprometido nos leilões de áreas exploratórias como programa exploratório mínimo (PEM), ou nos leilões de áreas inativas como programa de trabalho inicial (PTI). É um compromisso assumido na oferta e reflete o grau de interesse das companhias nas áreas, ou seja, quanto maior os valores de PTI ou PEM ofertados, maior o potencial petrolífero percebido pelas companhias para a área. O valor é dado em Unidades de Trabalho (UT's) que serão convertidas em atividades exploratórias. Requer garantia financeira das empresas para respaldar o programa de trabalho compromissado;

• Conteúdo local – é um percentual que indica o montante de bens e serviços nacionais que as companhias pretendem contratar nas fases de exploração e produção. É um compromisso de oferta nos leilões de áreas exploratórias voltado para estimular o crescimento da indústria brasileira. Por essa razão, não conta para a nota final nos leilões de áreas inativas com acumulações marginais, no qual tem um caráter compulsório limitando as companhias a contratarem um mínimo de 70% de bens e serviços nacionais na produção dessas áreas.

No Brasil, ao contrário de alguns países no mundo, os *royalties* não são um fator de oferta. O sistema fiscal que incide sobre a produção de petróleo considera o pagamento entre 5% e 10% sobre o volume total da produção a título de *royalties,* sendo que para todos os blocos exploratórios oferecidos nas licitações o *royalty* foi fixado em 10%. Existe ainda a taxa de participação especial (PE) que protege o governo de um pagamento a menor realizado pelas companhias que fizeram descobertas de grandes volumes de hidrocarbonetos. Essa taxa apresenta uma alíquota progressiva, variando de 10% a 40% sobre a receita líquida da produção, a depender do volume produzido, da lâmina d'água do campo e do tempo de produção. Parte da receita arrecadada pela agência com o pagamento de *royalties* e de PE é repassada aos estados produtores e municípios, beneficiando centenas de cidades, sendo o restante destinado ao Ministério de Ciência e Tecnologia (Siqueira 2006). A taxa de ocupação ou retenção de área paga pelas companhias concessionárias, aumenta conforme cresce a atratividade da área exploratória e possui um valor fixo para as áreas inativas com acumulações marginais (ANP 2008).

Esse modelo de leilão difere dos demais realizados no mundo (Sunnevåg 2000) por incluir, além do bônus de assinatura, o programa de trabalho e o percentual de conteúdo local mínimo como variáveis de oferta.

Os leilões de áreas para exploração, desenvolvimento e produção de hidrocarbonetos A partir da quebra do monopólio do petróleo as atividades de exploração e produção em solo brasileiro passaram a ser feitas sob um regime de concessão. Nesse regime a União é a detentora do recurso mineral no subsolo e as companhias que adquirirem os direitos de explorar e produzir petróleo serão detentoras desse recurso a partir do ponto de medição em superfície, ou seja, ponto definido pela ANP no qual os volumes recuperados de hidrocarboneto são apurados para recolhimento das participações governamentais e demais tributos devidos.

No período de transição entre o estabelecimento da nova legislação – Lei do Petróleo 9.478/97 – e o início das licitações públicas promovidas pela ANP, a participação da PETROBRAS no novo cenário foi definida em um conjunto de negociações conhecido por "Rodada Zero", e que não se tratou de um leilão na sua essência. Consolidada em 1998 e, em conseqüência do Artigo 33 da referida lei, a Rodada Zero resultou na assinatura de 397 contratos de concessão entre PETROBRAS e ANP, sendo 115 para áreas exploratórias, 51 para áreas em desenvolvimento e 231 para campos em produção. As demais áreas sedimentares, até então analisadas pela PETROBRAS, foram devolvidas a ANP (Furtado 2004).

Os direitos de explorar e produzir petróleo a partir de 1999 foram concedidos por licitações públicas anuais promovidas pela ANP, de acordo com o modelo supracitado. Num total de nove leilões realizados até abril de 2008, apenas a oitava licitação não foi concluída.

Entre 1999 e 2002 a ANP realizou quatro leilões de áreas exploratórias de forma seqüencial com um bloco sendo ofertado após o outro e a proposta vencedora era composta de bônus de assinatura (85%) e conteúdo local (15%). O programa exploratório mínimo era obrigatório e definido pela ANP, em geral, como um levantamento sísmico 3D nos primeiros 3 anos da Fase de Exploração, e a perfuração de poços nos 2º e 3º Períodos Exploratórios (mais 3 anos de duração). Porém, em 2003 a ANP fez modificações nas regras do leilão que foram implementadas a partir da quinta licitação. Tais ajustes estão em vigor até a presente data destacando-se os seguintes aspectos:

• Forma de licitação dos blocos – os blocos, licitados um a um de forma seqüencial, passaram a ser ofertados simultaneamente dentro de um setor, onde este sim, é ofertado de forma seqüencial. Dessa forma cada envelope selado a ser apresentado para um setor específico, pode conter ofertas para um ou mais blocos daquele setor. Essa mudança torna o leilão mais fechado que nas rodadas 1 a 4, onde era possível conhecer, quando da abertura do bloco, quais companhias iriam apresentar oferta para o mesmo levando a possíveis modificações nas propostas dos competidores;

• Tamanho de área – os blocos possuíam tamanhos variados e suas coordenadas geográficas eram definidas pela agência reguladora. A adoção de um modelo de células permitiu a ANP definir um tamanho de área padrão por setor terrestre, marítimo de água rasa, água profunda e ultra-profunda, e para setores de novas fronteiras. Esse conceito facilitou a definição de blocos e permitiu a devolução de tamanhos regulares de áreas ao final de cada fase exploratória;

• Programa de trabalho – inicialmente a ANP determinava um programa exploratório obrigatório a ser cumprido pela companhia vencedora do bloco. Atualmente, o PEM é um fator de oferta determinado pelas companhias e é considerado programa exploratório mínimo a ser realizado na área adquirida. A vantagem de deixar o PEM como uma variável de oferta é que as companhias estão livres para ofertar o programa que desejarem e, obrigadas a cumpri-lo, gerarão dados de geologia e geofísica para uso da ANP, que após o período de confidencialidade, poderá torná-los públicos para os leilões futuros;

• Definição da proposta vencedora – antes definida como a maior pontuação calculada considerando um peso de 75% para o bônus de assinatura e 15% para o conteúdo local, hoje existe mais uma variável de oferta e os pesos foram modificados conforme a fórmula abaixo. Essa mudança impactou a avaliação dos blocos e o compromisso de desembolso nos processos de licitação, na qual a proposta vencedora é definida da seguinte forma:

Proposta Vencedora = 40% Bônus + 40% PEM + 20% CL

A literatura reporta que as companhias oferecem para áreas exploratórias, em geral, cerca de 30% do valor monetário esperado (VME) estimado para a área, porém na prática podem oferecer até mais de 100% (Furtado & Suslick 2003).

Os leilões de áreas inativas com acumulações marginais Após a promulgação da Lei 9.478/97 a Petrobras concentrou seus esforços para obter a concessão das áreas de maior potencial exploratório e dos campos em fase de desenvolvimento ou em fase de produção. Um número equivalente a 62 campos que já haviam produzido ou que se encontravam na etapa de desenvolvimento não foram reivindicados pela empresa no prazo previsto, ficando à disposição da ANP. A PETROBRAS, no ano de 2001, já havia realizado uma oferta de campos de alto grau de explotação, onde foram vendidos 73 campos nas Bacias Potiguar, Sergipe-Alagoas, Recôncavo Baiano e Espírito Santo (Brasil Energia 2000). De 1998 até 2005, a PETROBRAS devolveu outros 15 campos à agência reguladora, que ficaram conhecidos como "campos marginais da ANP" (Siqueira 2006).

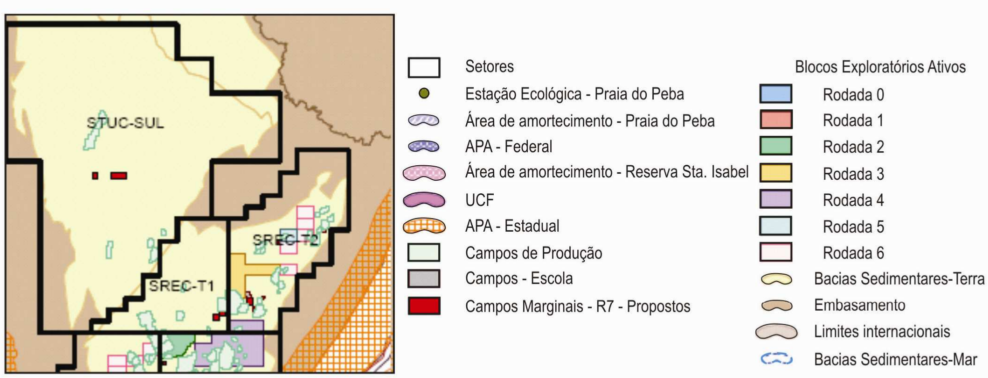
Inicialmente, a ANP tentou incluir algumas dessas áreas inativas em blocos exploratórios ofertados nos leilões de exploração, o que não se revelou um modelo atrativo para os concessionários que optaram por devolver essas áreas. Devido a essa constatação, e visando agregar mais valor a esses recursos da União, a ANP, atendendo à Resolução nº 2/2004 do CNPE, incluiu na Sétima Rodada de Licitações parte dos 54 "campos marginais" em seu poder àquela época, promovendo então a 1ª Rodada de Licitações de Áreas Inativas com Acumulações Marginais. A 2ª Rodada de Licitações dessas áreas ocorreu em acordo com a resolução supracitada em que os campos considerados marginais pelas grandes empresas podem despertar o interesse de empresas de menor porte (ANP 2008).

Devido ao porte das jazidas e sua localização em bacias maduras e terrestres, onde a infra-estrutura para tratamento e transporte do petróleo e do gás natural já estão instaladas, foi possível a formação de um mercado de pequenas empresas atraídas pela oportunidade de produzir petróleo no Brasil sem o risco do insucesso exploratório. Esse novo mercado promete aumentar os volumes de petróleo produzidos nas bacias terrestres e fomentar o retorno gradual da indústria de bens e serviços brasileira.

O que difere essencialmente um leilão de área exploratória para um leilão de áreas inativas com acumulações marginais é a fórmula utilizada no cálculo dos pontos que cada oferta totaliza. O bônus de assinatura tem um peso de 25% e o programa de trabalho inicial (PTI) 75%; o conteúdo local, entretanto, não é considerado uma variável de oferta sendo seu percentual compulsório em 70%. Deste modo, tem-se que:

Proposta Vencedora = 25% Bônus + 75% PTI

Para esse tipo de leilão foi criado o operador do tipo D, onde a empresa cujo patrimônio líquido é superior a R$10.000,00, fica qualificada para trabalhar em terra nas áreas inativas com acumulações marginais. A dimensão em km² das áreas inativas é, em geral, menor que a dos blocos exploratórios terrestres (Fig. 6), isto porque são campos de petróleo já descobertos, onde toda a porção não considerada dentro das coordenadas que delimitam o campo, foi devolvida a agência reguladora.



Fonte: Brasil Rounds (ANP 2008)

Figura 6 - Mapa de localização de algumas áreas inativas com acumulações marginais na bacia do Recôncavo e Tucano.Sul.oferecidas na 1ª Rodada promovida pela ANP. Notar a diferença em termos de dimensão entre um bloco exploratório e as áreas inativas que são menores por se restringirem ao tamanho das acumulações de petróleo nelas contidas.

DISCUSSÃO E RESULTADOS Para analisar corretamente os resultados das licitações exploratórias apresentados na tabela 1, bem como nas **figuras 7 e 8**, que se seguem, é preciso lembrar que:

• No ano de 2003 (5ª Rodada) ocorreram várias alterações no sistema fiscal brasileiro (como por exemplo, a elaboração das Leis Noel e Valentim para o Estado do Rio de Janeiro, bem como a revisão do Repetro – regime aduaneiro especial de admissão temporária de bens importados para explorar e produzir petróleo), e no cenário regulatório (modelo de células para definição de áreas, cartilha do conteúdo local, redefinição das regras do leilão), afetando diretamente as atividades e os processos de licitação de áreas para exploração e produção de petróleo. O resultado dessas modificações potenciais e de fato, associadas aos inexpressivos resultados comerciais dos blocos adquiridos nos leilões precedentes, levaram as companhias a reduzir os investimentos na aquisição de novas áreas exploratórias na 5ª Rodada. Esse efeito pode ser visto na tabela 1 onde das 12 companhias qualificadas apenas 50% apresentou oferta. É importante ressaltar que a PETROBRAS adquiriu quase 80% do total dos blocos arrematados nesse leilão, porém apenas 3 blocos em parceria (Fig. 7), melhor comparando, apenas 200 km² de área adquirida em parceria contra 20.900 km² de área adquirida exclusivamente pela PETROBRAS (Fig. 8);

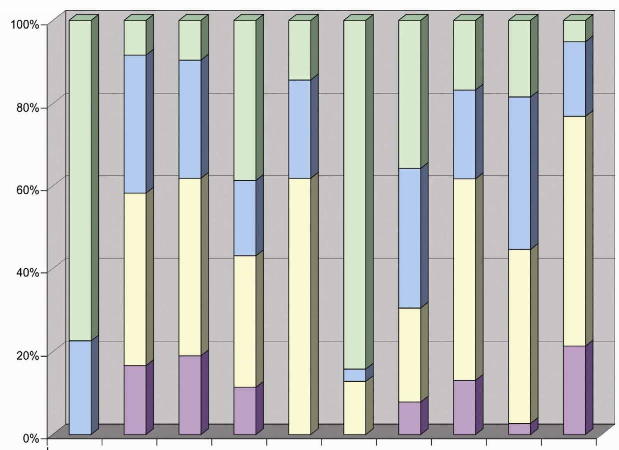
• No ano de 2006, a 8ª Rodada foi paralisada devido a duas liminares impetradas contra a cláusula do edital que limitava – no mínimo em dois e no máximo em seis – o número de blocos que cada companhia poderia arrematar na condição de operadora em cada área. Como a cláusula restritiva não foi suprimida do edital, a 8ª Rodada foi suspensa quando apenas 58 dos 284 blocos previstos haviam sido licitados. É relevante reportar que essa cláusula restritiva, justificada como uma forma de proteger os interesses do país contra a aquisição de grandes áreas exploratórias por companhias estrangeiras, foi suprimida do edital da 9ª Rodada visando manter o ritmo das atividades de exploração e produção, importantes para a manutenção da auto-suficiência em petróleo e a redução das importações de gás natural. A ANP estuda a possibilidade de retomar a 8ª Rodada para não afetar a segurança jurídica e a previsibilidade do processo licitatório, mantendo a estabilidade regulatória do país e a alta qualificação alcançada pelo Brasil em rodadas anteriores (Lessa 2006). Os dados aqui apresentados são, portanto, parciais e referem-se aos 38 blocos que receberam ofertas até a suspensão do leilão, sendo que os mesmos ainda não pertencem

Tabela 1 - Quadro geral de resultados dos nove leilões de áreas exploratórias realizados pela ANP, contendo número de companhias participantes, total de bônus de assinatura pago e área arrematada.

(*) Os resultados da 8ª licitação são parciais, devido à suspensão temporária do leilão.

	Companhias de Petróleo			Bônus de Assinatura (R$)	Área (km²)	Preço do Brent (US$/bbl)
	Qualificadas	Apresentaram Ofertas	Vencedoras			
1ª Rodada (jun/1999)	38	13	11	321.656.637,00	54.660	17,97
2ª Rodada (jun/2000)	44	27	16	468.259.069,00	48.079	28,50
3ª Rodada (jun/2001)	42	26	22	594.944.023,00	48.629	24,44
4ª Rodada (jun/2002)	29	17	14	92.377.971,00	24.351	25,02
5ª Rodada (ago/2003)	12	6	6	27.448.493,00	21.947	28,83
6ª Rodada (ago/2004)	24	21	19	665.196.028,00	39.657	38,27
7ª Rodada (out/2005)	46	32	30	1.085.802.800,00	194.631	54,52
8ª Rodada(*) (ago/2006)	43	27	23	587.372.561,00	11.887	65,14
9ª Rodada (nov/2007)	67	42	24	2.109.408.831,00	45.659	72,50

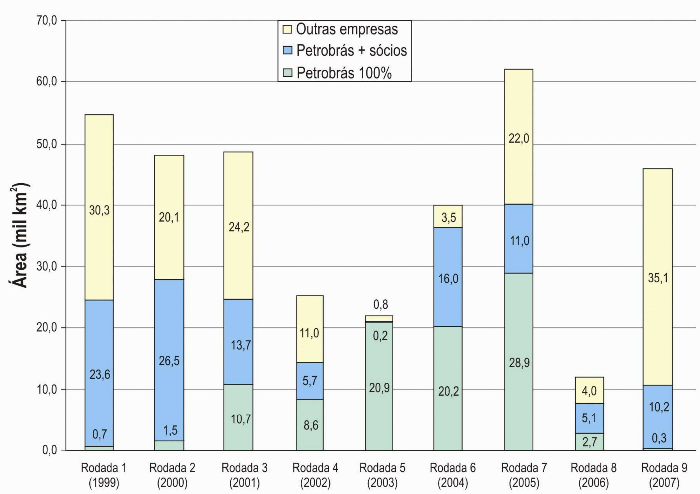
Fonte: Brasil Rounds (ANP 2008) e BP Statistical Review (2007)



	Rodada 0 1998	Rodada 1 1999	Rodada 2 2000	Rodada 3 2001	Rodada 4 2002	Rodada 5 2003	Rodada 6 2004	Rodada 7 2005	Rodada 8 2006	Rodada 9 2007
Companhias + sócios	0	2	4	5	0	0	12	33	1	25
Outras companhias	0	5	9	14	13	13	35	122	16	65
Petrobrás + sócios	26	4	6	8	5	3	52	54	14	21
Petrobrás	89	1	2	17	3	85	55	42	7	6

Fonte: adaptado de Moraes Jr et al. (2004)

Figura 7 - Resultados das estratégias de competição e cooperação das rodadas exploratórias 1 a 9. O número de blocos adquiridos está dividido em quatro categorias: 100% PETROBRAS (verde escuro), PETROBRAS e parceiros (verde claro), 100% de outras companhias (laranja escuro) e parceria entre companhias que não a PETROBRAS (laranja claro).



Fonte :adaptado de Rodriguez & Suslick (2008)

Figura 8 - Total de área (1000 Km²) licitado nos leilões da ANP. A barra azul refere-se ao montante de área adquirida pela PETROBRAS com parceria e a barra verde sem parceria. A barra de cor amarela representa o total de área arrematado pelas companhias sozinhas ou em parcerias entre si.

Tabela 2 - Quadro geral de resultados dos dois leilões de áreas inativas com acumulações marginais realizados pela ANP, contendo número de companhias participantes, total de bônus de assinatura pago e número de campos arrematados e oferecidos.

	Companhias de Petróleo			Bônus de Assinatura (R$)	Número de campos arrematados / ofertados	Investimentos Previstos (R$)
	Qualificadas	Apresentaram Ofertas	Vencedoras			
1ª Rodada (out/2005)	91	53	16	3.045.804,00	16 / 17	62 milhões
2ª Rodada (jun/2006)	55	30	10	10.677.058,00	11 / 14	24 milhões

Fonte:Brasil Rounds (ANP 2008)

às companhias que apresentaram ofertas por não possuírem contrato de concessão assinados até a presente data. Vale ressaltar que essa foi a única licitação em que as áreas da bacia de Campos não foram ofertadas;

• Em termos de dinâmica de processo, a participação das empresas nos leilões de áreas marginais e nos leilões exploratórios será analisada conjuntamente, porém a discussão sobre os resultados e as estratégias adotadas pelas companhias em cada leilão será tratada de forma independente.

As tabelas 1 e 2 fornecem uma visão da dinâmica da participação das companhias por licitação de áreas exploratórias e de áreas inativas com acumulações marginais, respectivamente. Na tabela 1 observa-se que o número de companhias no processo de qualificação é em muito superior (63%) ao número de companhias que efetivamente participa do leilão apresentando oferta, exceto na 6º Rodada onde 87.5% das companhias participaram ativamente. Nos leilões de áreas inativas com acumulações marginais há um grande número de pequenas firmas que se qualifica objetivando produzir petróleo sem ter os riscos do insucesso exploratório e contando com a existência de infra-estrutura próxima para escoamento da produção. A tabela 2 mostra que 18% dessas companhias qualificadas adquiriram áreas no leilão, e que mais de 55% das companhias participou apresentando oferta, o que pode ser tido como um indicativo de sucesso do leilão.

O atual ciclo de alta de preços do petróleo estimulou as companhias petrolíferas a produzir volumes consideráveis de hidrocarboneto, resultantes dos investimentos realizados na explotação de jazidas até então, não economicamente viáveis. Como a demanda mundial (30 Bilhões de barris anuais) está em muito superior às descobertas (4 Bilhões de barris) e as companhias estão com seu índice de reposição de reservas muito baixo, a combinação de elevados montantes em caixa com a oferta de áreas no mundo implicou na elevação da competição nos leilões de áreas exploratórias (Rodriguez *et al.* 2006). O efeito imediato do aumento da competição em um leilão pode ser notado pelo aumento dos valores pagos a título de bônus de assinatura para se ganhar o bloco de interesse. No Brasil, a partir de 2003 quando o preço médio anual do petróleo *brent* passou de US$28/bbl para US$72/bbl em 2007, as empresas começaram a pagar maiores valores de bônus por área exploratória, culminando na Rodada 9 com o pagamento de cerca de R$2,0 Bilhões para adquirir em torno de 45.500km^2, ou seja, a área exploratória passou a custar quatro vezes mais do que no ano de 2000 (Rodada 2), quando do início do ciclo de alta de preço do petróleo (Tab. 1).

Esse mesmo cenário também estimulou a entrada de novas companhias de pequeno e médio porte no mercado do petróleo. Percebendo o interesse dessas companhias em realizar investimentos para produzir petróleo em campos de baixa economicidade e sem o risco exploratório, a ANP vislumbrou a possibilidade de oferecer ao mercado áreas que estavam inativas, porém que continham acumulações marginais, ou seja, com volumes de petróleo que poderiam dar um retorno econômico aos investidores em um cenário de alta de preços de petróleo. A tabela 2 mostra o elevado número de empresas que se qualificaram nesse processo confirmando a motivação das pequenas e médias empresas de participar dessa fatia do mercado. As firmas pagaram bônus de cerca de R$13,5 milhões para revitalizar 27 áreas inativas com uma previsão de investimentos equivalente a R$86 milhões.

Alguns indicadores da dinâmica dos leilões podem ser traçados pelo elevado montante de dinheiro investido na indústria do petróleo. O sucesso de um leilão costuma ser medido por essa variável, e também pelo número de empresas participantes. A tabela 3 apresenta uma lista parcial dos nomes e procedência de companhias internacionais e nacionais que adquiriram direitos para exploração, desenvolvimento e produção de petróleo no Brasil, inclusive em áreas inativas com acumulações marginais. Essa lista é um retrato atual da diversidade de empresas que investem no país, porém não definitivo, dado a complexidade do jogo da indústria do petróleo que admite aquisições e fusões de companhias, bem como mudanças quase imprevisíveis nas estratégias internacionais que levam as companhias a participarem de licitações por todo o mundo. Atualmente, existem 28 empresas brasileiras e 36 empresas afiliadas de companhias estrangeiras atuando como concessio-

Tabela 3 - Lista parcial de companhias atuantes nas atividades de exploração e produção no Brasil, além da PETROBRAS.

Companhias na Atividade Petrolífera Brasileira		
Exploração	Desenvolvimento e Produção	Revitalização de Campos Marginais
ExxonMobil (EUA)	Shell (Holanda)	Koch (EUA)
Maersk Oil (Dinamarca)	Repsol (Espanha)	Egesa Engenharia (Brasil)
Statoil/Hydro (Noruega)	ChevronTexaco (EUA)	Proen (Brasil)
Petrogal (Portugal)	El Paso (EUA)	Severo Villares (Brasil)
BG (Reino Unido)	Starfish Oil & Gas (Brasil)	Ral Engenharia (Brasil)
ENI (Itália)	Norse Energy (Noruega)	Alcom (Brasil)
Hess (EUA)	Queiroz Galvão (Brasil)	Rio Proerg Engenharia (Brasil)
Ecopetrol (Colômbia)	Devon Energy (EUA)	Vitória Ambiental (Brasil)
OGX (Brasil)	SK (Coréia)	Gênesis 2000 (Brasil)
BrazAlta (Canadá)	Petrosynergy	Chein Transportes (Brasil)
ONGC Videsh (Índia)	W Washington (Brasil)	Construtora Pioneira (Brasil)
Karoon Gas (Austrália)	Inpex Corp. (Japão)	Egesa (Brasil)

Fonte:Brasil Rounds (ANP 2008)

nárias no Brasil. Os valores reportados nas tabelas 1, 2 e 3 sugerem que se pode considerar os leilões brasileiros como um sucesso.

A dinâmica de participação das companhias nos leilões de áreas exploratórias variou ao longo das nove rodadas em função das diferentes condicionantes técnico-econômicas de cada licitação que levaram a adoção de estratégias distintas. A análise da figura 7 permite uma compreensão do processo e das atuações das companhias:

• Apesar de não ser uma licitação propriamente dita, os resultados da Rodada Zero são aqui apresentados para mostrar que a PETROBRAS optou por ceder parcialmente os direitos de exploração e produção em 20% das áreas que reteve após a quebra do monopólio. A estratégia adotada pela companhia visava tornar a empresa mais competitiva e ágil concentrando seus recursos técnicos e financeiros em 80% das suas áreas de maior potencial exploratório;

• As companhias qualificadas para participar nas licitações 1 a 4 optaram por formar parcerias com a PETROBRAS por razões como o seu elevado conhecimento das bacias sedimentares brasileiras e por deter sistemas de escoamento da produção. Por outro lado, a PETROBRAS teve que redefinir sua estratégia para a realização das atividades exploratórias em função da nova regulamentação que impôs um prazo curto e pré-determinado para as empresas explorarem e avaliarem os blocos adquiridos nos leilões. A oportunidade de partilhar recursos críticos se tornou atrativa, e a PETROBRAS preferiu a estratégia de oferta em conjunto, através da formação de parcerias, do que a de realizar ofertas sozinha.

Considerando a tática adotada pelas companhias de dividir os investimentos e partilhar riscos e informações para juntas adquirirem o bloco de maior potencial do leilão, as Rodadas 6 e 7 mostraram estatísticas semelhantes as das Rodadas 1 a 4. Entretanto, a estratégia que levou a formação de consórcio nessas rodadas foi claramente distinta das demais. Após as mudanças implementadas no ano da Rodada 5 (2003), que tiveram como conseqüência a retração da participação das companhias naquela rodada, as empresas mostraram-se mais confiantes nas regras adotadas pela ANP, no regime fiscal brasileiro, e no potencial exploratório do país, devido aos resultados positivos que algumas companhias tiveram em blocos adquiridos em leilões anteriores. Consequentemente, a estratégia de formação de consórcio parece mais focada em diminuir a competição entre as firmas ou partilhar os investimentos do que dividir informações;

A Rodada 9 apresenta resultados significativamente diferentes das rodadas anteriores. A formação de parcerias entre companhias se tornou, portanto, uma forma de partilhar recursos críticos (sondas de perfuração, embarcações do tipo FPSO, dentre outros), que devido à escassez de oferta no mercado do petróleo alcançaram elevadas taxas diárias, impelindo as companhias a investir em conjunto. Outra razão para a formação de parcerias é o aumento potencial de se ganhar a área de maior potencial geológico em uma licitação, e que pode resultar no aumento de reservas de petróleo das companhias caso ocorra o sucesso exploratório.

A aquisição de blocos depende de como uma companhia lida com o montante em dinheiro disponível para ofertar como bônus, sua percepção do potencial exploratório que resultará no programa de trabalho (PEM) comprometido e de suas expectativas no projeto de produção que refletirá nos percentuais de conteúdo local. Como a fórmula que computa as ofertas atribui pesos para essas variáveis existe uma gama de possibilidades para a composição de uma oferta. Furtado *et al.* (2008) apresentaram uma metodologia que considera o uso do PEM como um pagamento de longo-termo a ser adicionado ao bônus de assinatura que é um desembolso imediato para adquirir a área no sistema de leilão brasileiro. Furtado (*op.cit.*) observou que nas Rodadas 6 e 7 a estratégia das companhias para compor a proposta mais competitiva foi partilhar o montante de dinheiro disponível entre o bônus pago de imediato e o PEM, dado que essas variáveis apresentam o mesmo peso (40%) na fórmula da oferta. Ao invés de deixar quantias razoáveis de bônus sobre a mesa para ganhar a área específica, o que segundo Tavares (2000) não traz nenhum benefício ao vencedor, as companhias comprometem razoáveis programas de trabalho que serão realizados ao longo de toda a fase exploratória. Essa atitude traz vantagens a ANP que recebe além da quantia do bônus, uma quantidade segura de informações geológicas e geofísicas que se tornarão públicas após o período de confidencialidade, e poderão ser usadas nas próximas licitações tanto pela agência para uma melhor calibração dos valores de bônus mínimo, como pelas empresas para uma melhor avaliação técnica e valoração da área.

As regras dos quatro primeiros leilões estabeleciam que as companhias realizassem devoluções parciais de 50% da área no primeiro período exploratório, 25% da área remanescente do bloco ao final do segundo período e a totalidade da área no terceiro período ou, em caso de sucesso exploratório, declarasse a comercialidade da mesma. A consecutiva devolução de áreas afetou o portfólio exploratório da PETROBRAS que, por deter cerca de 400 mil km^2 de área concedidos na Rodada Zero, com prazo de apenas três anos, decidiu reduzir a aquisição de blocos nas Rodadas 1 a 4 (Fig. 8).

Com o avanço contínuo da devolução de áreas a PETROBRAS passou a investir na aquisição de áreas visando reconstruir seu portfólio exploratório, o que aconteceu nas Rodadas 5 a 7[4]. As demais companhias parecem manter um padrão estatístico de aquisição de área variando de 20 mil a 30 mil km^2. Na Rodada 9, entretanto, mesmo com a retirada dos blocos do pré-sal das bacias de Campos e Santos, o total de área adquirida por essas companhias chegou a 35 mil km^2 retratando o elevado interesse das firmas pela exploração de petróleo no Brasil

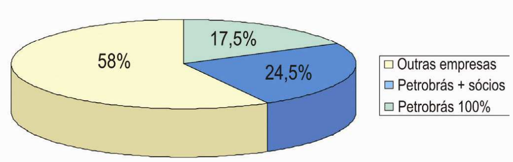
Apesar da PETROBRAS ser uma das poucas companhias que participou de todas as licitações, assumindo por vezes um comportamento bastante ousado em termos de bônus pago, PEM ofertado e número de blocos arrematados, a figura 9 mostra que atualmente existe um equilíbrio na distribuição das áreas exploratórias. De fato, aproximadamente, 160.000km^2 das áreas concedidas a PETROBRAS atua sozinha e em parceria em 42% do total de área exploratória e as demais companhias atuam nos 58% restantes.

Quanto aos leilões de áreas inativas com acumulações marginais deve-se ressaltar que a PETROBRAS não participou em nenhum dos leilões apresentando oferta, apesar de ter se qualificado para as duas licitações.

No primeiro leilão de áreas inativas com acumulações marginais foram licitados 17 blocos, em um total de 95 km² distribuídos no Estado da Bahia (11 áreas inativas localizadas nas bacias de Tucano Sul, Recôncavo e Camamu-Almada), e no Estado de Sergipe (6 áreas inativas na bacia de Sergipe-Alagoas).

O leilão surpreendeu pelo nível de competição presenciada. Apenas uma área não recebeu oferta (Curral de Fora), porém a área de Bom Lugar recebeu 21 ofertas e outras áreas receberam em torno de 6 a 8 ofertas. Com relação ao nível de investimento realizado na aquisição, as empresas se manifestaram de forma muito tímida (R$3 milhões de bônus), apesar de terem participado ativamente do leilão e de preverem investir R$62 milhões na a revitalização dessas áreas.

Dentre as novas empresas que se tornaram concessionárias das áreas inativas na 1ª Rodada destacam-se a Ral Oil & Gas que em 2007 já colocou em produção o campo de Foz do Vaza Barris (bacia de Sergipe)



Fonte: adaptado de Rodriguez & Suslick (2008)

Figura 9 - Distribuição de área em percentual entre as companhias, indicando um equilíbrio na distribuição de área licitada entre as companhias atuantes na exploração de petróleo no Brasil.

[4] O valor total de área licitado na 7ª Rodada constante na tabela 1 (194.631 km^2) difere do valor de 61.900 km^2 apresentado na figura 8. Essa diferença se deve ao fato de ter sido expurgado do gráfico o total de área arrematada nas bacias do Solimões e São Francisco. Essa diferença significativa comprometeria a análise pretendida do gráfico da figura 8 na escala apresentada.

e a Alcom com uma modesta produção na bacia do Recôncavo (Siqueira 2006).

O segundo leilão de áreas inativas com acumulações marginais aconteceu em 2006 e teve 14 blocos oferecidos, perfazendo um total de 305 km² distribuídos entre as Bacias terrestres do Espírito Santo (3 blocos), Potiguar (8 blocos) e na Bacia de Barreirinhas (3 blocos). Por restrições ambientais a ANP retirou da licitação 2 blocos na Bacia Potiguar (Riacho da Pedra e Diogo Lopes) e 5 na Bacia do Espírito Santo (Conceição da Barra, Jaó, Capela São Pedro, Foz do Rio Doce e Rio São Domingos) que haviam anteriormente sido selecionados para o leilão. No total foram 11 blocos arrematados pela quantia de R$10.677.058, a título de bônus de assinatura, efetuada por 10 companhias das 30 que apresentaram ofertas. Estima-se que as companhias vencedoras irão investir R$24 milhões em projetos que permitirão a revitalização desses campos e conseqüente produção.

O leilão pode ser considerado um sucesso no aspecto competitividade. Todos os blocos arrematados receberam mais de uma oferta, chegando a ter bloco com até 11 firmas fazendo proposta, como os blocos de Espigão na bacia de Barreirinhas, Rio Ipiranga na bacia do Espírito Santo (9 firmas) e São João na bacia do Maranhão (8 firmas). Apesar de o número de participantes ter sido menor na 2ª Rodada, o interesse das empresas de pequeno e médio porte parece ter crescido em função do pagamento de bônus três vezes maior para adquirir as áreas e pelo fato das companhias terem realizado ofertas preferencialmente sozinhas, não constituindo consórcios como no 1º leilão de áreas inativas.

Em resumo, nesse ambiente de abertura de mercado em torno de 65 companhias realizam atividades relacionadas a exploração e produção de petróleo no país, em áreas adquiridas nos leilões exploratórios e de áreas inativas com acumulações marginais da ANP, incluindo as áreas da Rodada Zero e da Licitação de Campos Maduros promovida pela PETROBRAS. Estima-se que 14 empresas, além da PETROBRAS, tiveram sucesso exploratório e declararam a comercialidade de acumulações localizadas em bacias terrestres e marítimas, e que hoje se encontram na fase de produção. A PETROBRAS responde por quase a totalidade do volume de óleo e de gás produzido. Além dessa, a Shell, a Repsol e a Devon produzem na bacia de Campos, Queiroz Galvão, Norse e Starfish em campos de terra e no mar, e ainda há a Petrosynergy, W. Washington, Aurizônia e Potióleo, dentre outras companhias de pequeno porte, que produzem na porção terrestre das bacias Potiguar, Recôncavo e Sergipe-Alagoas. Apesar da presença marcante de novas companhias atuando no mercado de produção de petróleo do país, o volume por elas produzido ainda é pequeno.

CONCLUSÕES O processo de leilão de áreas para exploração e produção de petróleo e gás natural no Brasil adota o modelo competitivo selado pela maior oferta. As vantagens desse modelo é ser transparente, ter regras claras e conhecidas com antecedência, e revelar as ofertas concorrentes de forma imediata, minimizando possíveis controvérsias a respeito dos resultados. Esse fato tem propiciado a atração das empresas de grande, médio e pequeno portes, elevando o nível de competição e trazendo benefícios ao país nos recolhimento de participações governamentais e demais tributos e no desenvolvimento da industria nacional.

Esse tipo de licitação vem seguindo uma tendência internacional e possui dinâmica semelhante tanto para licitar os blocos exploratórios quanto para as áreas inativas com acumulações marginais. Esses leilões diferem da maioria dos demais realizados no mundo por exigir um programa de trabalho e um percentual de conteúdo local mínimo como variáveis de oferta, além do bônus de assinatura. Esse procedimento gera informações de caráter geológico, propiciando um aumento da atividade exploratória e subsidiando o planejamento das futuras licitações.

O potencial geológico brasileiro vem se mostrando atrativo desde os anos 80 com descobertas de campos gigantes sobretudo nas bacias da plataforma continental. A partir desses resultados obtidos pela Petrobras e com a alteração da legislação, houve o despertar de interesse das empresas internacionais que vem participando ativamente em todos os leilões de blocos exploratórios. Atualmente o total de área exploratória em concessão das outras empresas já supera a área detida pela Petrobras.

Além da elevação do patamar dos preços do petróleo desde a primeira licitação, que estimulou o aumento dos investimentos no setor petrolífero, outro fator importante é a associação de uma política de incentivos e compromissos para a reativação das áreas inativas com acumulações marginais. Hoje, algumas dessas acumulações, adquiridas em leilões específicos, já se encontram em produção por empresas de pequeno e médio porte, inaugurando uma nova etapa na história exploratória das bacias terrestres maduras.

As recentes descobertas realizadas nas camadas pré-sal ainda estão em fase preliminar de conhecimento geológico, porém já indicam a existência de uma nova e promissora província petrolífera nas bacias marítimas. A alteração do risco geológico dessas descobertas pode significar uma mudança do paradigma vigente na atividade de exploração e produção no Brasil. Caso esse potencial confirme as expectativas e, conforme já indicado pelo CNPE, o governo brasileiro poderá analisar a legislação de forma a propor modificações no regime fiscal específico sem entretanto, alterar o regime de concessão das áreas para exploração, desenvolvimento e produção de hidrocarbonetos por licitação pública. Independente de qualquer revisão no marco regulatório o Brasil continuará a oferecer boas oportunidades de negócio na industria do petróleo e gás natural.

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4. A METHOD TO ESTIMATE BLOCK VALUES THROUGH COMPETITIVE BIDDING

A method to estimate block values through competitive bidding

Ricardo Furtado, Saul B. Suslick, and Monica R. Rodriguez

ABSTRACT

The bidding process is a mechanism that has been widely used by different countries to optimally distribute their oil exploratory acreages. One of the big challenges for both companies and government agencies is the estimation of the block values. Considering that the bid value is by and large a fraction of the estimated unknown reserve, the objective of this article is to reach a set of proxies of unknown values of the blocks through the successful bids. The estimation value of the block is calculated through a stochastic simulation of bid fractions using a compound probability distribution. The model was tested and validated using the public data available from the Brazilian seven licensing rounds. For these competitive bids, areas widespread in 22 sedimentary basins were offered to more than 50 oil companies that retained 610 blocks, paying $1.4 billion as a cash bonus. The model output was restricted to the Campos Basin because it is one of the most attractive areas for oil and gas opportunities, concentrating approximately 80% of the Brazilian national oil production with a supply of 1.8 million bbl/day. The simulation model indicated that this approach can be used as an auxiliary decision framework by oil companies for new investments and bidding strategies as well as by the regulatory agency to evaluate bid performance in different world regions and geological settings possessing similar competitive bidding schemes.

INTRODUCTION

Bidding is a process that maximizes the government's chances of a fair market value for the right to drill for and produce oil

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AUTHORS

Ricardo Furtado ~ *Center for Petroleum Studies, State University of Campinas (UNICAMP), P.O. Box 6052, Cidade Universitaria "Zeferino Vaz", Campinas, SP, Brazil 13083-920; furtado.ric@gmail.com*

Ricardo Furtado has been working in the petroleum industry since 1996 when he started his research about risk analysis, decision process, and bidding models at the State University of Campinas. He worked at Petrobras supporting studies of portfolio management, and he has worked at Schlumberger developing Merak business in Brazil. Ricardo holds a B.Sc. degree in statistics, an M.Sc. degree in geosciences, and a Ph.D. in science and petroleum engineering.

Saul B. Suslick ~ *Institute of Geosciences and Center for Petroleum Studies, State University of Campinas (UNICAMP), P.O. Box 6152, Cidade Universitaria "Zeferino Vaz", Campinas, SP, Brazil 13083-870; suslick@ige.unicamp.br*

Saul Suslick is a professor at the Department of Geology and Natural Resources, Institute of Geosciences, State University of Campinas. His main areas of interest are decision and risk analysis techniques, development of quantitative methods for mineral and petroleum applications (resources appraisal, geostatistics, forecasting, etc.), and mineral and petroleum economics studies (oil taxation models, mineral market analysis, etc.).

Monica R. Rodriguez ~ *Exploration and Production, Petrobras, Av. Republica do Chile, 65, Rio de Janeiro, RJ, Brazil 20031-912; monicarr@petrobas.com.br*

Monica Rebelo Rodriguez is a Brazilian senior geologist working for the petroleum industry since 1987 at Petrobras. She started as a field geologist, and she worked on reservoir characterization after getting her M.Sc. degree as a reservoir geologist and engineer in 1993 at the State University of Campinas. In 2000, she joined the E&P New Ventures Team as a business development advisor on buying and selling assets. Since 2006, she has been in the UNICAMP Ph.D. program.

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and gas on public lands. In an oil and gas lease setting, auctions can serve as an allocation mechanism and as a resource rent taxation. An auction provides the government both with better information about a company's perception of the value of a resource tract and with the potential of a considerably higher revenue from its licensing.

The biddable factors vary extensively among working program expenses in exploration and production phases, royalty, profit share, and cash bonus. Sunnevåg (2000) stated that Britain and Norway have a relatively high level of government regulation with a discretionary concession regime based on company applications for blocks in concession rounds and with an emphasis on the size of work programs specified by the interested companies. Despite some controversial aspects, several studies analyzed alternative bidding methods for petroleum leases (Mead et al., 1986; Mead, 1994) and concluded that the cash bonus system was the most effective means of allocating petroleum resources for exploration and exploitation.

An important aspect in the bidding process that did not receive much attention in the petroleum literature is how companies organize their exploration decision making. In the present scenario of the high volatility of oil prices, this determinant is very important to achieve optimal bonus bidding. The bidding behavior of companies for oil leases is also affected by their anticipation of future discoveries (i.e., the geological potential of the block). Oil companies commonly have good reasons for being secretive about how they determine their bids. Nevertheless, most of the oil firms participating in sealed, competitive-bid auctions are using formal decision-theoretical models to decide how to invest their money.

Another important aspect in bidding for exploration licenses is the function of information because the bidders do not know a priori the actual value of the oil blocks or tracts. Simulation studies indicate that because of uncertainty, participants should bid less than the estimated value to cover their potential loss (miscalculations) over the long run. According to Dougherty and Nozaki (1975), knowing your competitors and the likelihood of their bids carries equal importance when compared to a good estimation of the actual value of the block offered.

A key element of a bid round is, naturally, the acreage being offered and the availability of data. However, other market determinants are equally important in the bidding process, such as the level of the company's competition, risk aversion, taxation, government take, reserves expected, and oil or gas price and volatility, as well as the other macroeconomic settings (inflation, oil demand, etc.). These parameters have great influence on the company's decisions when it is difficult to model the firm behavior of future oil assets to be acquired. The other important factors in a bid level are expected fiscal and sovereign stability of the host country, corporate strategy (i.e., the appetite for more exploration blocks in area offered), whether the company already holds acreage (i.e., synergies and economies of scale), the geological potential of the areas on offer, and the financial strength of the companies, among others.

This article will show that the bonus offered in a competitive exploration bid is a function of the expected asset value or a fraction of the expected future reserves. The values of these future assets (or reserves) are unknown when companies are making their bids. Thus, assuming that the oil company is always looking for an optimum bid fraction, the objective of this article is to present a methodology using stochastic simulation that supplies a set of proxies of these unknown block values. Considering these aspects, another contribution is also the identification of the company's exploration and production expectation and strategic movements using the licensing rounds already accomplished. Despite their opposite objectives in the bidding process, the methodology proposed here can be very useful for both regulatory agencies and oil companies. The government can use the results to achieve higher bidding efficiencies and bonuses, whereas the oil companies can employ the methodology to optimize their bidding strategy decisions. As pointed out previously, this strategy depends on risks and uncertainties in the bidding process that involve determinants such as exploration failure, overbidding, oil or gas presence, volume expectation, reservoir characteristics, etc.

The licensing round in Brazil is used as a case study because of several aspects. First, in 1997, the Brazilian government agreed to open the petroleum sector for the oil industry, ending a 50-yr monopoly of oil and gas exploration and production. A regulatory agency grants the rights for petroleum exploration through a sealed, competitive bidding method. The oil companies considered Brazil to be the new El Dorado for petroleum exploration and started investing heavily through the acquisition of rights to explore in the country since the first licensing round promoted by the National Petroleum Agency (ANP) (Moraes et al., 2004). Since 1999, eight licensing rounds have been held in Brazil, although in this article, we will focus on the first seven bid rounds in which 3126 blocks were released and approximately $1.4 billion were collected, involving more than 50 oil companies (ANP, 2006). Another reason for choosing Brazil as a case study is the fact that this region possesses a considerable amount of blocks, company bidders, and a sequence of events that represent a good sample for testing the simulation methodology that could be applied to mature regions (i.e., outer continental shelf [OCS] in the United States), as well as to other new greenfield petroleum areas.

One of the motivations for the oil companies to participate in Brazilian tenders was the discovery of giant oil fields made by Petrobras, the national oil company, during the 1990s in the Campos Basin. This is one of the reasons why the Campos Basin was selected as the target of this article among the basins offered in Brazilian tenders. The oil and gas production of this basin presently corresponds to more than 80% of the Brazilian national production that recently reached 1.8 million bbl/day, giving the country a position of self-sufficiency in domestic oil supply.

This article is organized in five sections. The introduction and the section titled Bidding and Associated Characteristics present a descriptive analysis of the structure, conduct, and performance of the market for petroleum bidding. The section titled Stochastic Model describes the advantages and limitations of stochastic modeling methodology to estimate the block value. The section titled Case Study: The Campos Basin presents an overview of some exploration and production information of the Campos Basin, which is necessary for the comprehension of the statistics and discussions presented. The Conclusions section presents general remarks and conclusions.

BIDDING AND ASSOCIATED CHARACTERISTICS

Capen et al. (1971) and Lohrenz (1987) developed an approach to estimate an optimum and competitive bidding under high-risk situations. They argued that especially in the context of oil-lease bidding, the best competitive bid could be a good predictor of the asset's value. They proposed a common-value model in which the asset valued was the same for all bidders but unknown to them. Lohrenz (1987) and Capen et al. (1971) assumed that all bidders make statistically independent estimation errors. Hence, bidders who make unbiased estimates of the asset value will tend to be disappointed in the value of what they win, especially if there is strong competition. In general, they will tend to win blocks in which their estimate was optimistic and lose others in which it was pessimistic. Capen et al. (1971) employed the term "the winner's curse" for bidders who do not sufficiently adjust for these biases as a punishment brought on competitors who do not react to the increasing competition by restraining their own, in their own best interest. In bidding, competition increases as more bidders bid higher. This creates a situation in which the winner's curse can occur. In other words, the competitors that do not follow their preferences over risk, playing sharply in high-level competition, will probably suffer from the winner's curse.

When evaluating the participation of companies, solo or in joint ventures, in the federal offshore oil and gas leases in the United States, Capen et al. (1971) concluded that the companies were paying more for the property than its ultimate value. Lohrenz (1987) developed a study suggesting guidelines for bidding in federal offshore oil and gas leases in the United States by evaluating the bid-fraction value. Dougherty and Nozaki (1975) presented a basic pattern of optimum bid fraction using pattern variations caused by changing parameters, the probability of winning, and the expected return. Competitive bids have always pushed oil companies to identify the optimum bid fraction that provides the maximum probability for a winning scenario. In this sense, Tavares (2000) proposed a scheme for a bidding strategy minimizing the money left on the table by the companies.

Wilson (1977) showed that price formation by competitive leases satisfies the law of large numbers for both statistic means and economic sense. If the sealed lease winner is the highest bid offered, envisaging that the object leased has a defined monetary value, the bonus maximum is almost certainly the object's real value. Wilson (1977) assumed that the asset has the same value to all bidders. Although the asset value is unknown, each competitor has bid values independently and identically distributed conditioned to the value. Therefore, players do not know the real value of the object, but the seller will receive this value in a bidding process.

Wilson (1977) emphasized that companies have to adopt a strategy that considers the number of competitors and estimates the area's value to define the bonus offered in a competitive lease process. Therefore, the first step for participation in a competitive bidding process is to define which blocks are adherent to the company strategy, estimate their value, and then determine the amount of competition expected.

Capen et al. (1971), Dougherty and Nozaki (1975), Wilson (1977), Reece (1978), Lohrenz and Dougherty (1983), Lohrenz (1987, 1991), Schuyler (1990), Kretzer (1993, 1994), and Tavares (2000) developed studies on the hypothesis that a bonus value offered in a competitive leasing is a function of asset value, i.e., companies offer a fraction of the estimated reserve value. Considering this hypothesis, it is assumed that the bonus value offered in the auction process is a fraction of the reserve value expected by companies. A possible approach is that the company's estimated value (expected monetary value, EMV) commonly also has a probability distribution because many inputs are uncertain. Hence, the fraction as described here should be seen in that context, i.e., the fraction itself has an uncertainty range.

Johnston (2003) stated that a company has to offer a bonus value between zero and the EMV of the area's estimated value to enhance the expectation of some earnings for acquiring the concession and avoiding the winner's curse in addition to the possibility of being a successful bidding competitor.

STOCHASTIC MODEL

One of the first requirements for the bidding methodology proposed demands a sealed bidding, which gives more transparency to the whole bidding process for the industry. The concept of this model implies that bidders present offers knowing neither their competitor's bid nor the number of competitors involved in the process. The first assumption used for the stochastic simulations is that the bidding bonus is a fraction of the tract's estimated value, which is evaluated by the bidder.

$$b_i = c_i \times V_i \qquad (1)$$

where i is a bidder index, b is the bonus value, c is a fraction of the estimated value, and V is the tract's estimated value. In addition, V_i can be estimated through the EMV (EMV_i), considering that all bidders are submitted to the same magnitude of exploratory capital exposed to the chance of loss, as indicated by

$$V_i = \mathrm{EMV}_i = p\ \mathrm{NPV}_1 + (1 - p)\ \mathrm{NPV}_2 \qquad (2)$$

where p is exploratory success probability, NPV_1 is the net present value of success, and NPV_2 is the net present value of an uneconomical block.

Equation 1 illustrates that the real block value is a function of the bonus value and the bonus fraction value. However, only the bonus value is known, and, to achieve the real block value, it is necessary to estimate a fraction of the bonus value.

The bonus fraction value is between 0 and 1, and its distribution follows the lognormal probability distribution (equation 3) (Note that Rothkopf and Harstad, 1994, used a Weibull distribution to estimate the gains of each bidder. The Weibull distribution arises in the statistics of extreme values). This statement seems reasonable considering that the uncertainty related to the estimated block

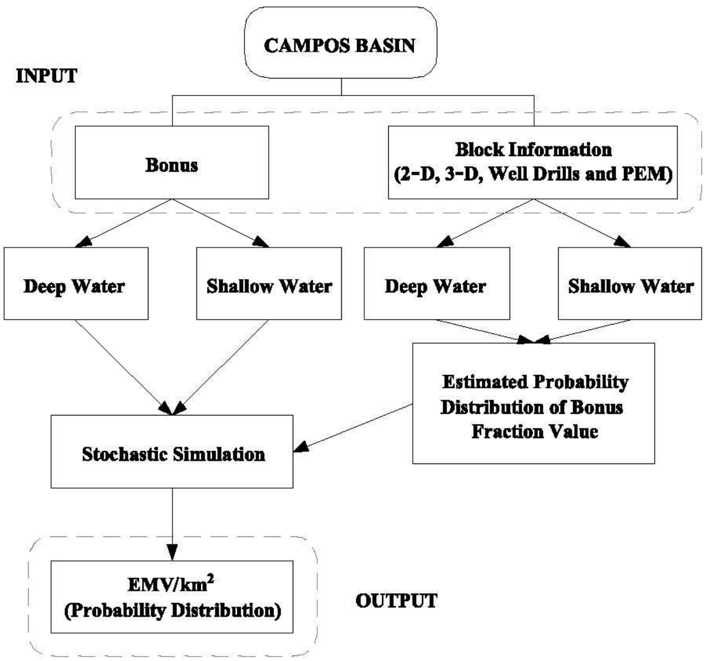


Figure 1. Flowchart of block-value stochastic simulation. PEM = minimum exploratory working program; EMV = expected monetary value.

value is large and the decision maker is commonly risk-average. The bidders may approach 1 if some strategic decisions are necessary such as the existence of asymmetric information, geologic endowment, investment in contiguous block leases, etc. Considering that the lognormal distribution is asymmetric and its distribution could be right skewed, this distribution properly fits the estimation of the fraction bonus value. It can be observed that as c value increases, the probability of winning the bid becomes higher and, consequently, the expectation of monetary gain in the block decreases because the actual value is not directly related to the bonus value (and vice versa).

$$f(c_i) = \frac{1}{c_i\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2\sigma^2}\log_e c_i - \mu\right)$$
$$\text{for } 0 < c_i < 1, \text{ and } \sigma > 0 \qquad (3)$$

where "mi" and "sigma" are the parameters of lognormal distribution, average, and standard deviation, respectively.

Input Variables

The methodology used to perform this stochastic simulation follows four steps, as indicated in Figure 1:

1. Classification of the area or basin in groups, according to their geological settings (deep-water and shallow-water sectors of the Campos Basin in the specific case)
2. Estimation of the probability distribution of the bonus fraction value and calculation of the average bonus by block, according to the knowledge and the data available for each group category referred to in the first step
3. Stochastic simulations of the bid-fraction values using the Monte Carlo simulation method
4. Estimation of mean EMV by the area's probability distribution for each group previously defined in step one (The first attempt to apply this methodology can be found in Furtado and Suslick [2003, 2005])

As mentioned previously, the first step of this methodology consists of dividing the offered blocks and available information according to their geological characteristics and investment attractiveness using the following groups of the Campos Basin: deep-water sector (more than 400 m [1312 ft] of water depth) and shallow-water sector (less than 400 m [1312 ft] of water depth). This type of input for this model is not restricted to the specific study case but can be found in the most competitive bidding schemes for petroleum blocks. Depending on the geological setting, operational conditions, or other local regional characteristics, different types of data partition or classification can be employed in the bidding area.

To perform the stochastic simulation, it is necessary to define both input and output model parameters: the bonus value (b), the probability distribution of the fraction of the market reserve value (c), and, as output, the probability distribution of the EMV.

An analysis of the real data is important to perceive that certain blocks received more than one offer with a high possibility of large discrepancies in the bonuses offered.

$$b_{ki} = \frac{\sum_{j-1}^{m} b_{kij}}{m} \qquad (4)$$

where k is the deep-water or shallow-water sector index, i is the block index, j is the bid-offered index for a specific block, and m is the number of bids offered for a specific block.

A lognormal distribution of the fraction value of the reserve (c) was assumed with mean μ and variance σ^2. The value of μ and σ of the probability distribution of the c value for each block was estimated in different manners because it was based on the comparison of the available information on the acreage areas according to the classification adopted in this article. The variance estimation has considered only the values of one specific area, reflecting the information dispersion of each exploratory area. In other words, the mean was estimated considering the information available among the exploratory regions and the variance of dispersion inside one specific region. In addition to the above-mentioned inputs, for each area, the mean probability distribution is estimated based on the definition of an indicator (IM). The first step for estimating the μ of the four former bids is the calculation of IM, an indicator from the two-dimensional (2-D) and three-dimensional (3-D) seismic information, the area size, and the number of drilling wells available in the acquired blocks (equation 5). This information was used to simulate the data of the first four Brazilian licensing rounds. For the following three rounds, the regulatory agency included the minimum exploratory working program (PEM), a new variable in the definition of the winning proposal. This was another measure that was weighted with the bonus value (equation 6). The meaning and the impact of the PEM and its relationship with the bonus and bidding strategy will be explained in the next section.

$$\mathrm{IM}_h = \left(\frac{\sum_{i-1}^{n} S2_{hi}}{\sum_{k-1}^{l}\sum_{i-1}^{n} S2_{ki}} \times 0.2 + \frac{\sum_{i-1}^{n} S3_{hi}}{\sum_{k-1}^{l}\sum_{i-1}^{n} S3_{ki}} \times 0.3 + \frac{\sum_{i-1}^{n} P_{hi}}{\sum_{k-1}^{l}\sum_{i-1}^{n} P_{ki}} \times 0.5 \right) \times \frac{\sum_{i-1}^{n} A_{hi}}{\sum_{k-1}^{l}\sum_{i-1}^{n} A_{ki}} \qquad (5)$$

where h and k are sector indexes (deep and shallow water), l is the number of areas, i is the block index, n is the number of blocks, $S2$ is the 2-D seismic value for block i, $S3$ is the 3-D seismic value for block i, P is the number of drilling wells in block i, and A is the block dimension. The indicator (IM) represents the quality of information available in the Campos Basin. See the Appendix for a detailed block value estimation.

Some linear transformation of IM can be used to obtain μ as a value that reflects the bid-fraction average. This value is limited to the interval 0.05–0.55 for blocks placed in deep-water sectors and 0.05–0.85 in shallow-water sectors in this case study (Appendix). The specific interval is an arbitrary value defined by the decision makers, reflecting the uncertainty level associated with each sector, i.e., blocks situated in shallow-water sectors have less uncertainty than deep-water blocks because of the amount of geological data already acquired through the last 30 yr of exploration. The decision makers have to develop studies to properly and precisely define these range values.

The IM values for licensing rounds 5 to 7 are obtained by

$$\mathrm{IM}_h = \frac{\sum_{i=1}^{n} \mathrm{PEM}_{hi}}{\sum_{k=1}^{l}\sum_{i=1}^{n} \mathrm{PEM}_{ki}} \times \frac{\sum_{i=1}^{n} A_{hi}}{\sum_{k=1}^{l}\sum_{i=1}^{n} A_{ki}} \qquad (6)$$

where PEM is the minimum exploratory working program, h and k are sector indexes (deep and shallow water), l is the number of areas, i is the block index, n is the number of blocks, and A is the block dimension.

The use of PEM is supported by the assumption that this value reflects the company's interest in the exploratory area. It is an important strategic value in Brazilian licensing rounds because it has the same weight (40%) as the bonus value in the final score of the lease. In addition, it is directly correlated to acquisitions of new information because it is a compulsory working program that the company has to follow after licensing concession.

The same procedure is used to calculate the bid-fraction variance (IV). The IV values for licensing rounds 1 to 4 are obtained by

$$\mathrm{IV}_{kz} = \frac{1}{\left(\frac{S2_z}{\sum_{i=1}^{n} S2_{hi}} \times 0.2 + \frac{S3_z}{\sum_{i=1}^{n} S3_{hi}} \times 0.3 + \frac{P_z}{\sum_{i=1}^{n} P_{hi}} \times 0.5\right) \times \frac{A_i}{\sum_{i=1}^{n} A_{hi}}} \qquad (7)$$

where h is the sector index (deep and shallow water), l is the number of areas, i and z are the block indexes, n is the number of blocks, $S2$ is the 2-D seismic value for blocks i or z, $S3$ is the 3-D seismic value for blocks i or z, P is the number of drilling wells in blocks i or z, and A is the block dimension.

A linear transformation of IV can be used to obtain σ^2, reflecting the amount of information available for each sector. This value is a proxy of bid-fraction variance that is used in the lognormal distribution. It has to be in the interval 0.01–0.20. This is an arbitrary range value that has to be defined by the decision makers, considering the uncertainty level associated with the exploratory area.

The IV values for licensing rounds 5 to 7 are obtained by

$$\mathrm{IV}_{kz} = \frac{1}{\frac{\mathrm{PEM}_z}{\sum_{i=1}^{n} \mathrm{PEM}_{hi}} \times \frac{A_z}{\sum_{i=1}^{n} A_{hi}}} \qquad (8)$$

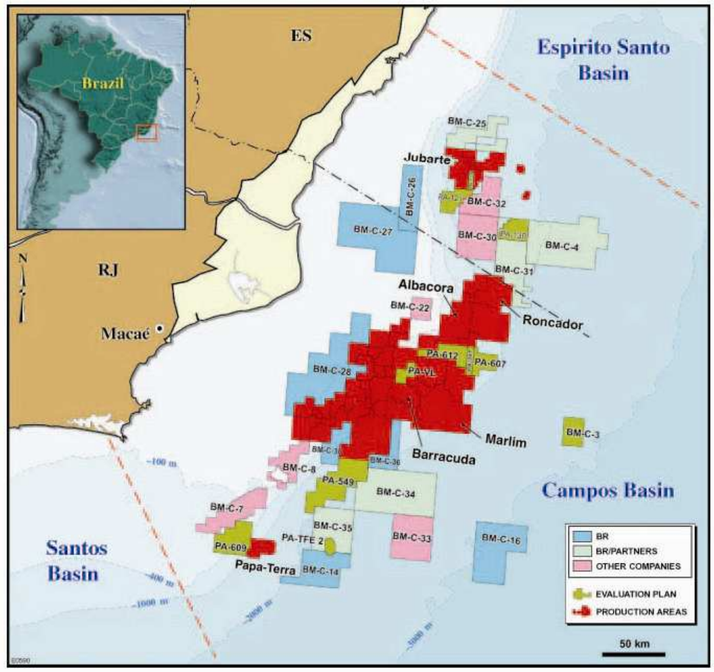
where PEM is the exploratory working program, h is the sector index (deep and shallow water), l is the number of areas, i and z are the block indexes, n is the number of blocks, and A is the block dimension.

In summary, blocks with more information (lesser uncertainty) will have higher IM (information quality) (equations 5, 6) and smaller IV (bid-fraction variance) (equations 7, 8) because it is expected that estimation accuracy is directly correlated with the amount of information available. A good estimation reduces the risk aversion and the uncertainty of the bonus value offered, diminishing bid-fraction variability. In other words, the methodology is a rational framework for optimizing the bonus value according to companies' risk preferences, avoiding the winner's curse and resulting in a minimum amount of money left on the table. The model proposed in this article can capture this feature of licensing concession based on sealed bonuses and can be applied in almost all situations involving the competitive bidding process.

Output Variable

The EMV per block dimension is estimated using the output from stochastic simulation. In this methodology, several s stochastic simulations were performed, generating a collection of s EMV/km^2 values for each selected area with a probability distribution of known mean and variance. With this probability distribution, it is possible to evaluate the company's block value expectation and derive all of the strategic analysis for the bid rounds for a specific area. However, it is well known that the

Figure 2. Campos Basin setting, block distribution, and production areas. ES = Espirito Santo; RJ = Rio de Janeiro; BR = Petrobras.



value of a block is determined by the quality of the subsurface opportunity(s) present.

CASE STUDY: THE CAMPOS BASIN

From the oil industry's point of view, one of the most attractive basins in Brazil is the Campos Basin, known worldwide as prolifically oil prone because of its giant fields (Figure 2). Based on its attractiveness, this basin was selected to show the simulation results for mainly two reasons. First of all, the Campos Basin can be considered a representative sample because it possesses block offerings in the first seven sequential licensing rounds. The second reason is the strong competition in shallow-water and deep-water areas, which is comparable to other competitive bidding regions. Besides the track record of exploratory success, the existing infrastructure installed for oil and gas production in the Campos Basin adds value to any oil opportunity that could be discovered. This is an ideal sample for testing our model hypothesis because the oil companies that participated in these seven bid rounds can be expected to have considered all these previous aspects when elaborating their strategic decisions.

Located on the Brazilian continental margin, this basin began to be explored for petroleum at the end of the 1960s, motivated by the positive results of the offshore exploratory activities on the continental shelf of the U.S. Gulf of Mexico. The exploratory activities performed in the Campos Basin showed successful results in the early 1970s. The shallow-water targets were Albian carbonates structured as rollovers because of the fault system generated by the salt dome movement. The first oil field discovered in 1974 was the Garoupa field, still under production. Following the depositional trend of high-energy carbonates, several oil fields were mapped and developed. Tertiary sandstone oil reservoirs were found as a secondary exploration target in water depths lower than 400 m (1312 ft) (Mendonça et al., 2004).

The advances in technology and its rapid development for both seismic acquisition and drilling in water depths more than 400 m (1312 ft) allowed geoscientists to explore new offshore frontiers. The Campos Basin, with its proven active petroleum system in shallow waters, was a natural candidate for the application of these technologies. In the 1980s, in water depths more than 400 m (1312 ft), a set of canyons cutting the platform were observed. A detailed investigation of this geological model leads to the discovery of the giant Marlim field, a depositional fan system with 6 billion bbl of original oil in place. A series of tertiary sandstone turbidites were mapped in this decade, resulting in the discovery of other giant oil fields such as Albacora field (volume of original oil in place [VOOIP] = 4.5 billion bbl) and Barracuda (VOOIP = 2.7 billion bbl). Information regarding general geological and geophysics features, reservoir characteristics, development, and production projects is available in the literature (Assis et al., 1998; Luchesi and Gontijo, 1998).

In 1996, right before the opening of the petroleum sector to foreign oil companies, Roncador oil field was discovered at a depth of approximately 1500 m (4921 ft) with 9 billion bbl of original oil in place. As the offshore drilling technology reached 2500 m (8202 ft) of water depth, new geological settings were mapped. In 2000, a new giant oil field (Jubarte field) was discovered in the northern sector of the Campos Basin, opening a new perspective. From 2000 to 2006, some oil companies made successful discoveries, declaring the commerciality of more than six oil accumulations in this region, such as Argonauta, Ostra, Abalone, and Nautilus (Shell/Petrobras/ExxonMobil); Polvo field (Devon/SK); Papa Terra (Petrobras/ChevronTexaco); and Chinook (EnCana/Kerr-McGee). In this article, we will keep the original corporate names of the companies, which acquired the blocks in each licensing round, despite the merging and acquisition between the oil companies worldwide that occurred during the period covered by the licensing bid rounds.

Bidding Statistics

A total amount of 43 blocks was leased in the Campos Basin from licensing rounds 1 to 7 through the competitive sealed bidding method (Table 1). These blocks correspond to approximately 30,000 km^2 (11,583 mi^2) and represent 21% of the total amount of signature bonus received by the government.

Table 1. Campos Basin Bidding Statistics

Campos Basin		Deep-Water Sector	Shallow-Water Sector	Total
Blocks	Offered	45	102	147
	Leased	19	24	43
Area (km^2 × 10^3)	Offered	52.14	27.42	79.56
	Leased	21.44	9.12	30.56
Bonus (million dollars)		281.47	23.11	304.58

Recall that, during 2003, several changes occurred in the Brazilian fiscal system and the regulatory scenario, directly affecting oil exploration and production, as well as the bidding process. New bid rules, and the unexpressive commercial results of the acquired blocks, led the oil companies to reduce their investments in the acquisition of new exploration areas in the fifth licensing round. Petrobras was the sole company to invest in the Campos Basin in round 5, acquiring 19 blocks in the shallow-water sector. This trend is clearly indicated in Table 2. The inclusion of round 5 could introduce some bias in the interpretation and judgment of the company's strategies that should be avoided, so this specific round was excluded from our data set.

Table 2 indicates the number of blocks acquired in both sectors (deep and shallow water) in the Campos Basin, grouped by licensing rounds 1–4, 5, and 6–7. The number of blocks acquired is classified by companies participating solo or in partnerships with Petrobras or among themselves.

Block size is also relevant information on Table 2. From licensing rounds 1 to 4, the blocks released had a variable size with a minimum bonus price, predefined by ANP. After the fifth licensing round, ANP applied a cell-model method defining a standard block size per sector. The blocks located in offshore shallow-water sectors totaled 180 km^2 (69 mi^2) and 720 km^2 (278 mi^2) in deep-water sectors. Considering these differences

Table 2. Block Distribution by Lease Rounds and Companies

	Rounds 1–4	Round 5	Rounds 6–7
	D/S*	D/S	D/S
Petrobras 100%	1/1	0/19	2/0
Petrobras with partners	3/0	0/0	5/0
Companies 100%	3/2	0/0	0/1
Companies with partners	2/1	0/0	3/0
Total	9/4	0/19	10/1

*D = deep-water sector; S = shallow-water sector.

in size, it is not right to conclude that one company with many acquired blocks has more acreage in a shallow-water sector than another company, for example.

After the opening of the oil sector, the quality and amount of existing available geological data were the same for all oil companies, except for the wells drilled 2 yr before the opening and some proprietary geophysical data that were kept as confidential by the companies who acquired them in accordance with the regulatory provisions. However, Petrobras has a long history of success exploring the Brazilian sedimentary basins and a well-known expertise in drilling and producing offshore deep-water areas. The companies envision such knowledge and proprietary geological data as a source of asymmetric information that could lead to competitive advantages. For these reasons, some company strategies were to bid in partnership with Petrobras for eight deep-water blocks. Other oil companies adopted a solo bidding strategy, reflecting their expectation of high returns as well as their risk aversion, besides their wish to retain 100% of the block value presenting a lower offer per area. Companies associated in joint ventures among themselves acquired just five deep-water blocks. However, even for shallow-water blocks, the companies probably felt comfortable to present proposals without Petrobras because of a considerable amount of information available for this area, which has more than 38 oil fields under production.

Table 3 presents the proportional area retained and the investments made by the 20 companies in the Campos Basin. Emphasizing that these investments consider both signature bonus and the equivalent amount of money committed in the minimum working program (PEM) is important. Although the working program is a variable that represents the company's commitment to perform geological and geophysical acquisition, it reflects in amount of money and its conversion from a program unit (UT) to cash money is clearly stated in ANP rules.

This is a picture of the total amount exposed to bidding results at lease time, i.e., the licensing area acquired and investments presented on each licensing round (Table 3). These data show the company's hydrocarbon reserve value expectation at the moment of the tender. Analyzing these statistical data, attention should be paid to companies' current situations in Brazil to avoid misunderstandings about investment levels and the total exploratory area. It is not the intention here to consider any company's acquisition or merger (Shell/Enterprise, Devon/Ocean Energy/Santa Fé, Repsol/YPF), withdrawal, farm in, farm out, swap, or relinquishment of areas, as provided in the concession contract made by the companies after bidding. Nor is this the present list of companies with active concessions in the Campos Basin.

Petrobras invested $195.51 million to acquire 31 blocks in the Campos Basin from licensing rounds 1 to 7 (except for round 2 with an area of 9800 km^2; 3784 mi^2). Shell leased blocks in four rounds, offering approximately $48 million to acquire 3648 km^2 (1408 mi^2) of exploratory area. Devon bid in licensing rounds 6 and 7, investing $108 million and acquiring 1319 km^2 (509 mi^2).

Analyzing the investments made by square kilometers in the deep-water sector of the Campos Basin (Figure 3), we observe that four distinct groups of companies are competing in Brazilian lease rounds. Devon, Repsol YPF, and Statoil offered bonus plus the PEM above $65,000/km^2. The amount offered (winning bids) by Kerr-McGee, EnCana, Petrobras, and SK is somewhere between $35,000 and $40,000/km^2. The third group, composed of Amerada Hess, Ocean Energy, and Shell, offered values of around $15,000/km^2. Agip, BHP, Enterprise, Texaco, and Total invested values lower than $10,000/km^2.

Table 3. Block Area and Total Investments in the Campos Basin for All Rounds per Company

		Area (km^2)*		Investment (10^6 US dollars)**	
Company	Rounds	D	S	D	S
Agip	1	2191		16.85	
Amerada Hess	3	700		10.49	
BHP	4	603		4.96	
Devon	6, 7	1319		107.96	
EnCana	6	179		6.45	
Enterprise	3	423		0.52	
Kerr-McGee	6	340	179	12.49	0.54
Ocean Energy	3	1299		19.47	
Odebrecht	2		235		1.00
PanCanadian	2		1920		2.61
Petrobras	1, 3, 4, 5, 6, 7	5454	4378	185.76	9.75
Repsol YPF	7	354		23.96	
Santa Fé	2		704		3.01
Shell	2, 3, 4, 5	3648		47.85	
SK	2, 6	275	626	10.10	2.67
Statoil	7	354		23.96	
Texaco	1	2154		3.35	
Total	3	565		0.70	
Wintershall	3		1077		10.12
YPF	1	1582		13.36	

*S = shallow-water sector; D = deep-water sector.
**Bonus value + working program expenses in monetary value (PEM).

Two groups can be identified for the shallow-water sector (Figure 4). Wintershall offered up to $9400/km², whereas Kerr-McGee, Odebrecht, Petrobras, Santa Fé, SK, and PanCanadian offered below $4500/km². Petrobras' investments made per area are strongly affected by the fifth-round results, in which the company acquired 19 blocks offering lower investments because it faced no competition.

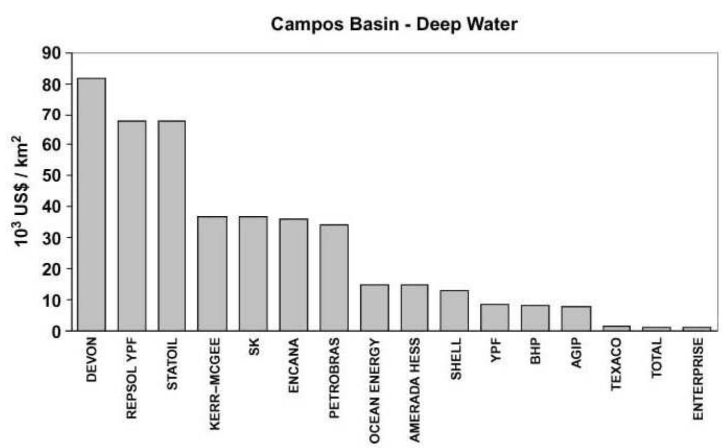
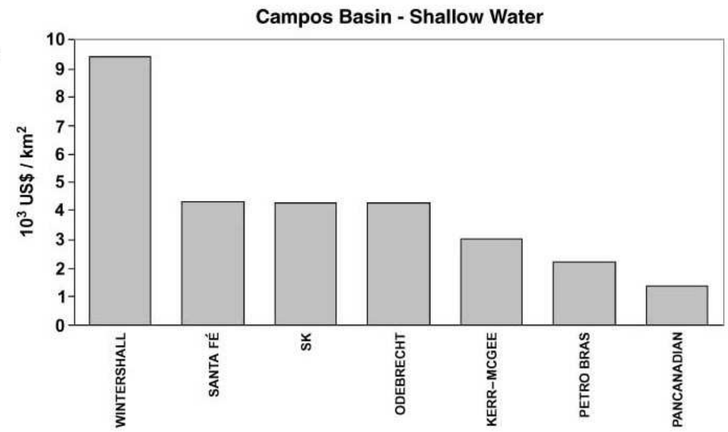


Figure 3. Investment by square kilometers in the deep-water sector of the Campos Basin.

Figure 4. Investment by square kilometers in the shallow-water of the Campos Basin.



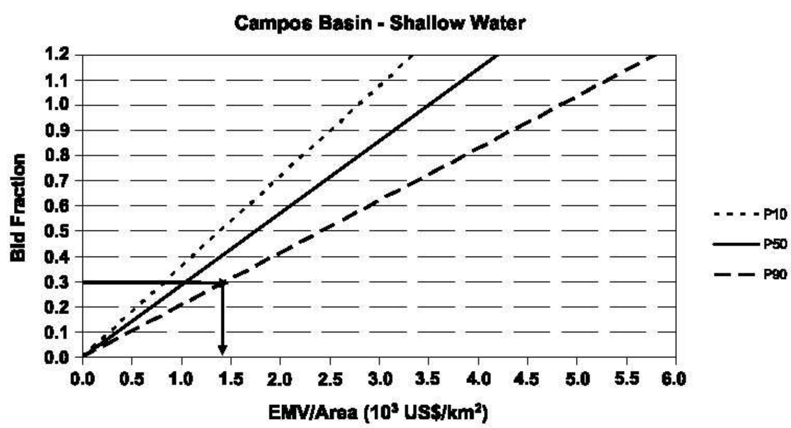
Model Results and Discussion

The methodology is applied for both deep-water and shallow-water blocks acquired from licensing rounds 1–7. The results achieved with the stochastic simulation allow oil companies to better define their strategies to bid for a specific sector of the Campos Basin with some confidence. The main steps of the stochastic model and EMV estimation procedures are detailed in the Appendix.

Figures 5 and 6 present the stochastic simulation results for shallow-water and deep-water sectors, respectively. These graphics represent the bid fraction (y axis) and the EMV/km^2 (x axis) to be estimated. The three curves are the probabilities of the 10, 50, and 90% chance of the selected bid fraction. So, for a specific bid fraction and one of the three probability curves, the simulated EMV per acreage (10^3 dollars/km^2) can be easily obtained. This value, multiplied by the block dimension, gives a proxy of optimum bonus value that can be offered in the lease round. This mathematical operation is used envisaging the variable normalization as the block dimension varies from licensing rounds 1 to 5.

Capen et al. (1971) and Dougherty and Nozaki (1975) indicated that, in a strong competitive environment, the companies should consider a bid fraction ranging from 20 to 30% to assure the return of their investments if they win the bid. By choosing a bid fraction of 0.3 and considering a 90% chance of having this fraction (P90), a maximum value of

Figure 5. The EMV simulation results for the Campos Basin shallow-water areas. EMV = expected monetary value; P10, P50, P90 = 10, 50, and 90% chance of the selected bid fraction.



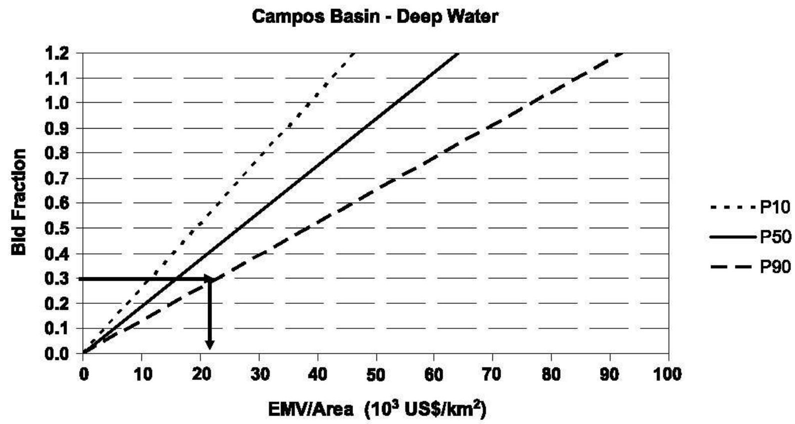


Figure 6. The EMV simulation results for the Campos Basin deep-water areas. EMV = expected monetary value; P10, P50, P90 = 10, 50, and 90% of the selected bid fraction.

$1450/km² should be used to calculate the total amount of bonus to be paid as an optimum value for a shallow-water block in the Campos Basin (Figure 5). This estimation is strongly related to the geological attractiveness of this area.

The same rationale is applied to Figure 6, and a value equivalent to $23,160/km² is the basis for the bonus estimation for deep-water blocks.

According to these figures, any oil company interested in presenting a proposal for the referred sectors of the Campos Basin can compare its internally derived value from subsurface assessment with the analyses of different bid-fraction scenarios and uncertainty levels to define the best strategy for a bonus offer.

Stochastic simulation results for both shallow-water and deep-water blocks can be compared with the actual bid offers made by the companies competing for blocks in all licensing rounds (Tables 4, 5, 6), except for round 5, because of the low level of sample representation.

As previously mentioned, round 5 was a turning point in the Brazilian licensing model, which modified the bonus weight in the bidding process. The most relevant adjustments made to this process by the regulatory agency were (1) the definition of block size based on a cell model that was built up by the company bidder, (2) the changes from a previous defined exploratory working program to a minimum exploratory working program (PEM) to be bid by the companies, and (3) the introduction of the PEM that, besides the bonus and the local content (CL), was used to estimate the winning bid using the following weights:

Table 4. Rounds 1 to 4 EMV Simulated Results for Shallow-Water Areas

Block	Area (km²)	Company and Partnerships	Bid (million dollars)	Simulation* (million dollars)	Simulation** (million dollars)
BM-C-6	686	Petrobras†	2.78	0.99	3.31
BM-C-7	1920	PanCanadian†	2.61	2.78	9.27
BM-C-8	1565	Odebrecht/Santa Fé†/SK	6.68	2.27	7.56
		Maersk†	7.44		
BM-C-19	1077	Wintershall†	10.12	1.56	5.20
		PanCanadian†	2.66		

*P(EMV/km² $\leq$ 1.45) = 90% and c = 0.3.
**P(EMV/km² $\leq$ 4.83) = 90% and c = 1.0.
†Operator.

Table 5. Round 6 Actual and Simulated EMV Results for Deep-Water Areas

Block	Area (km^2)	Company and Partnerships	Bid (million dollars)	PEM (UTs)	Simulation* (million dollars)
C-M-101	716.48	Devon**/EnCana/Kerr-McGee/SK	16.67	2287	16.59
C-M-103	311.19	Petrobras**/Shell	6.37	54	7.21
C-M-151	398.61	Petrobras**/Shell	11.37	1150	9.23
C-M-61	488.25	Devon**/Kerr-McGee/SK	9.50	2196	11.31
		Petrobras**/Repsol YPF	12.48	2047	

*$P(EMV/km^2 \leq 23.16) = 90\%$ and $c = 0.3$.
**Operator.

40% bonus, 40% PEM, and 20% CL. Previous licensing rounds considered only bonus (85%) and CL (15%) to define the winner. The local content (CL) is a commitment assumed by the companies in terms of investments in exploration and production (services, equipment, etc.) that must be made in the domestic market. The motivation of these investments is to promote national industrial development, as required by the government through the execution of contracts among Brazilian companies. The failure of these companies to honor the CL commitment is subject to predefined penalties mainly because it was one of the items that defined the winning proposal in bidding rounds.

This information is relevant when considering the winning proposal; for example, Block BM-C-8 leased in the second round (Table 4), whose winner was the consortium operated by Santa Fé. Although it had offered a bonus lower than Maersk's proposal, the higher percentage of local content offered by the consortium made the difference. In 2005, the consortium found an oil accumulation, the Polvo field, that presented a promising level of feasibility for future development and production (Brazil Energy, 2005).

The existing geological data for the Campos Basin shallow-water sector is available for all companies willing to acquire the rights to explore this area. The proven exploration results and the existing facilities of oil fields under production give more regional knowledge about the area to the technical team, reducing the risk aversion of the decision makers. As stated by Lohrenz (1991), the more information supplied to bidders by the government, the more accurate and closer to the true value of the area are their estimates. A comparison between the simulation results for bid fractions of

Table 6. Round 7 Actual and Simulated EMV Results for Deep-Water Areas

Block	Area (km^2)	Company and Partnerships	Bid (million dollars)	PEM (UTs)	Simulation* (million dollars)
C-M-401	324.27	Petrobras**	7.16	2000	7.51
C-M-403	311.39	Petrobras**	12.53	1000	7.21
C-M-471	648.62	Devon**/Petrobras	51.92	2131	15.02
		Repsol YPF**/Statoil	9.02	1172	
C-M-473	708.97	Devon**/Petrobras	30.52	3157	16.42
		Repsol YPF**	24.66	2202	
C-M-535	657.18	Devon/Petrobras**	9.85	1000	15.22
C-M-539	707.67	Repsol YPF**/Statoil	13.55	2133	16.39
		Devon**/Petrobras	20.23	1108	

*$P(EMV/km^2 \leq 23.16) = 90\%$ and $c = 0.3$.
**Operator.

0.3 and 1.0 (Table 4) indicates that companies are confident to make offers committing up to the maximum EMV instead of being more conservative by using the 0.3 bid fraction proposed by the literature. The simulation results for shallow-water blocks, using a bid fraction of 1.0 (Figure 5), are very close to the actual bonus offered, suggesting that the strategy applied by companies interested in presenting a proposal for this lower risk region is to offer a higher bonus value.

An exception is made for Block BM-C-7. The strategy adopted by PanCanadian in round 2 was to offer a lower bid bonus for a higher number of blocks in shallow-water areas of the Brazilian continental shelf. This is a kind of strategy proposed in the literature by Capen et al. (1971) and Lohrenz (1991), which could enhance a chance of a new player using only disclosed information made available by the government in the data packages to win a block. Just 5 yr later, 50% of the Chinook Oilfield discovered in Block BM-C-7 was sold to Hydro for $300 million. Wintershall, also a new player in Brazil at that time, chose an opposite, aggressive strategy for one specific block, BM-C-19. The proposed methodology suggests a bonus value of $5.20 million as a reference value for this block in a scenario of noncompetition. Analyzing the competition for the block and applying the stochastic simulation result, Wintershall could have avoided the winner's curse risk. Four years later, Wintershall relinquished Block BM-C-19 without any oil show despite the amount of money left on the table ($7.46 million).

The definition of an ideal bid fraction to estimate the value of the offer should consider both risks and uncertainties related to the area. The shallow-water sector of the Campos Basin has a proven and active petroleum system reducing the associated risks and uncertainties. Considering this, it is fair to select a higher bid fraction in a competitive environment to enhance the competitor's chance of winning the block. This indicates how calibrated and robust the method is if a company wants to acquire the rights to explore shallow-water areas in the Campos Basin, selecting its preferential bid fraction to apply the method with confidence.

For deep-water sectors of the Campos Basin, a simple comparison between actual and simulated results (Tables 5, 6) shows that the developed methodology is also a powerful tool to define the optimum bonus from a selected bid fraction. However, the variable minimum exploratory working program (PEM) has a fundamental importance when analyzing the winning proposal. A strategy to avoid the money left on the table and somehow the winner's curse when bidding for areas with a high potential of hydrocarbon accumulation is to offer an equivalent amount of the simulated EMV as a signature bonus plus an aggressive PEM.

The higher the number of exploratory working program units (UTs) offered as a PEM, the higher the value that block has for the bidders. Committing an aggressive PEM to the regulatory agency during the licensing rounds suggests that the bidder has a very good knowledge of the geological setting and the potential plays and considers a high probability of exploratory success. A company committing 2000 UTs has probably seen two leads to be drilled in the block (1000 UTs correspond to drilling one well).

Considering the simulation results presented in Tables 5 and 6, it is clear that the bidders obtained a good advantage from these ANP new rules. The strategy of concentrating all investments in a signature bonus instead of splitting into a PEM does not bring any benefit to the winner. Instead of concentrating all investments in one basket, the companies can allocate parts of these investments through the acquisition of new geological data to be acquired in the next 4 yr. Sharing investments between bonus and PEM has some advantages:

1. Bonus is an upfront cash payment whereas a PEM is a disbursement made in up to 4 yr.
2. Using a PEM reduces the amount of money-left-on-the-table in a winning proposal case.
3. The company that has asymmetric information can offer a higher number of UTs (PEM), being more aggressive in a strong competitive environment.
4. The acquisition of new geological data gives a competitive advantage to the companies in future licensing rounds by reducing the existing

uncertainties, which bring more accuracy for both EMV evaluation and decision-making processes.

Some disadvantages to being strongly committed to the execution of an aggressive, predefined exploratory working program are also observed:

1. If the company committed a high PEM to win the block, it may suffer from an unsuccessful exploratory result that could reduce the potential of the other existing leads to be drilled.
2. If there is no competition as supposed, a high committed PEM is unnecessary and may prevent the company from obtaining an optimal allocation of its investments.

Because of the reasons mentioned above, the signature bonus and PEM were not added together to determine the overall bid level put forward by a company solo or in joint venture. Although combining both seems to be more reasonable, it is difficult to estimate the upfront costs as well as the consistent weighting derived from a working program commitment. This combination involves different costs, strategies, and value of information procedures, which are out of the scope of this article.

The companies bidding in round 6 paid signature bonuses similar to those proposed by the stochastic simulation values generated for bid fractions of 0.3 (as seen in all blocks listed in Table 5).

The consortium Petrobras/Shell presented two proposals for both Blocks C-M-151 and C-M-103 (Table 5). This consortium probably considered Block C-M-103 as a low-risk opportunity with no value for other competitors. So, they offer a bonus lower than that simulated for the block, and a small PEM is too low to make any difference in case of a competition. This strategy reflects the consortium perception of both blocks' potential and no competition. Perhaps the value perceived by the consortium for this block is associated with some previous information and synergy with other targets in the area where the consortium has ongoing exploration activities. However, the strategy adopted by the consortium for Block C-M-151 changed significantly. Although the actual and simulated results are close ($11.4 million and $9.2 million, respectively), the competition analysis made by the consortium should have indicated a strong competition for the block, which did not happen, resulting in an unnecessary commitment of the PEM.

For Block C-M-61, assigned to Devon's consortium (Table 5), the bonus paid was lower and the PEM was slightly over that proposed by the Petrobras consortium. The difference between the first and second proposal was too small, and the local content was the variable that appointed the winning bid in this block.

As for round 7 (Table 6), the companies used the same rationale as a strategy to win Blocks C-M-401 and C-M-535. For potential areas, if the simulated EMV per area is high, then the decision makers can strategically deal with numbers and compose the offer with a lower signature bonus and committing a PEM up to the optimum bid suggested by the stochastic simulation. The offer presented for Block C-M-403, a bonus 174% over the simulated value and 1000 UTs, could be interpreted as a strategy based on a wrong assumption of a high-competition scenario.

Another example of how the PEM could be the determinant variable to appoint the winner can be seen in Block C-M-539. The strategy used by the winning consortium was the offer of a signature bonus 83.7% lower than the simulated value compared to the second proposal (123.4% over the simulation), and a PEM (2133 UTs) two times greater than the second bid (1108 UTs).

Blocks C-M-471 and 473 could be considered as golden blocks for the consortium composed by Petrobras and Devon. Such a huge amount of bonus and the high commitment of the working program offered by the consortium have no explanation, except that the blocks were the best blocks on offer according to them in terms of their potential. Even if there is an associated high risk, as per the behavior of the companies in the licensing round presenting an aggressive offer, a high award could be expected. Repsol YPF shared the same interpretation for Block C-M-473, as seen by the proposal presented, suggesting that the block was definitely the golden block of round 7 in the Campos Basin.

The method developed should always be updated to incorporate information regarding recent

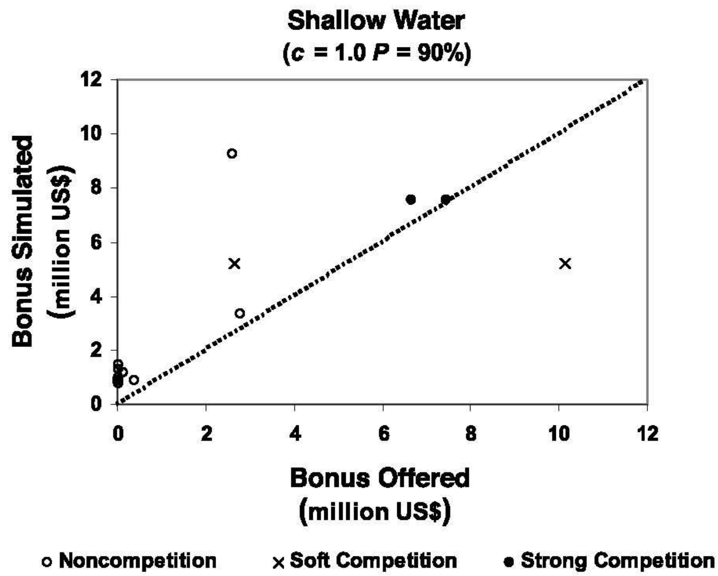


Figure 7. Actual and simulated bonus for shallow-water areas with the total number of competitors and offers.

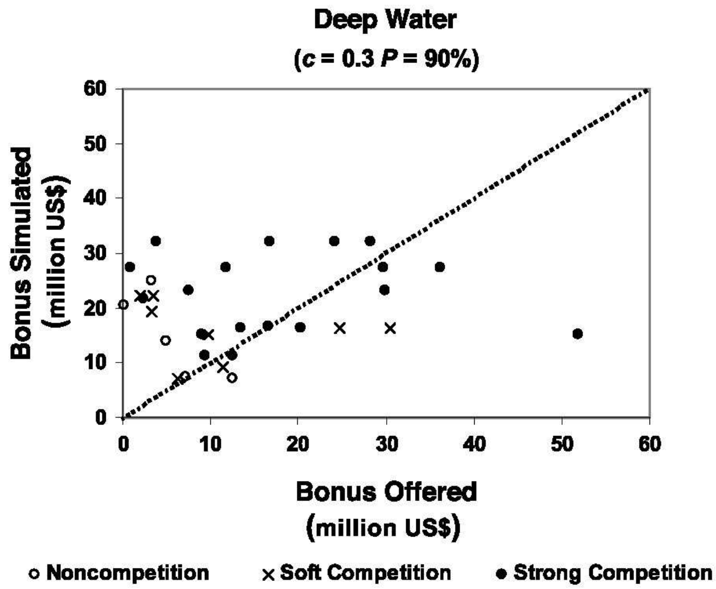
exploratory results, which are still under confidentiality contract provisions, and infrastructure availability, which is difficult to model and may justify the differences between simulated and actual bonuses offered for golden blocks.

One disadvantage of the EMV probability curve is detected in the examples mentioned above when there is a strong competitive scenario. An alternative to these constraints is to employ the simulated EMV per area result as a reference instead of an optimum bonus. The simulated EMV should be used as the ideal bonus, but the decision makers will devote keen attention to the PEM variable, which, in the last two rounds, was the key element to define the winner. As mentioned before, the winning proposal calculation changed from rounds 1–4 to 5–8. For the four previous licensing rounds, the formula to determine the winner considered only the signature bonus and the local content (CL), weighted at 85 and 15%, respectively. Since round 5, besides the signature bonus and CL, a new variable was considered, the PEM commitment. Since that time, the formula is obtained with 40% bonus, 40% PEM, and 20% CL.

Figures 7 and 8 show that both simulated and actual bonuses are directly correlated with competition levels among bidders presenting offers, attesting that the proposed methodology is adherent and can be applied to any competitive, sealed-bidding model, similar to the Brazilian tender process. According to Capen et al. (1971) and Dougherty and Nozaki (1975), whenever more than three companies compete among themselves, a high level of competition is created. Following the same rationale, only one company bidding characterizes a noncompetition environment and up to three competitors bidding is classified as a low-competition level.

For shallow-water areas (Figure 7), only two points are not close to the correlation line. These are the BM-C-8 and BM-C-19 cases mentioned above, which represent an apparent right and wrong decision strategy. For example, the use of the proposed methodology by the decision maker suggests an offer for BM-C-19 at about half of the bonus effectively paid by the bidder. For the BM-C-8 case, the decision maker used a good strategy of lower bonus when there was almost no competition to win the block, whose simulated value was up to four times over the correlation line. This graphic also shows that, for a higher number of bidders, characterizing a high level of competition (more than three competitors), bonuses offered are higher

Figure 8. Actual and simulated bonus for deep-water areas with the total number of competitors and offers.



than those made by the bidders facing no competition (only one competitor).

Figure 8 shows that, for a sample of 19 blocks in deep water, more than 42% present a high level of competition (19 offers made by 10 bidders), almost 32% present a low level of competition (9 offers, 7 bidders), and 26% present no competition (11 offers, a sole bidder). In the high-competition situations, more than 63% of the offers are close to the intersection line, indicating that simulated bonus values are consistent with the values offered by the companies. Contrarily, the number of blocks with a low level of competition and with only one bidder presents a more erratic behavior (around 45% of the offers are well correlated with the simulated values).

As stated by the specific literature for the OCS of the U.S. Gulf of Mexico (Hoffman et al., 1991; Saidi and Marsden, 1992; Tavares, 2000), effects of joint bidding are associated with the presence of more bidders (high competition) and lead to higher bids, implying more competitive auctions. In Brazilian licensing rounds, the same effect is observed in Figures 7 and 8. The high competition identified in deep-water areas proves that the higher the number of bidders, the higher the bids offered (Figure 8). In a noncompetition scenario, the bidders commonly offer a lower bonus to maximize the potential return on their investments, as can be seen in Figure 7. The simulated bonus values are slightly over the actual bonus (Figure 8), suggesting that a lower bid fraction should be considered to better reflect the bidder's strategy of capital return in noncompetition situations. The offers presented in a low-competition environment are quite difficult to predict, mainly because of the companies' behaviors (corporate characteristics, such as risk aversion). Under low-competition circumstances, a straight enhancement of the bonus offered related to the simulated bonus may be driven by a wrong judgment by the bidders in relation to the expected level of competition. This behavior can be observed in both Figures 7 and 8.

Assuming that competitors have good knowledge of exploration and production activities and are frequent bidders, the strategy taken from each company's decision maker to bid jointly is probably based on (1) pooling of resources, (2) gain of information, (3) anticompetitive purposes, and (4) better risk diversification, given limited resources to invest. The last option does not lead to a less competitive behavior in auctions. Besides pooling capital and exchanging information, companies sharing either marketing or supply synergy, strategically aligned or even envisioning other ventures, commonly adopt joint bidding.

CONCLUSIONS

The methodology developed in this study is a robust tool for the estimation of EMV per acreage by companies that make offers to acquire rights for petroleum exploration through any competitive, sealed-bidding system worldwide.

In the present scenario of the high volatility of oil prices and the uncertainty of market determinants, this type of approach may be used as part of the exploration decision process to achieve an optimal bonus bidding. The bidding behavior of companies in hydrocarbon leases is also mainly determined by the anticipation of future discoveries or the geological potential of the area on offer. The methodology presented may give an insight of the exploratory expectation of the oil companies as verified for the Brazilian case, but some improvements are still necessary to forecast a "golden block's" value vis-à-vis with the petroleum assessment.

The comparison between lease and model results suggests that, in sealed, competitive-bid auctions, companies commonly employ formal decision-theoretical models to decide on their bids to invest their money. These companies' behaviors are captured by the methodology as discussing bid strategy regarding money allocation, joint bidding, and the number of areas to be acquired.

Stochastic simulation results indicate that the method is consistent and may be used to support decisions made by the companies, even considering their risk-aversion degree. The decision maker may gain advantages when selecting the bidding strategy to be adopted once the amount of competition for the tender is carefully analyzed. The higher the number of bidders, the higher the bid values offered per area, according to the symmetry observed with the stochastically simulated values and actual bids.

The effects of how asymmetries in the distribution of information among the bidders affect their behavior in a strategic competition setting were not directly discussed in this article. Equilibrium bidding in such cases means that less-informed companies generally bid less frequently than the informed buyer, and, if they bid, they submit high instead of low bids. However, the simulation results indicated that bidders are confident to use a higher bid fraction (up to 1.0) to make their offers for high-potential areas with the considerable amount of public information available.

The proposed methodology, in addition to its simplicity, robustness, and satisfactory results when comparing simulations with actual values, indicates that this approach can be applied for other regions or any other countries that use a competitive, sealed-bidding system for leasing petroleum exploration areas.

APPENDIX: STOCHASTIC MODEL: STEP BY STEP

This is a step by step guideline on how to calculate the EMV for each sector following the proposed methodology. In this guide, blocks leased between rounds 1 and 4 were considered (PEM was not included in the lease process for these rounds). For the three following rounds, the inclusion of PEM (equations 6, 8) is necessary and the basic procedures are practically identical.

Available Information

The available information is shown in Tables 7 and 8.

Using Equation 5 to Calculate IM

$$\mathrm{IM}_h = \frac{\text{Total area}_h}{\text{Total area}} \times \left(\frac{\text{Total } S2_h}{\text{Total } S2} \times 0.2 + \frac{\text{Total } S3_h}{\text{Total } S3} \times 0.3 + \frac{\text{Total } P_h}{\text{Total } P} \times 0.5\right)$$

where h is the sector index.

$$\mathrm{IM}_{\mathrm{DW}} = \frac{16{,}168}{21{,}416} \times \left(\frac{6694}{16{,}409} \times 0.2 + \frac{14{,}804}{21{,}840} \times 0.3 + \frac{13}{39} \times 0.5\right) = 0.3409$$

$$\mathrm{IM}_{\mathrm{SW}} = \frac{5248}{21{,}416} \times \left(\frac{9715}{16{,}409} \times 0.2 + \frac{7036}{21{,}840} \times 0.3 + \frac{26}{39} \times 0.5\right) = 0.1344$$

Linear Transformation to Obtain Bid-Fraction Average (μ)

The bid-fraction average value ($\bar{c}$) has to be limited by an interval minimum and maximum to avoid any unexpected value. In this article, values are arbitrarily limited to the interval 0.05–0.55 for deep-water blocks and to the interval 0.05–0.85 for shallow-water blocks. The mean parameter of the

Table 7. Deep- and Shallow-Water Basic Information

Sector (*h* or *k*)	Block (*i* or *z*)	Round	Bonus (million dollars)	Rank	Company	Average Bonus (million dollars)
Deep water	BM-C-3	1	3.38	1	Petrobras	3.38
	BM-C-4	1	28.18	1	Agip	18.29
			24.15	2	Texaco	
			16.88	3	ESSO	
			3.96	4	British Borneo	
	BM-C-5	1	3.35	1	Texaco	3.35
	BM-C-10	2	36.20	1	Shell	19.70
			29.70	2	Chevron	
			11.87	3	Petrobras	
			1.01	4	PanCanadian	
	BM-C-14	3	2.33	1	Total Fina	2.33
	BM-C-15	3	29.96	1	Ocean Energy	18.78
			7.61	2	Shell	
	BM-C-16	3	0.17	1	Petrobras	0.17
	BM-C-24	4	4.96	1	BHP	4.96
	BM-C-25	4	3.51	1	Shell	2.78
			2.05	2	EnCana	
Shallow water	BM-C-6	1	2.78	1	Petrobras	2.78
	BM-C-7	2	2.61	1	PanCanadian	2.61
	BM-C-8	2	6.68	1	Santa Fé	7.06
			7.44	2	Maersk	
	BM-C-19	3	10.12	1	Wintershall	6.39
			2.66	2	PanCanadian	

lognormal distribution of the bid fraction used in Monte Carlo simulation is obtained by the following equation:

$$\mu_h = \frac{\mathrm{IM}_h}{\max\{\mathrm{IM}\}} \times \lim\{\max\} + \lim\{\min\}$$
$$\mu_{\mathrm{DW}} = \frac{0.3409}{0.3409} \times 0.55 + 0.05 = 0.60$$
$$\mu_{\mathrm{SW}} = \frac{0.1344}{0.3409} \times 0.85 + 0.05 = 0.39$$

Using Equation 7 to Calculate IV, which Depends on Both Sector and Block

$$\mathrm{IV}_{hz} = \frac{1}{\frac{\mathrm{Area}_i}{\mathrm{Total\ area}_h} \times \left(\frac{S2_z}{\mathrm{Total}\ S2_h} \times 0.2 + \frac{S3_z}{\mathrm{Total}\ S3} \times 0.3 + \frac{P_z}{\mathrm{Total}\ P_h} \times 0.5\right)}$$

where h is the sector index and z is the block index.

Examples:

$$\mathrm{IV}_{\mathrm{DW\ BM-C-3}} = \frac{1}{\frac{1660}{16,168} \times \left(\frac{606}{6694} \times 0.2 + \frac{0}{14,804} \times 0.3 + \frac{0}{13} \times 0.5\right)} = 537.94$$
$$\mathrm{IV}_{\mathrm{SW\ BM-C-8}} = \frac{1}{\frac{1565}{5248} \times \left(\frac{3032}{9715} \times 0.2 + \frac{6664}{7036} \times 0.3 + \frac{18}{26} \times 0.5\right)} = 4.84$$

Linear Transformation to Obtain Bid-Fraction Variability (σ)

The bid-fraction standard deviation value has to be limited by an interval minimum and maximum to avoid any unexpected value. In this article, values are arbitrarily limited to the interval 0.01–0.20 for all blocks. The standard deviation parameter of the lognormal distribution of the bid fraction used in Monte Carlo simulation is obtained by the following equation:

$$\sigma_{hi} = \frac{\mathrm{LN}(\mathrm{IV}_i)}{\mathrm{LN}(\max\{\mathrm{IV}_h\})} \times \lim\{\max\}$$

Examples:

$$\sigma_{\mathrm{DW\ BM\ C\ 3}} = \frac{\mathrm{LN}(537.97)}{\mathrm{LN}(1224.31)} \times 0.20 = 0.1769$$
$$\sigma_{\mathrm{DW\ BM\ C\ 8}} = \frac{\mathrm{LN}(4.84)}{\mathrm{LN}(92.25)} \times 0.20 = 0.0697$$

Following the methodology indicated in the article, Table 9 summarizes the two lognormal parameters for the bid fraction for all blocks.

The bid fraction can be fitted as a lognormal probability distribution with mean μ and standard deviation σ (Table 9).

Table 8. IM and IV Calculations*

Sector (*h*)	Block (*i*)	Area (km²)	*S2* (km²)	*S3* (km³)	*P* (Drilling Wells)	IM	IV
Deep water	BM-C-3	1660	606			0.3409	537.94
	BM-C-4	2777	1178				165.42
	BM-C-5	2154	423				593.92
	BM-C-10	2365	891				256.80
	BM-C-14	1882	450				638.97
	BM-C-15	1999	479				565.15
	BM-C-16	1768	250				1224.31
	BM-C-24	603	1527	2114	7		74.96
	BM-C-25	960	890	12,690	6		32.73
	Total	16,168	6694	14,804	13		
Shallow water	BM-C-6	686	2160		2	0.1344	92.25
	BM-C-7	1920	3253	372	3		19.45
	BM-C-8	1565	3032	6664	18		4.84
	BM-C-19	1077	1270		3		58.12
	Total	5248	9715	7036	26		
Total		21,416	16,409	21,840	39		
Weight		1	0.2	0.3	0.5		

*See equations 5 and 7.

Table 9. Parameters of Bid-Fraction Lognormal Distribution

Sector	Block	*M*	μ
Deep water	BM-C-3	0.60	0.1769
	BM-C-4		0.1437
	BM-C-5		0.1797
	BM-C-10		0.1561
	BM-C-14		0.1817
	BM-C-15		0.1783
	BM-C-16		0.2000
	BM-C-24		0.1214
	BM-C-25		0.0981
Shallow water	BM-C-6	0.39	0.2000
	BM-C-7		0.1312
	BM-C-8		0.0697
	BM-C-19		0.1796

Expected Monetary Value per Area

$$\left(\frac{\text{EMV}}{km^2}\right)_i = \frac{\text{Average bonus}_i}{\text{Bid–fraction lognormal distribution}_i} \times \frac{1}{\text{Area}_i}$$

where the average bonus and area are obtained from Table 7 and the bid-fraction lognormal distribution is obtained from a Monte Carlo random process using the parameters presented on Table 9 for each block.

Monte Carlo simulation gives one EMV/km^2 random value for each interaction per block. Then, the average value of these results is calculated for each interaction. In the end of the process, the output is a collection of mean values, which is fitted as a probability distribution. The statistics derived from these simulations are used to estimate the block values.

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5. BIDDING SCHEMES AND THEIR IMPACT ON RISK ASSESSMENTS BY OIL COMPANIES

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Bidding Schemes and Their Impact on Risk Assessments by Oil Companies

M.R. Rodriguez, PETROBRAS and S.B. Suslick, SPE, State University of Campinas

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Abstract

Petroleum auctions in US-GOM and Brazil are a common value first-price sealed bid, with fundamental differences on bidding systems defined by the regulators regarding the winner proposal. The US-GOM bidding model for offshore exploration areas considers the higher bonuses values as the winner offer. In Brazil, two main variables define the winner: the signature bonus and the minimum exploration program (PEM). The PEM aggregates value to the government, as it is a firm commitment to acquire geological data on the first exploration years. The amount of PEM committed reflects the importance of the exploration area for the bidders. This information not necessarily could be addressed by the simple high bids' analyses as in the US-GOM system. The Brazilian bidding model allows the bidders to a "full risk assessment" on their competitor's bidding behavior. This paper compares the risk perceptions of oil companies using the US-GOM and Brazilian bidding results for years 2005 and 2006, assuming the same oil price scenario and areas of similar geological settings. Another contribution of this paper is to present a competition model for evaluate different risk perceptions by using measures such as cash bonus (upfront money) and PEM (a long-term disbursement) generated by diverse bidding schemes. Preliminary results show that Brazilian high bids are in the same range of US-GOM bonuses (20,000.00 to 30,000.00 US$/km^2). Nevertheless, considering bonus and PEM as the winner offer, Brazilian high bids double the American ones. The competition model used for evaluate the firm performance in both bidding systems indicates that the utilization of bonus and PEM allow companies' decision makers to perform a better portfolio management, but demands the inclusion of a solid risk perception to select the best areas for bidding.

Introduction

In order to exploit natural resources efficiently, regulatory agencies can choose, among several approaches, a model to assign exploration rights for the companies that guarantee a performance in accordance with the best practices of the industry. Focusing on the petroleum industry there are two main processes to allocate petroleum lease: the informal ones, such as direct negotiation, and the administrative process, such as auctions.

This paper focus on auction, a licensing process that requires rules clearly established before the start-up process, giving transparency benefits for both bidders and auctioneers, mitigating potential corruption and encouraging competition through a fair process (Cramton, 2005). The bidding process is a mechanism that has been widely used by different countries to optimally distribute their oil exploratory acreages. The auctioneer is concerned with the long run health and growth of his business, not with maximizing his expected revenue from a single auction. These are accomplished by balancing sellers (government) and buyers (companies) targets, i.e., it should have high enough prices to keep sellers consigning assets for sale and it should have low prices to keep bidders voluntarily attending in sufficient numbers (Rothkopf and Harstad, 1994).

Another characteristic of the auction model is that it discloses information: how valuable the bidders believe the lease is to be, and which bidder values it most. This information is considered a competitive advantage, since the bidders do not know a priori the actual value of the oil blocks. Knowing the competitors and the likelihood of their bids carries equal importance when compared to a good estimation of the actual value of the block offered, avoiding participants to bid less of their estimated values, a normal practice considering uncertainties in the valuation and to cover their potential losses in case of exploration failure (Iledare et al., 2004).

These features pushed both US and Brazilian Government to adopt auctions models for licensing offshore exploration areas. The Brazilian leasing mechanism, elected by the regulatory national agency (ANP), is a common value auction based on a competitive first-price sealed bid method. A similar auction model was elected by the Minerals Management Service (MMS) for leasing Outer Continental Shelf (OCS) areas of the US - Gulf of Mexico (Hoffman et al., 1991).

These bidding schemes favor government's expectation to maximize the chances of a fair market value for the right to drill for and to produce oil and gas on public lands. In an oil and gas lease setting, auctions can serve as an allocation mechanism and a reference for resource rent taxation. An auction provides for the government better information about a company's perception of the value of a resource tract and with the potential of considerable higher futures revenues from its licensing.

The goal of this paper is to analyze the impact of variables other than signature bonus offered by the oil companies to build a winner offer, considering bidding model characteristics, strategies, and results. The Brazilian model is compared with the U.S. OCS model and the advantages of using the exploratory working program (PEM) as a bidding variable is discussed.

This paper is organized in three sections. The first section address the bidding process by giving a general description and and comparisons between Brazilian and US-GOM bidding schemes. The second part focus on constraints and differences that impact the risk assessment of oil companies participating in a licensing round in both types of biddings. This section addresses the impact of exploratory working program (PEM) in the lease valuation and winner bid. The final section presents general remarks and conclusions.

Bidding Process

In 1953, Eisenhower, the President of the USA, signed the Outer Continental Shelf Lands Act authorizing the Interior Department to define the rules and schedules to buy and sell petroleum rights. Since 1954, the Minerals Managememt Service (MMS) have been regulating the bids for this area. The assignement of exploration rights by auction at OCS for over 40 years granted MMS a long experience in elaborating, conducting, and modeling the leasing process leading the oil companies (bidders) to trust in the system and to invest in the country (Saidi & Marsden, 1992). The bidding schemes for the OCS areas consider a first-price sealed bid model, with the acution occurring twice a year, and the winner is defined as the company presenting the higher bonus offer for a specific tract (MMS, 2007).

Until 1997, the upstream activities in Brazil had been conducted exclusively by PETROBRAS, when the Petroleum Law 9.478/97 was approved ending a 42-year monopoly of oil and gas exploration and production in the country. Since 1998, the Brazilian petroleum regulatory agency (ANP) has been yearly promoting licensing rounds for leasing acreage for petroleum exploration rights under a concession regime. The adopted model is a competitive sealed bid auctions, in which the winner is the oil company presenting not only a higher cash bonus, but also committing an expressive amount of future investment by using an exploration program and a local content percentage in services and operations to be applied in exploration and production development phases.

One of ANP's main targets is to define the rules allowing the set up and the maintenance of a competitive market that bring advantages for the Brazilian economic development in the petroleum sector. Based upon the government taxation system created by the Petroleum Law and using the international petroleum price as a reference, ANP elected the auctioning process and designed a model for Brazilian acreage licensing rounds with the purpose for enhance the domestic oil and gas reserves and attract national and international oil companies (ANP, 2007). Since 1999, the regulatory agency has been promoting a number of nine licensing rounds.

The bidding processes for US OCS GOM, as well as for Brazil, are based on a competitive first-price sealed bid model, but there are fundamental characteristics that differ one from another. Generally, the lease sales in both countries consider a sequential process that follows the structure presented in Fig. 1, i.e., companies interested in bidding shall be financial, legal and technically qualified, and pay a participation fee to take part in the sale.

Instead of describing the similarities and the differences of each bidding system, Tables 1 and 2 show relevant aspects of the US OCS and the Brazilian bidding schemes, respectively, enabling a direct comparison and a whole comprehension of both systems.

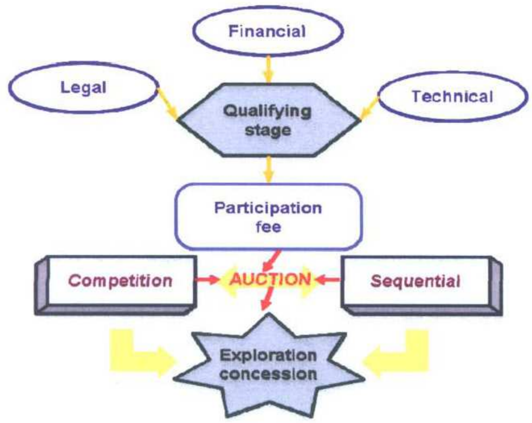

Figure 1 – Schematic bidding process main steps. The first step is the technical, financial, and legal qualification stage, followed by the payment of a participation fee to bid in the sequential and competitive auction to become a concessionaire of an exploration area.

Table 1 – Summary of US Outer Continental Shelf bidding model main characteristics

Date of the First Lease	1954 (promoted twice a year, in general) – Concession regime
Model	First-price, competitive, sealed, simultaneous, area nomination by compamaies
Winner Offer Definition	The higher bonus. A royalty percentage offer was also used before. MMS may reject the higher offer according to its discitionary criteria.
Working Program	Seismic acquisition or a well drilled up to 5 years for áreas located 0 < water depth < 400m; up to 8 years for 400 < water depth < 800m; up to 10 yearsa for water depth > 800m
Area and Block Size Definition	Cells with defined size (shallow water - 5000 acres/unit and deep water - 5760 acres/unit).
Minimum Price	According to the geological potential of the tract. MMS has the right to reject na offer if it is too high over the fair market value.
Fiscal System	Rental area increases over the years, variable royalties of 16.7% for water depths lower than 400m and 12.5% for water depths greather than 400m. There is a possibility of royalty relief for producing volumes for deeper waters. Corporate tax 35%
Exploration and Production Regime	Concession rights with partial relinquishment areas (50% and 25%) following the progress of exploration activities.
Production Ownership	Concessionaire possesses the production ownership that is mandatory to sell its production for the domestic market.
Production Licensisng	Automatically renewed by MMS

Table 2 – Summary of Brazilian bidding model main characteristics

Date of the First Lease	1999 (annually promoted) – Concession regime
Model	First-price, competitive, sealed, simultaneous (sequential up to the 4th licensing bid), sector nomination.
Winner Offer Definition	40% bonus + 40% PEM + 20% Local Content.
Exploratory Working Program (PEM)	Up to the 4th lease - seismic (3 yeras) + 1 well (2 years) + 2 wells (2 years).
	After the 5th lease the companies define the amount o f PEM to be committed.
Area and Block Size Definition	Up to the 4th lease defined by ANP.
	After the 5th lease área size is defined according to a cell model and have a known dimension varying from onshore (mature and new frontier basins) and offshore shallow, deep and ultra deep water blocks.
Minimum Price	Defined by ANP according with geological potential of the region included in the lease.
Fiscal System	Rental area increases over the years, royalty (5%-10%) over gross production, special participation fee for high production profile volumes with fees ranging from 10% to 40% varying over deep water regions.
Exploration and Production Regime	Concession rights with partial relinqushment of 50% and 25% according to the exploration results.
Production Ownership	The production ownership belongs to the concessionaire, which is allowed to a free commercialization, exception made in force majeure situations.
Production License	After 27 years of life cycle production concession, ANP may renew or not the production licensing.

Model and Data Used

One of the purposes of this study is to compare the value per area unit offered for Brazilian and US OCS tracts. The model proposed allows the comparison between OCS bonus offers with Brazilian bonus plus PEM offers. The local content variable was not taken into account, because its difficulty to be measured and converted into exploratory expenses to be added to bonus and PEM variables. In fact, the methodology applied by the regulatory agencies to calculate the winner offer change considerably, and required a considered efforts and adjustments to proceed with this comparison, which are not the focus of this paper.

In Brazilian leases, besides the cash bonus, bidders also offers an amount of working units corresponding to the exploratory working program (PEM) that they envisage to perform in the area. The PEM working units are equivalent to the amount of money bidders will invest for each area. While bonus is an upfront payment that doesn't bring any priori information to the bidders, PEM can be considered a long-term flow payment to be spent in up to 4 years to collect geological data of each area. So, it is a fair approach to analyze the Brazilian winner offers as a total amount of bonus plus PEM committed to acquire the area.

Despite the contrast in the investments, area size is also an issue between the two bidding schemes. Although US OCS tracts size is based on a cell model, so as in Brazil, there are offers made to areas with different sizes. A normalization procedure was applied to avoid the effect of comparing big offers for big areas with big offers for small areas. The OCS tracts were converted from acres to square kilometers, and all tracts studied were normalized by their size to obatian the variable bonus per area unit (US$/km^2).

All data used was selected acoording to their similarities in terms of leasing offer dynamics. From MMS data bank sales 190 (2004) and 194 (2005) US OCS Central Area were selected and compared to lease sales 6th (2004) and 7th (2005) promoted in Brazil, data recovered from ANP public data bank. The areas were aggregated into shallow and deep water groups for these countries.

- US OCS Sales Group – contain the winner offers for areas located at Atwater Valley, Walker Ridge and Mississipi Canyon. During years 2004 and 2005, the industry focused its interest for deep water tracts. Only Mississipi Canyon areas received offers for shallow water tracts.
- Brazilian Sales Grooup – comprises the winner offers for shallow and deep waters areas located at Campos Basin in 2004. Notice that during year 2005, there were no offers for Campos Basin shallow water tracts, just for deep ones.

Results

In order to guarantee a full comprehension of the proposed comparison analysis, it is important to highlight some crucial issues:

- The number of areas on offer per bid in Brazil is much lower than those put on offer by MMS (Figure 2);
- Brazil is still in a learning process on how to licensing exploration areas, 10 years experience against USA which has over 40 years of tendering petroleum rights;
- The existence of a well established competitive environment, a commercialization system and an active petroleum market in US OCS, positively impacts the economic value of the areas on offer. In Brazil, the existence of an undeveloped production flowing system and an incipient oil market reduces the expected value of the areas leased;
- The changes on the oil price scenario, which have been increasing considerably from year 2003 on, allow companies to produce more oil from some economic marginal projects, consequently increasing their revenue for investment on acquisition of new exploration areas envisaging the oppportuity to discover giant fields, enhancing their reserve over production (R/P) ratio;
- Brazilian data from 8th and 9th bids, years 2006 and 2007 respectivelly, were not included in this study, because the concession contracts were not yet signed between the regulatory agency and the winner companies. Then, the areas still belong to the government and any disbursement was made by the winners, and
- The US OCS high bonus bidding system and the introduction of a new variable PEM added to the bonus in the Brazilian bidding scheme to define the winner offer proposal.

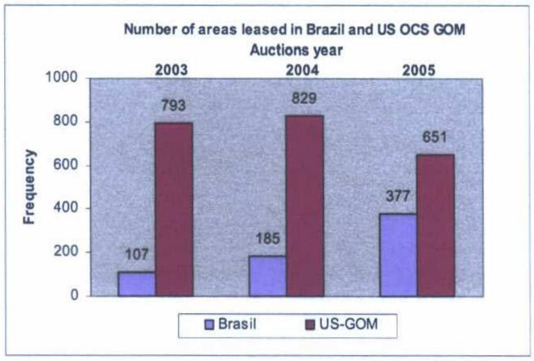

Figure 2 – Total number of areas on sale per auction from year 2003 to 2005 in both Brazil and US GOM Outer Continental Shelf.

Central Area of US OCS data, such as number of areas receiving offer, total bonus and acreage leased, are presented in Table 3 for deep and shallow water areas, so as the result of bonus per area unit. Table 4 presents for Campos Basin Brazilian bids the same data besides the variable bonus + PEM per area unit obtained from the above described methodology.

Lease sale offers made in year 2004 for US OCS and for Brazilian deep water areas are in the same range of value per area unit, varying from US$20.000/km^2 to US$30.000 km^2 (Tables 3 and 4). It means that companies are paying similar values for exploration rights in these countries. Exception is made for Missssissipi Canyon areas, which have attracted in year 2005 the attention of the oil companies enhancing the bonus average for US$80.000/km^2. The competition for deep water Campos Basin areas was also strong and the average amount of money committed was US$160.000/km^2, i.e., as bonus plus PEM. The increasing offer per area unit can be understood as an effect of the oil price growing. In year 2004 the oil price reached US$40.86/bbl and one year after, in 2005, it jumped for US$56.27/bbl, which may be heated the demand for oil and gas potential areas located in countries recently opened to foreigner petroleum exploration capital. The figures shown in tables 3 and 4 support this idea. Comparing the bonus per area unit made by the companies for deep water areas among themselves, it can be observed that they are almost the same. On the other hand, notice that Brazilian licensing values for year 2005 doubled when compared to US OCS amount of money offered for the most potential areas.

Table 3 – Statistics of deep and shallow water offers for Atwater Valley, Walker Ridge and Mississipi Canyon - Central Area of the Outer Continental Shelf, US-GOM, years 2004 and 2005.

Central OCS US-GOM Lease Sale		Mississipi Canyon		Atwater Valley	Walker Ridge
		Shallow Water < 400m	Deep Water > 400m		
190 2004	Areas with offer	8	42	20	42
	Area (acre) with offer	90,091.28	385,920.00	167,040.00	374,400.00
	Bonus (US$)	8,501,628.00	26,122,280.00	9,480,892.00	29,409,797.00
	Bonus (US$/km^2)	48,789.84	26,682.17	20,331.61	30,040.15
194 2005	Areas with offer	5	58	5	39
	Area (acre) with offer	14,972.73	881,280.00	51,840.00	270,724.5
	Bonus (US$)	1,571,500.00	108,376,803.00	2,701,000.00	18,667,783.00
	Bonus (US$/km^2)	17,580.27	80,161.84	23,174.69	20,890.34

Table 4 – Statistics of deep and shallow water offers for Campos Basin areas, Brasil, years 2004 and 2005.

Brazilian Lease Sale		Campos Basin	
		Shallow Water < 400m	Deep Water > 400m
6th 2004	Areas with offer	1	4
	Area (km2) with offer	178.58	1,914.52
	Bonus (US$)	396,418.67	46,879,525.67
	Bonus (US$/ km^2)	2,219.78	24,449.78
	Bonus + PEM (US$/km^2)	4,638.81	55,779.10
7th 2005	Areas with offer	---	6
	Area (km^2) with offer	---	3,358.11
	Bonus (US$)	---	132,205,513.78
	Bonus (US$/ km^2)	----	38,164.25
	Bonus + PEM (US$/km^2)	----	159,392.77

Although the average bonus paid by companies in year 2005 for US OCS shallow water areas were similar to the average bonus offered for deep water areas, there was a significant decrease in the bidding bonus average for the shallow water areas offered in year 2004. A more complete analyzes of the geological potential of the areas on offer in both lease sales should be made to reach a conclusion regarding this diferrence. It could be attributed to the lower hydrocarbon potential of the areas or to a higher interest of the companies in specific deep water areas, as it is observed in the lease case of Mississipi Canyon.

Despite Campos Basin shallow water areas did not attract companies' attention in the 6th and 7th licensing bids in Brazil they were strongly disputed by biders from the 1st to the 5th lease sales, reaching an average bonus bidding of US$8,800/bbl. The data shown in Table 4 were not statistically representative to enable a discussion and a further comparison with the US OCS data.

It seems that for US OCS shallow water areas the strategy adopted by the companies to win the bids is to offer average prices equivalent to the prices paid for deep water areas, restriction made for the high exploration propsective areas. The high values offered to the shallow water sector of US GOM Central Area can be attributed to the low risk of finding gas and oil fileds, the existence of a wide flow system infra-structure, well defined tariffs, and a closer market consummer. The petroleum exploration and production activities generate a considerable amount of public information contibuting to a better evaluation of the areas directly affecting the offer value presented by the companies.

The flexibility created by the working program PEM enforced by ANP allows companies to collect a higher amount of geological information, increasing the information level and its availability for the companies in future bids. Considering that the value to be offered is free and not contingent to any requirement, the company that gives higher PEM's value directly indicates to the market its estimation of the area value.

The 7th licensing round in Brazil was characterized by a change in companies' bidding strategy verified for the 6th auction. Campos Basin deep water areas received an average bonus per area unit (US$/km^2) around US$38,000/km^2. Adding the amount of money equivalent to the PEM committed this average value is almost four times higher (~US$159,000). Instead of offered a high cash amount as signature bonus, which may be close to the real area value for a particular company, the strategy adopted was to concentrate the most part of investments in a lonmg-term disbursement (up to 4 years) that may be achieved through a future geological and geophysical (G&G) data acquisition. It means that companies were offering more money as a firm commitment to perform a minimum working program PEM, than as it was for cash bonus. This strategy is valid whenever the companies' area evaluation presents good opportunities (leads or prospects) that will be fully investigated by seismic survey or drilling wells. Balancing the investments between bonus and PEM to compose the final offer enhances companies' chance to be the winner, and further acquire G&G data - a future competitive advantage in next licensing rounds. The amount of PEM committed reflects the importance of the exploration area for the bidders. This information not necessarily could be addressed by the simple higher bids' analyses as in the US OCS GOM system. The Brazilian bidding model allows the bidders to a "full risk assessment" on their competitor's bidding behavior (Furtado et al., 2008).

Conclusions

The results obtained in this study reveal that offers made by companies to acquire areas in the US OCS Gulf of Mexico can be compared to offers made in Brazilian auctions, if the working program value PEM is added to the signature bonus. The ability to deal with bonus and PEM to compose the final offer reflects the real interest of a company in a potential area considering the bidding scheme adopted by the regulatory agency in Brazil. Thus, the bonus plus PEM summation indicates a valid methodology when compared to the simple high bid's bonus system applied in the OCS lease sales.

In years 2004 and 2005, when the oil price start raising from US$40/bbl to US$56/bbl, the oil industry seems to invest in deep water areas, which are risky opportunities but with a high hydrocarbon potential. In year 2005 companies paid around US$80,000/km^2 for Mississipi Canyon (US OCS) deep water areas, and US$160,000/km^2 for deep water blocks in Campos Basin (Brazil). Shallow water areas located in Campos Basin have not been attracting the oil companies interest, as it can be observed by the lower values offered, around US$4,600/km^2, even considering the amount offered as PEM. On the other hand, companies bidding in the US GOM are still focusing on shallow water areas located in the OCS, paying an average of US$32,500/km^2 per area unit.

The significant difference in the lease valuation areas between these two regions are support by the above-ground factors such as political stability, fiscal incentives, risk-country factors, domestic market, logistics and infra-structure for production flow, etc. Despite these factors are more attractive for the US OCS environment, the valuation obtained in this paper indicated a trend that favors Campos Basin which confirmed the attractiveness and a strong petroleum potential for deep waters as well as the recognition by different players of the Brazilian bidding process.

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6. EXPERT SYSTEM APPLIED TO DECISION MAKING PROCESS FOR COMPETITIVE PETROLEUM EXPLORATION SALES

Expert System applied to decision making process for competitive petroleum exploration sales

Monica Rebelo Rodriguez, Osvair Vidal Trevisan, Boris Asrilhant

Abstract

This article proposes a method to estimate the competition level in future Brazilian petroleum leases, built upon Campos Basin history data. The method can be applied to all competitive licensing structures, independently of the type of exploration agreement used (concession or production sharing contracts). The level of competition in both agreement models is broadly the same, but there are some intrinsic differences, widely reviewed by the literature, that could lead to changes in the licensing results. The estimation of the competition level is directly related to the definition of the winning offer. In Brazilian licensing procedures the winner bid results from a combination of three attributes: (1) signature bonus value; (2) minimum exploration program; and (3) local content level. This combination makes the estimation of competition level a key issue for decision-makers to strategically define the most competitive offer that could enhance the possibility to win the area. The proposed methodology is based on the capture of knowledge expert's to build a knowledge automation expert system, using EXSYS CORVID® software, that could help decision-makers while estimating competition for a petroleum acreage licensing sale on

Campos Basin - the most successful exploration and production (E&P) pool for the last 30 years in Brazil. The method collected the judgment of 36 professionals occupying different hierarchy levels, working for 20 companies performing E&P activities offshore Brazil, such as super-majors, majors and independent petroleum companies. The results brought to light by this study allow companies to use a reliable method to objectively estimate competition level for Brazilian petroleum lease sale, helping decision-makers to develop bidding strategies aligned with companies' exploration portfolio long term strategies.

1. Introduction

This article proposes a method to estimate competition level for future Brazilian petroleum leases, built upon Campos Basin history data.

The method can be applied to all competitive licensing structures, independently of the type of exploration agreement used (concession or production sharing contracts), but varying the premises adopted. The level of competition in both agreement models is broadly the same, but there are some intrinsic differences, widely reviewed by the literature, that could lead to changes in the licensing results.

The estimation of the competition level is directly related to the definition of the winning offer. According to Capen et al. (1971) and Lohrenz (1987), the optimal bid estimation is based on the highest signature bonus value. However, for the Brazilian licensing procedures, the winner bid results from a combination of three attributes: (1) signature bonus value; (2) minimum exploration program; and (3) local content level. This combination makes the estimation of competition level a key issue for decision-makers to strategically define the most competitive offer that could enhance the possibility to win the area.

Achieving more with less requires formulating and deploying sound strategies. Today's Exploration and Production (E&P) Licensing competition demands excellence both in strategy and in its execution by senior management to win the bid. One of the most important process for a petroleum company when planning to participate in an E&P Licensing acreage is estimate the level of competition it should face. As part of a whole decision making process that has long-term implications and short time to decide, top managers should consider not only the well known mathematical techniques, but human perceptions and judgments involved to reach high risk decisions. The focus should be on developing a comprehensive methodology for solving strategic level decision making problem which are at present tackled in an ad-hoc manner.

The proposed methodology consist in capturing competitor’s knowledge to build a mathematical model based on expert system, which should help decision-maker estimate the level of competition in a licensing sale. The method for capturing expert’s knowledge uses both interviews and questionnaires, was developed specifically for this purpose. These tools took into consideration aspects raised from the literature that are identified as fundamental on the estimation of competition level. Having captured these expertise and using a computer program - EXSYS CORVID®, based on an expert system, which is a branch of artificial intelligence, it was possible to develop a knowledge automated expert system using the questionnaires´ answers to build the rule-based logic and blocks logic in order to bring the best recommendation, instead of either a guess or a trivial solution.

The questionnaire, used to investigate the main competition variables, adopted a hypothetical scenario considering a Brazilian licensing sale for petroleum acreage located at Campos Basin, a mature offshore sedimentary basin because it has been: (1) offered in eight out of ten licensing sales held in the country, providing a significant amount of unbiased data on bid results; (2) the offshore basin with higher number of competitors bidding for areas; and (3) a successful exploration pool for the last 30 years, presently accounting for around 85% of the total Brazilian petroleum production, which positively impacts the evaluation companies have about the areas offered in each lease sale.

The method applied to estimate competition level for Campos Basin areas in Brazilian leases takes into account: (1) the judgment of 36 staff individuals of super-majors, majors and independent petroleum companies, positioned at different hierarchy levels; (2) the petroleum potential areas in each lease round; (3) E&P corporate strategies, structure and size of the licensing qualified companies; and (4) the overall scenario of worldwide E&P activities.

The results brought to light by this study allow companies to use a reliable method to objectively estimate competition level for Brazilian petroleum lease sale, helping decision-makers to develop bidding strategies aligned with companies' exploration portfolio long term strategies.

This article is organized in four sections. The first section explains the role of competition in a licensing sale, followed by another chapter dedicated to present the methodology developed to help decision making estimates the expected level of competition. The third section points out the results obtained with the expert's knowledge captured, which is the base of all research on competition. A set of conclusions wraps up the research project performed and the results achieved.

2. The Role of Competition in Petroleum Licensing Environment

Auctioning petroleum rights is a game where players take strategic decisions considering other players´ behavior, turning competition evaluation into a focal point for bidding strategies. The game theory literature contains a number of papers about optimal common value auctions that maximize revenues, as well as the importance of the game rules and characteristics of the economic environment for equilibrium models. It also assumes that bidder's private information is symmetrically distributed or bidders have no uncertainty over what the auctioned asset is worth to them (Porter, 1995).

According to Cramtom (2005), offering exploration acreage through auction is advantageous due to the tendency this process has to transfer rights and obligations to the most capable companies to explore them. This can be reached through the existing competition among players. Oil companies estimating higher value for a specific area can make a better offer enhancing their chance to win the willing acreage

Another advantage of competition in sealed bid auctions is to grant the success of the licensing process. As stated by Cramtom (op.cit.), highly competitive bids always grant government higher financial return drift resulting from the success of a sealed bid auction. Whenever there are more players bidding in the auction game, more amounts of cash signature bonuses are committed as a result of companies' geological evaluation of available areas. These bonuses reveal the companies' value for the area, suggesting that competitors are aware of companies' perception which may result in higher offer values in the upcoming auctions. As the level of competition increases, more aggressive optimal bids are offered, leading to the conclusion that the best competitive bid could be a good predictor of an asset's value (Rothkopf & Harstad, 1994)

Depending on the number of players (competitors), companies risk aversion, technical expertise and the economic criteria of each company, the offer presented for each exploration area reflects a fraction of a market value for each company evaluation, and may vary significantly.

Competition is a parameter used by Reece (1979) to evaluate which kind of licensing model grants a higher rent of return to the government. He developed a mathematical model using the number of competitors as a variable that represents competition. The assumptions adopted considered that companies are not acting in a "cartelized" manner they focus the maximum rate of return, make independent offers, and know the associated costs of the area they are bidding for. Reece (op.cit.) also assumes identical bidding strategies for all companies.

After analyzing the revenues captured by the government in models based on signature bonus, profit share and royalty taxes, Reece (op.cit.) concluded that the higher slice of total rent is obtained when adopting a Production Sharing Contract model and the lowest return is obtained with a Signature Bonus model for any number of competitors playing the game. In a Signature bonus model, from competitors' side, Capen et al. (1971) suggest that they should present lower offers whenever there are a higher number of players in a particular petroleum auction to avoid the winner's curse. According to their analyses a higher number of players implies in more acreage acquired, but with low value spent per area. As the number of players increases, competitors tend to enhance their offers paying higher values than the worth one, consequently letting money on the table. Another negative aspect of committing a higher bonus bid is the possibility of winner's curse. According to its technical and economic evaluation one company overestimates forecasted reserves bidding a higher bonus value for this acreage. E&P activities show results below the expected bidding profitability, i.e., the volumes are lower than forecasted causing a lower internal rate of return. This phenomenon is known as winner's curse (Figure 1).

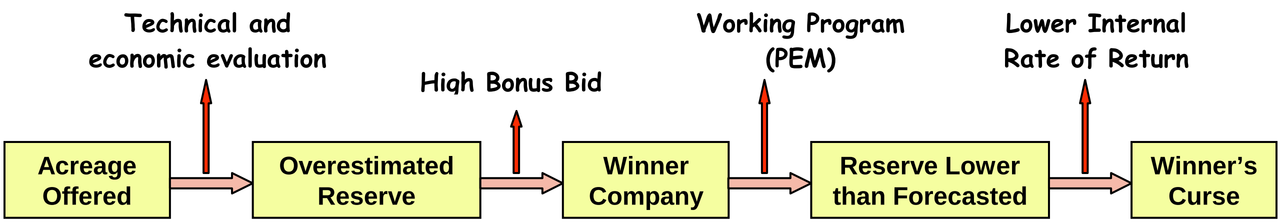


Figure 1 – Schematic diagram from acreage evaluation up to obtain a proved reserve bearing a winner's curse

Johnston (1994) states that for a bidder having success on the auction and still have some profits with the activities developed over the winner area it should bid below the expected monetary value (EMV). The bonus (b) corresponds to a fraction (c) of the EMV (equation 1). This "c" value (bid fraction) should be comprised between 0 and 1 for EMV values ranging from 0 to 100%. Capen et alii (1971) assume "c" as representative of a fraction of the market reserve value that should vary from 20% to 30% (c=0.2 up to 0.3) due to the area attractiveness, available information and reserve uncertainties to avoid a winner's curse.

$$b = c \times EMV \qquad \text{(Equation 1)}$$

The increased competition produces increased allowance for a winner's curse. According to Rothkopf & Harstad (1994), the winning bidders expect profit to decline approximately as the square of the number of bidders and decreases when estimating accuracy increases.

Hartsock (1977) developes a mathematical model to help companies with bidding strategies based on their behavior on US-GOM tenders. He was looking for answers to questions like: Should a bid combine spend companies leasing budget by bidding very high on a few low-risk area, thus enhancing their chances of winning some area, or should they distribute the budget over more areas by bidding less on each area while reducing the chances of winning any single area? And, is it more beneficial for a company to bid with a group, thereby spreading the risk by reducing the expected cost, or should a company bid alone assuming the full risk?

Hoffman et al. (1991) analyze auction games in which companies developed partnership (consortium) to present only one offer, apparently to share risk capital and information. They use direct correlations of an auction measurement and concluded that competition is positively correlated with market variables. Besides this, they observe that variables such as "number of competitors" and "number of offers" should be considered independently one from another when analyzing auction results in order not to mask the game comprehension.

Literature widely states that companies pool to split technical risk and commit more cash value for the offer (Iledare et al., 2004; Saidi & Marsden, 1992). Hoffman et al. (1991) observe a positive correlation between the number of players (company presenting offer in a licensing sale) and the number of consortium attesting that making a joint bidding offer not necessarily reduces the total number of players presenting offer. Repsold (2003) points out that consortium have a tendency to unify the proposals toward the higher one, and to, along time, disclose companies techniques and strategies, allowing an important knowledge on competitors behavior. Conversely, Rothkopf & Harstad (1994) conclude that firms have concern about revealing information to rivals that will create disadvantages during the current auction and they may go to great effort to withhold private information which is a key to future bidding profitability.

Saidi & Marsden (*op.cit.*) identify that consortia formed through the association of two, three, or even four companies presenting one offer for a specific area, tend to be the winner against offers made by sole companies. Consortium could associate companies with different profiles and financial support, allowing more competitive offers that could result in the area acquisition with a lower capital exposition for each company. In this sense, consortium can be considered more aggressive enhancing the likelihood to win their higher priority acreage or buying higher number of low priority areas with considerable money left on the table.

Emphasizing that companies participating in a petroleum exploration licensing are: a) serious and competent for doing E&P activities; b) legal, technical and financially qualified for the licensing; and c) have a firm intention to present offers and acquire acreage aligned with their strategies; divergence of opinions among competitors could result from reasons such as the existence of information.

Porter (1995) discuss the role of information in the Outer Continental Shelf lease sales, and posted that it can play a crucial role in auctions, as information level varies among competitors. Part of the information is available for all players, but others are restricted to few companies. The available information is called public, and is generally sold by the regulatory agency for the players interested in making an offer which shall pay for the geological data. The restricted or private information one is known only by the companies performing E&P activities around the area offered in the licensing. In this sense it is right to state that public information generates symmetry among competitors while private one, creates an asymmetry which is favorable for the well informed company (Tavares, 2000).

Reece (1979) observes that in licensing where players have the same level of information, i. e., only symmetric information, companies tend to obtain similar values for the auctioned area, and government revenue fractions are higher than the competitors, independent of the licensing model applied. For Sunnevåg (2000), to estimate competition through the number of competitors is irrelevant when only public information is available. In petroleum licensing with asymmetric information, companies´ evaluation may vary significantly, resulting in different values for the asset auctioned. The strategic variable, in this case, is the number of companies possessing private data. Therefore, any asymmetric information is a competitive advantage for one company over the others, enhancing its possibility to make profits.

It is reasonable to consider that information has a fundamental role in reducing uncertainties on acreage technical and economic evaluation. Companies with more data and knowledge can make more precise evaluation of the hydrocarbon potential of an area, and decision-makers feel more confident in ranking the areas they will bid for, and how much should be committed as signature bonus for each one.

Although all the authors above mentioned agree that the three more important variables to analyze competition in a licensing round are: a) the area auctioned, b) the qualified companies, and c) the available information; in general, they developed their mathematical models for bidding optimization. Academics are interested in a methodology that could give a better offer estimation to win the bid paying as less as possible to not left money on the table. Competition is mainly evaluated from a revenue return point of view.

The purpose of this study is, using these three main variables, estimate the expected level of competition in a Brazilian licensing sale.

3. Research Methods and Methodology to Estimate Competition Level

The main purpose of this study is to estimate the expected level of competition in a particular petroleum exploration licensing sale, based on the capture of experts knowledge which are directly involved in the decision making process. These experts are the ones who define the most competitive offer that could result in winning the bid for the specific acreage.

Despite the fact that professionals of the oil industry usually do not document the way they estimate competition in the specialized literature, all companies participating in an E&P competitive bid perform competitive analyses. Artificial intelligence and Operational Research methods (OR) can be pointed out as the most common methods applied.

Different from the standard optimization techniques, which are appropriate to solve problems for predictable environments, deterministic behavior of people, or for small and narrow contents - the multi-criteria decision making process have been studied under the general classification of OR problems. Its purpose is to deal with taking decisions in the presence of a number of often conflicting criteria, and is divided into two groups: multi-objective and multi-attribute decision making (Bhushan & Rai, 2004). As multi-attribute deals with discrete decision spaces, where decision alternatives are predetermined, two analytical methods were tested to estimate the level of competition: 1) the weighted sum method (WSM), and 2) the analytical hierarchy process (AHP). WSM is a decision matrix approach used to evaluate each alternative with respect to each criterion and then multiplies that evaluation by the importance of the criterion. AHP is a structured technique for dealing with complex decisions. Rather than prescribing a "correct" decision, AHP helps decision-makers find the one that best suits their needs and their understanding of the problem (Saaty, 2008). Despite that these methods catch some characteristics of the decision making process, both AHP and WSM do not reach reliable results, but allow a better understanding of the decision making process and the variables involved. They do not capture the decision-maker judgment, which is a fundamental element when analyzing competition. Some of those methods deal with preferences that differ from judgment, a cognitive aspect of the decision making process (Bazerman, 2006).

As artificial Intelligence encompasses many aspects of human behavior such as speech, language, movement, among others, knowledge automation expert systems - a branch of Artificial Intelligence, which focuses on the capture and dissemination of problem solving knowledge via computer programs – tends to be a powerful tool for estimation of the level of competition. These expert systems are used to advise, diagnose, or troubleshoot problems that were once only performed by humans. This option will be used by this research project.

The method adopted by this research to collect data can be divided into two groups: quantitative or qualitative research, and deskwork or fieldwork. Among the existing research approaches, surveys were adopted to collect data by asking pre-established questions in a specific order to a group of individuals who are representative of a targeted population. This research project applies two types of survey: questionnaires and semi-structured interviews.

- Questionnaires, as observed by Blaxter et al. (1996, in: Asrilhant, 2001), are one of the most commonly used research techniques in the social sciences. They are mainly used for collecting primary data, whether they are quantitative or qualitative. Questionnaires are usually posted, but they can also be administered by telephone, e-mail or face-to-face. Questionnaires must involve properly framed questions, so that the respondents can clearly and unequivocally understand them. A researcher must also test and amend a questionnaire before its administration. There are two formats of questions: closed and open-ended. A type of closed question is the forced-choice question. This allows the respondents to select one or more responses from an exhaustive and mutually exclusive list of alternatives. The other type of closed question uses a response options format. Finally, open-ended questions allow for free answers;

- Interviews, another research technique, represent an extensively applied method of investigating the participants' experiences, perspectives and understandings in some depth. Interviews are categorized into different formats, such as structured, semi-structured or unstructured. A structured interview is a formal instrument based on an interview schedule. It comprehends a set of clear instructions, and questions are asked in a specific order. The semi-structured interview is less formal, including open-ended questions. Questions are not posed in a rigid order, and can be re-worded for a specific interview. Unstructured interviews do no impose clear rules. They are based on an interview agenda where open-ended questions are developed during the interviews (Clarke and Dawson, 1999a, in: Asrilhant, 2001).

The proposed research methodology is divided into three phases: 1) the exploratory investigation, (2) the knowledge capture, and (3) the expert system development. The methodology began with a qualitative approach. A set of semi-structured, preliminary face-to-face interviews were carried out to give a sense of reality to the research problem, motivate the design of the next steps of the proposed research methodology and support the reviewed literature to describe the research hypotheses. The exploratory investigation was followed by a quantitative approach. A questionnaire, which was the main source of data in the current study, tested the research hypothesis, generalized the exploratory findings, consolidated the overall findings, and supported the development of the logic base rules to build the expert system model. Finally, a computer work was performed based on the principles of artificial intelligence incorporating the expert knowledge captured by the questionnaire to help decision-makers estimate the level of competition. In this research project, the presence of the interviewee during the questionnaire application was fundamental to explore relevant issues that could give more details regarding the issues investigated by the questionnaire. Table 1 summarizes the phases of the proposed research methodology.

3.1 Exploratory Investigation

The exploratory investigation consisted of the pilot testing of the questionnaire. It was set as a transition from theory to method which relates and checks theory with practice, as a prototype of the core investigation, and motivated the design of the next phases of the current research methodology. The exploratory investigation was performed in two stages: (1) exploratory deskwork, and (2) exploratory fieldwork (Table 2). The exploratory deskwork aimed to seek a correspondence between the elements obtained from theory and practice, defining the set of main elements to be placed within a conceptual framework. The exploratory fieldwork is the part of the research dedicated to obtain from experts their consent on the deskwork mapped variables. The definition of fieldwork should consider the current fast technological evolution aggregating such a kind of work done virtually, such as telephone interviews and e-mailed questionnaires.

TABLE 1 - Research Methodology Phases

Phase		Research Techniques	Objectives	Period
Number	**Denomination**			
I	Exploratory Investigation	Semi-structured preliminary interviews	To define the relevant elements in practice and theory to design a questionnaire for competition level estimation	February to September, 2009
II	Knowledge Capture	Semi-structured face-to-face and emailed questionnaire	To identify the logic reasoning behind experts´ judgments on competition level	November, 2009 to February, 2010
III	Building an Expert System	Computer program based on artificial intelligence that uses blocks logic and rule-based logic	To build an automated system that represents experts´ thoughts on competition to help the decision making process.	January to June, 2010

TABLE 2 – Exploratory Investigation Stages

Stage		Research Techniques	Objectives	Period
Number	Denomination			
I	Exploratory Deskwork	Theory Analysis	Definition of a set of relevant elements both corresponding in theory and practice	August, 2008 to January, 2009
II	Exploratory Fieldwork	Face-to-face and virtual interviews. Semi-structured questionnaire prototype	To collect experts perception on the variables and the level of competition	February, 2009 to June, 2010

Exploratory Deskwork

The exploratory deskwork target was to search for the identification of a set of relevant elements from the literature and seek a correspondence between theory and practice. The elements should be supported by the literature to ensure their completeness and credibility in order to be effective and acceptable. Elements must be carefully examined in order to assess the extent to which they are included, and whether any element should be combined, eliminated or re-stated, along with the examination of potential interrelationships amongst them.

Widely discussed by the theory presented in Section 2, the elements identified were grouped in four main sets. The first one is related to the importance of the geological and economic potential of the area been offered in a particular tender (prospectivity, proximity to existing production facilities, among others). The second set refers to possible competitors (number of qualified companies, strategies, past tender behavior, E&P activities in the basin, among others). The third group focuses on information (symmetric or asymmetric, amount and quality, confidence on information source). The last category holds joint bidding arrangements envisaging area acquisition.

These necessary and sufficient sets of relevant elements for the estimation of competition level in decision making process are the basis for the exploratory fieldwork, which follows.

Exploratory Fieldwork

The main purpose of the exploratory fieldwork is to check and calibrate the elements identified for estimating the level of competition in E&P licensing acreage. Interviewing experts, whose knowledge rose from the business world of upstream oil and gas sector, helped achieve this purpose.

The exploratory fieldwork was conducted interviewing eight professionals of the upstream oil and gas industry. It was carried out doing seven semi-structured face-to-face interviews and one e-mailed questionnaire for group of decision-makers holding top, medium and junior positions (two executive directors, two senior advisors, two business consultants, and two technicians). Each interview lasted, on average, one hour. The relevant elements and their operational definitions were produced, based on the ranking of the most important elements, such as: (1) the geological potential of auctioned asset, (2) the total number of companies qualified and their E&P profile; and (3) the available information on companies´ E&P strategies. During the questionnaire testing a second round of contact was conducted by e-mailing the questionnaire to four professionals, among the eight previously interviewed. This second approach supported the re-examination of the proposed set of elements and the possible interrelationships amongst them, helping the design of the final version of the questionnaire.

3.2 Knowledge Capture

This is the core investigation methodology on this research and consisted of design and administration of a questionnaire.

According to Awad (2003), knowledge is human understanding of a specialized field of interest that has been acquired through experience and study. Davenport and Prusak (2000) define knowledge as a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Hence, a knowledge base is a set of facts and inference rules for determining new information and “smarter” knowledge to support decision making. It is not a simply database. It is an understanding gained through study that includes perception, skills, training, common sense, and experience.

Intelligent behavior implies the ability to understand and use language and store and access relevant experience. Humans acquire expertise, learnt via experience. Expertise incorporates the ability to reason and make deductions as well as common sense (unreflective opinions of ordinary human beings). Knowledge is neither data nor information. Although it is related to both, it embraces a wider sphere than information. Data are unorganized and unprocessed facts. Information has meaning, purpose and relevance. Therefore, evaluated data becomes information when meaning or value is added to improve the quality of decision making.

A questionnaire is the main tool to capture expert’s knowledge in the domain of competition for petroleum acreage acquisition. It must be able to address the research question, test the research hypothesis, and catch respondents´ know-how to support the building of an expert system for expected level of competition estimation helping decision-makers elaborate the strategies to enhance their companies chances to win the bid. The questionnaire aimed to identify: (1) the elements to which decision-makers pay considerable attention while estimating competition level; (2) the inter-relationship among these elements; (3) the level of expected competition; and (4) decision-makers opinion about competition level and the licensing model applied by government.

The knowledge capture comprised three stages. The first stage was the questionnaire design, which consisted of four steps: (1) sampling procedure; (2) questionnaire structure; (3) measurement and operational definition of the research variables; and (4) questionnaire reliability and validity. The second stage referred to the questionnaire administration, which consisted of three steps: (1) primary access; (2) pilot testing; and (3) main survey.

Questionnaire Design

It describes the sampling procedure, as observed by Chou (1998), refers to the selection of a subject from a population of interest. The sampling procedure is divided into four areas of consideration: (1) unit of analysis; (2) sample size; (3) sample frame; and (4) sample design, as discussed in the following. This research project aims to estimate the level of competition to be used in a decision making process to define the most competitive offer for a specific area in a petroleum exploration lease. Sample size is an important step in the sampling procedure. The assumption of normality is, according to Hair et al. (1997), an influential constraint in dealing with basic statistics. The characteristics of the distribution (e.g. mean and standard deviation) and t- and F-tests are generally based on the premise of a normal distribution. According to the Central Limit Theorem, a sample size of at least thirty observations is necessary to take normality for granted. Samples with less than thirty observations are considered small and require special tests to determine statistically significant findings.

This project research has a sample size of thirty-six valid observations. The sample frame refers to the identification and description of the targeted population. The focal population of this study is the Brazilian upstream oil and gas sector. The selection of the representative companies of the population was based on two complementary criteria: (1) concessionaires of E&P offshore areas; and (2) corporate structure and size. The concessionaire criteria was based on the number of current companies technically qualified by the petroleum regulatory agency to explore and produce oil and gas offshore Brazil. Consulting the petroleum regulatory agency data base (ANP, 2010) the number of current 77 concessionaires could be split into 46 companies performing onshore activities and, 31 operators or partners for E&P shallow or deepwater areas. A total number of 20 offshore concessionaires was sampled corresponding to 65% of the total oil and gas companies currently working offshore Brazil. The second criterion was used to pick up those 20 concessionaires according to their corporate structure and size. Six groups were formed to be representative of the diversity profile of companies and Public or Government Agencies operating in the Brazilian petroleum upstream sector: Super Majors, American Independents, International Oil Companies, Domestic Companies, and International Regional Companies.

As it occurs in most of the companies, the decision making process is generally done by more than one expert directly involved in the competition evaluation, it is important to sample as much experts as possible to obtain different judgments on competition. On the other hand, as petroleum licensing is a competitive process and any piece of information is considered to be a competitive advantage, experts must be confident on an interviewee's ethical behavior. This research surveyed 36 experts, which were assured confidentiality by not disclosing their particular and professional identities, opinions and name of companies surveyed. Only the findings of this study are to be published as a whole.

The main purpose of the questionnaire applied in this study is to capture how experts estimate competition level on a Concession Contract Licensing model. Considering that there were no existing questionnaires available for this purpose, the current questionnaire was an useful exploratory, descriptive instrument. The structure of the ten-page questionnaire consists of: a) cover letter, including a guidance for completing the questionnaire and a hypothetical petroleum exploration licensing round scenario; b) three sections of closed questions, and c) a fourth section comprised of one open-ended question. The guidance for completing the questionnaire included the aims of the research, fixed values and numbers of some discretionary variables in order to restrict the universe of dependent variables and some variables' definitions. When presenting the questionnaire face-to-face, the interviewee usually stated that they only need to answer questions which were relevant to them, and, if they had not been involved in any petroleum competitive bidding process they could either introduce the interviewee to another expert or forward the questionnaire to someone who had been involved with this subject.

The questionnaire is structured in three main sections related to the three most important issues to be evaluated in competition level estimation: a) information; b) acreage; and c) companies' profile. The first section of the questionnaire referred to the companies qualified for the licensing bid sale. The idea of this part is to capture expert judgment about the identification of potential competitors they could face according to their financial position and strategies for that specific licensing sale. The second section referred to the areas on offer by the regulatory agency in the specified mature sedimentary basin. The purpose of the third section was to assess how information affects the competition level evaluation. These three sections also contain questions that mix the subjects, i.e., questions involving potential area with information, and/or number of potential competitors. The rationale behind these questions was to investigate the inter-relationships of those variables and how they may change expert's perception on the competition level. The fourth section, composed by just one open-ended question, envisaged to capture the industry perception on how the new regulatory policies could impact the level of competition in the new Brazilian licensing model such as the Production Sharing Contract, under government analysis. Finally, respondents were advised that the research findings will be published after analyzed, and respondents will be notified about the publication.

A total number of 25 multiple-choice questions plus some related questions were considered in the questionnaire. The multiple-choice type questions are either excludent (yes or no questions) or ranking scale questions. According to DeVellis (1991, in: Asrilhant, 2001), there are several formats for the scale items, such as the binary and the semantic differential, which are applied in this study and briefly discussed here. The binary scale involves a “yes-no” format, and the semantic differential scales adopt a five response options.

Besides obtaining relevant information, another main goal of a questionnaire design is to collect this information with maximum reliability and validity (Warwick and Linninger, 1975 in: Key, 1997), because in scientific research accuracy is of great importance. Generally, scientific researches measure physical attributes, to which precise values can be assigned. As this study deals with experts’ knowledge it is essential to remind that values assigned to mental attributes can never be completely precise. The related imprecision is often looked upon as being too small to be of a practical concern. However, the magnitude of imprecision is much greater in the measurement of mental attributes than in that of physical attributes. This fact turns very the determination of the reliability of a measuring instrument (Willmott and Nuttall, 1975 in: Key, 1997).

- Reliability is the tendency toward consistency found in repeated measurements, as defined by Carmines and Zeller (1979). A reliable research instrument is the one that yields the same results on repeated trials. Although unreliability is always present to a certain extent, consistency could be reached with the results of a quality instrument gathered at different times. There are three main methods for measuring the reliability of an instrument: retest, alternative, and internal consistent (Key, 1997). Although pilot testing increase the consistency of the questionnaire, two administrations of the same instrument for a small group was performed to compare their past and present responses allowing the measurement of a reliability coefficient. The retest method was applied to 20% of the previous participants, and the average index of reliability reached 77%, proving the questionnaire design to be reliabie;

- Validity is the extent to which a measuring instrument measures what is supposed to measure and can be checked through three basic approaches: content, criterion-related and construct validity (Carmines and Zeller, 1979). The content validity measures the degree to which the test items represent the domain of the trait been measured. It is strongly suggested to use a panel of experts in the field to be studied to identify a content area (Key, 1997). Interviews during the exploratory fieldwork and the pilot testing of the questionnaire done with some experts contributed to checking the questionnaire’s content validity. The current questionnaire is believed to have sound content validity.

The total amount of 36 questionnaires was responded by qualified experts and is reliable and valid for the purpose of this research project.

<u>Questionnaire Administration</u>

It is appropriated to state that obtaining a significant number of potential respondents who would be willing to answer the questionnaire was a critical issue in this research. As the first author of this paper is an expert involved for more than ten years analyzing competition and partnerships developed in Brazilian E&P acreage sales it was straightforward to establish a list of contact and invite qualified professionals in a wide range of companies to participate in this research. Some experts that are doing similar business all over the world were also contacted and freely accepted to contribute in both pilot test and questionnaire administration phases.

The methods or tools chosen for knowledge capture is not a straightforward routine, and depend on the nature, personality and attitude of the expert and whether the expert system will be built around a single or multiple experts, both have advantages and limitations. In spite of a single or multiple expert interviews the knowledge developer should be aware of different levels of expertise that influence communication quality. Higher level experts generally give concise explanations, but often skipping vital details. Moderate level experts tend to provide detailed explanations, being quick to give answers. Conversely, new experts tend to offer brief, fragmented answers, suggesting shallow knowledge. One possibility to improve knowledge capture by the developer is eliciting an expert's knowledge through concrete case situations or scenarios.

In this study the choice was to capture knowledge by applying a face-to-face questionnaire for multiple experts with different levels of knowledge, working for a wide range of petroleum companies, such as international oil companies, majors, and government agencies, among others.

The tactic adopted was to contact experts that have already done business together in, at least, one of the ten previous Brazilian E&P Licensing Sales. Nineteen individuals invited by phone calls freely accepted to contribute with this research project. Eight were also selected to participate in the pilot testing of the questionnaire. These experts work for different oil companies and hold diverse positions on the hierarchy. Acting respect and trustfully with the research project, they recommended other experts working inside their companies or even working for other oil companies and/or petroleum institutions. A total number of 36 experts responded the questionnaire, and five refused to participate in the research, despite their awareness of the identity privacy and disclosing information policy of the project. The knowledge developer built a hypothetic scenario, presented in the questionnaire which was, even for the different companies, subject to the same boundary conditions in order to narrow the possibility of widening answers.

The adopted scenario considered a fixed oil price, knowing licensing date and period, and determined number and profile of qualified companies that could potentially bid for areas in a petroleum mature sedimentary basin, such as Campos Basin. Data like oil price, fiscal system, among others were set fixed to avoid considering economic and political risks that could imply in spread responses out.

The thirty-six questionnaires were grouped according to companies´ corporate structure (Figure 2), meaning that, out of the twenty companies surveyed, 10% of the total number of questionnaires was responded by Super Majors workers, 15% from American Independents, 15% from Public or Government Agencies, 15% from International Regional Companies, 20% from Brazilian Companies and 25% from International Oil Companies.

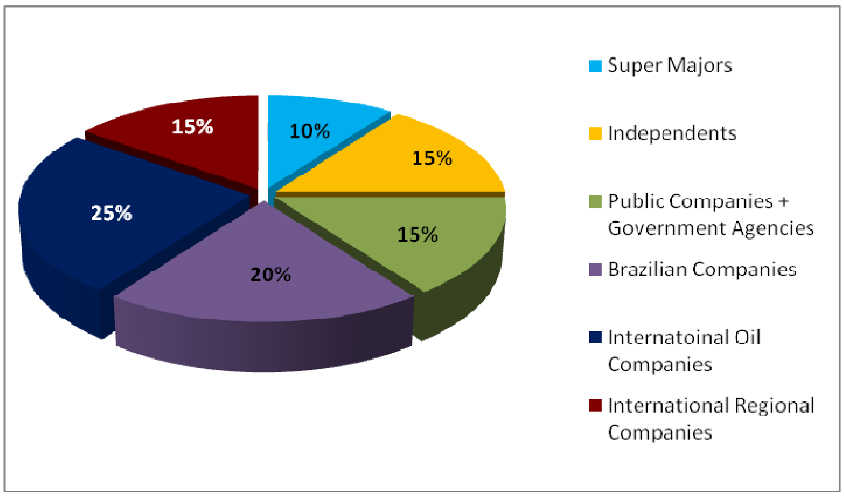


Figure 2 – Distribution of the 20 petroleum companies and government entities surveyed.

Figure 3 presents the distribution of respondents within the 20 petroleum companies and agencies. Three out of five pieces of the graphic show a percentage around 20% consultants, technicians and directors collaborating in this project. The smaller fraction corresponds to the amount of CEOs listened (11%) and the greatest proportion is represented by the managers sample (29%).

Listening to a wide range of view points allows the knowledge developer to consider alternative ways of representing knowledge. An additional advantage was that scheduling a formal meeting frequently creates a better environment for generating thoughtful contributions. However, the greater the number of participants involved, the harder to retain confidentiality and get a consensus opinion, which could jeopardize the success of the survey. The method used to approach experts was based on individuals formal meetings, believing that it could guarantee enough privacy to experts freely share information and answer the questionnaire, besides building up a trustful lie between expert and knowledge developer based on ethical behavior. The option to present the same questionnaire for all interviewees aims to avoid noise and uncertainties on the information captured granting a better translation of experts' judgment into logic rules. Another benefit of a structured interview is to eliminate experts' bias getting the same understanding through a standardized questionnaire, which ensures its validity and comparability.

Individuals are imperfect information processors tending to form a preference for one outcome justifying this preference on a fair basis. This introduces to the decision making process a bias according to their self-interest. What should be an impartial judgment than become an unconscious and powerful systematic bias leading the decision making process to fail (Bazerman, 2006). Understanding and limiting this bias in judgment could break some decision making patterns avoiding mistakes when taking decisions.

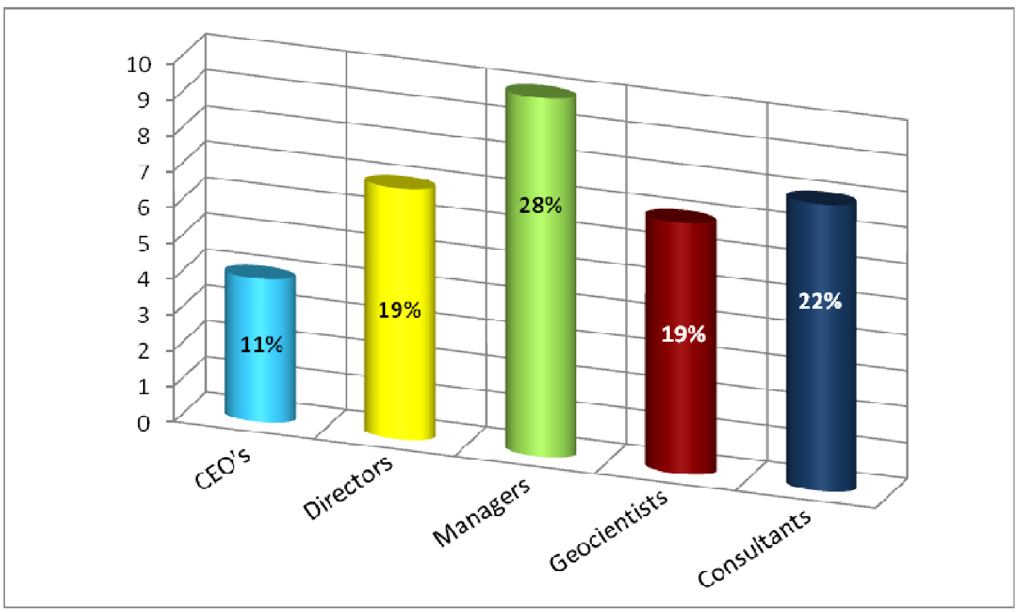


Figure 3 – Distribution per group of the 36 specialists on Brazilian petroleum licensing participating on the research.

3.3 Building an Expert System

This step of the methodology is a confirmatory investigation phase. The knowledge capture is the investigative experimental process, involving interviews and protocol analysis, used to build a knowledge automation expert system, which consists of:

- Using an appropriate tool to elicit information from an expert – the questionnaire;
- Interpreting the information and inferring an expert's underlying knowledge and reasoning process; and
- Using the interpretation to build the rules that represent an expert's thought processes or solutions.

Generally, academics suggest that a knowledge automation expert system aims to learn how an expert's mind works and how tough problems are conceived. It is also viewed as an engineering approach to problem solving using rules of thumb. Psychologists believe that rely heavily on modeling human cognition. Such a program normally uses rules of thumb (heuristics) described as logical statements to capture the decision making processes of the human expert (Awad, 2003).

The goal was to design a computer-based system that could capture and emulate a human decision making process. A machine that can work as well as a skilled human been. However, the distinction is that computer software can perform only that task and cannot handle new situations that require innovation or intuition. Expert systems tend to be more effective than other computer based applications, because they:

- may combine the knowledge of many experts in a specific field;
- can store an unlimited amount of information, and works much faster, than a human;
- are available 24 hours, and can be used at a distance over a network;
- are able to explain their information requests and suggestions;
- can process a client's uncertain responses and, by combining several pieces of uncertain information, may be able to make good recommendations; and
- can accumulate the knowledge of high level employees for any company, which is especially useful when they retire or leave company.

Although an expert system includes several key components (Figure 4), the essential one is the knowledge base - an organized collection of facts, heuristics and other information on the subject of a system's domain. An expert system is built in a process known as knowledge engineering, during which knowledge about the domain is acquired essentially from human experts. The part of the expert system that applies the knowledge to the problem's solving is called the inference engine. The explanation system explains the basis for the conclusion, reached by the expert system.

The intellectual editor is a tool for correction, learning or self learning of the knowledge base. A friendly user interface enables inexperienced users to specify problems for the system to solve and understand the system's conclusions.

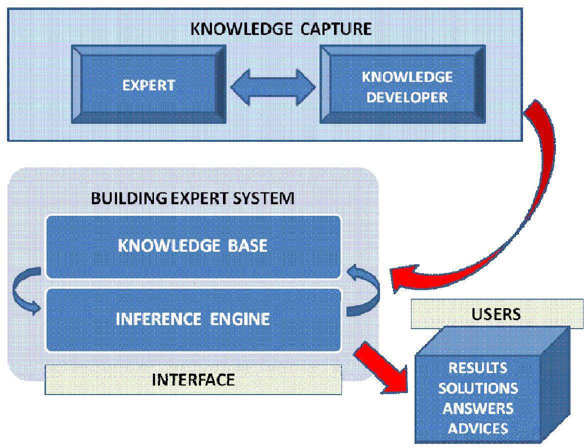


Figure 4 - Key components of an expert system based on the judgment view (knowledge-based) of petroleum experts on competitive in petroleum lease acreage.

Aiming to verify if this methodology could be applied to estimate the level of competition for E&P acreage acquisition, a method for capture expert knowledge was developed in order to build an expert system.

The first step to build an expert system is to identify the problem domain to be solved. If the problem requires years of experience and cognitive reasoning to solve, or should be considered a judgment maker rather than a calculation processor then, the domain is a qualified candidate for expert system methodology. The second one, and most important, is to capture tacit knowledge by knowledge developers who should have an understanding of an expert's level of expertise (Awad, 2003).

One of the features of a knowledge expert system is to transform information into practical advice. Hence, it is a powerful methodology to handle complex decision making processes, as it is a competitive estimation for a particular petroleum licensing.

Exsys Corvid® was the computer platform elected to build the expert system. It provides tree structures to organize related rules, and logic blocks to organize the related trees. When interviewing the experts, the knowledge developer should be directly related to the amount of time used to capture and convert knowledge into rules that computers can use. The decision making logic is stated by “if/then” rules, in the same way as explaining to another person how to make a decision.

The software applied uses an "object-structure" approach to design the system. Rules are defined using various types of variables that have related methods and properties, providing a wide range of flexibility and power. Some advantages of a full object-oriented approach are provided without having to understand complex programming, or describing a solution with many classes. This is similar to the concept used in Visual Basic, widely used and accepted. The object-structured nature of this software allows it to provide the optimum balance between power, flexibility and use.

The software inference engine runs the rules. It supports both backward “goal driven” and forward “data driven” chaining, or combinations of the two approaches. Backward chaining makes it particularly easy to build systems. If a system has a rule relevant to the current goal or variable, it will be automatically found and used by the system. All developer has to do is to add the rules anywhere in the system. Questions will be focused, only asking what is needed, yet never overlooking anything that might be relevant, combining and analyzing the user information, and displaying the system recommendations. Probabilistic logic ("fuzzy logic") is supported with many ways to combine confidence factors, allowing systems to find the "best" solution, and probabilistically rank multiple possible solutions. Despite this power, the inference engine is small and efficient.

The knowledge automated expert system built as a result of this research is valid under a specific scenario stated at the beginning of the questionnaire to restrict the wideness of possible answers and different interpretations. The assumptions adopted refer to some bidding characteristics, as listed in Annex 1.

The creation of a knowledge base consisted in transforming an expert's knowledge acquired by the questionnaire into variables and rules which allow the inference engine to run the command block for estimating the level of competition. A total of 14 variables was defined assuming static or numeric values. Some of them have their values set by the user while running the software. As it is an automated program, it interacts with users searching for those answers. The variables description, including questions made by the program, is displayed in Annex 1.

These variables are used by the knowledge developer to build in the "if/then" format rules. Each group of rules represents a logic block built according to each aspect of the licensing should be under analysis. In this study, five logic blocks were built: 1) petroleum price scenario; 2) number and profile of competitors; 3) acreage attractiveness; 4) strategic information available; and 5) estimation of competition level. Annex 1 also shows the name and details for each logic block built. Annex 2 presents the method applied specifically to the logic block ESTIMA_COMPET to help the knowledge developer to structure 72 logic rules, representing all possible licensing cases, each of them resulting in one of the three levels of competition.

Once the logic blocks are built it is imperative to structure the inference engine – a group of commands to perform the competition estimation. Although Awad (2003) has mentioned the use of backward chaining as the most applied procedure while building an expert system, this study's expected results were achieved applying forward chaining. Figure 5 is the image of Exsys Corvid® command block constructed to estimate the level of competition for the Brazilian Licensing. This routine ask for both variables and logic blocks, in a sequence defined by the knowledge developer, to run the software using forward rules procedures to calculate: 1) the number of competitors, 2) the area attractiveness, 3) the effect of strategic information over competition, and 4) the level of competition. Any user answering the question posed by the software can fast and easily reach the results.

Command Block: PROGRAMA V.2

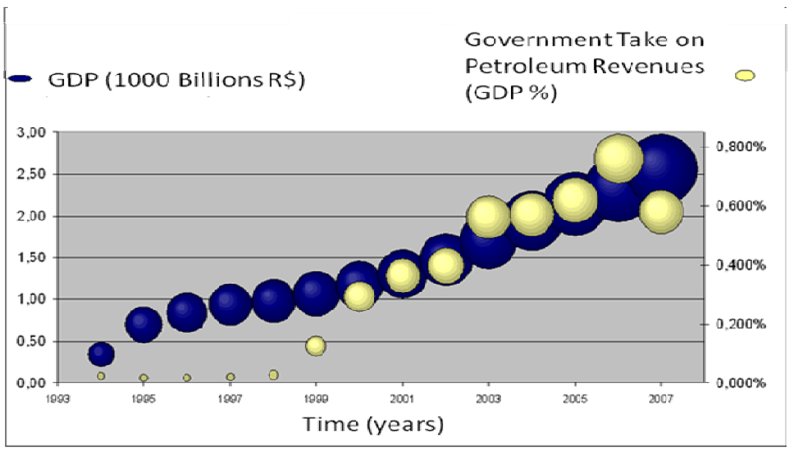
```
TITLE    // SISTEMA ESPECIALISTA
ASK  [PRECO_BBL]
FORWARD BLOCK=CENARIO_PRECO_BBL
ASK  [TIPO_BACIA]
ASK  [NUM_CIAS_SEMPERFILCOMPET]
ASK  [NUM_NOVAS_ENTRANTES]    // Entre com o numero de novas empresas entrantes
ASK  [NUM_CIAS_COMPETIDORAS]    // Entre com o numero de companhias tradicionalmente competidoras
FORWARD BLOCK=NUM_COMPETIDORES
ASK  [TIPO_AREA]    // Defina se as areas sao de Nova Fronteira ou de Elevado Potencial
┌─ IF TIPO_AREA = Elevado_Potencial
│   ├─ ASK  [EXPSUC_EP]
│   ├─ ASK  [RFDP_EP]    // Informe se as areas estao proximas ou longe de ring fences ou areas em Desenv Producao
// IF End
┌─ IF TIPO_AREA = Nova_Fronteira
│   ├─ ASK  [EXPSUC_NF]
│   ├─ ASK  [RFDP_NF]
// IF End
FORWARD BLOCK=ATRATIVIDADE_AREA
ASK  [DESCBAC]    // Informe se ha informacao sobre descoberta recente de HC na bacia
ASK  [DESCPLAY]    // Informe se ha informacao sobre descoberta recente de HC em play analogo em bacia similar
ASK  [MUDA_LEGISLA]    // Informe existencia de possiveis mudancas na legislacao que afetam a licitacao
FORWARD BLOCK=INFO_ESTRATEGICA
FORWARD BLOCK=ESTIMA_COMPETICAO    // Estima o nivel de competicao esperado para a licitacao
RESULTS
```

Figure 5 – Exsys Corvid® Command block image executed while running the software. This routine gives the result on the expected level of competition.

4. Results for Brazilian Competitive Lease Sales

In 1997, after almost 45 years of monopoly of petroleum E&P activities performed by the National Oil Company - Petrobras, the Brazilian Government established a new petroleum fiscal regime in the country. It sanctioned the Petroleum Law 9.478/97, and also created the Petroleum National Agency (ANP) to regulate upstream and downstream activities. ANP adopted a Concession Contract model to transfer E&P from Federal Union to oil companies. The Government is the subsurface natural resources´ owner and concessionaires are the production owners. Government take and free commercialization of the hydrocarbon produced are both concessionaires´ obligations and rights. This right is one of the concession model rules that mostly attract the oil industry attention.

Since 1999, with oil prices raising, the Brazilian Government slice of petroleum revenues has increased and the public debt has started its decline, positively impacting the government budget, reaching 0.76% of the 2006 Gross Domestic Product (GDP) (Figure 6). According to Santos (2009), this is the best criterion to evaluate the success of the new institutional system established by the Petroleum Law.



Source: Brazilian Central Bank and ANP (modified from Santos, 2009)

Figure 6 - Evolution of Gross Domestic Product (GDP) and Government Take from petroleum revenues since 1994. The increasing of Government Take after 1998 reflects the change from a royalty tax based fiscal system to a mix of royalty, rentals, income and special participation taxes.

The next section presents the results achieved when applying the methodology to the Campos basin licensing data base for the last 10 years of petroleum acreage lease through a Concession Contract model.

4.1 Competition under Current Concession Contracts

Define a winner offer in a Brazilian E&P acreage auction is not a simple task as it is for the most part of Concession Contracts lease sales worldwide. Up to the fourth licensing sale ANP transferred the rights and obligations of an area to the oil company which presented the higher bonus value. Furtado (2004) detailed the method applied by ANP, the characteristics of the tenders and performed statistical analysis to estimate each tender index of success. From the fifth auction onwards, some adjustments were made to auction rules, where the establishment of a working program, the most relevant biddable factor, consequently reducing the bonus weight in the bidding process (Rodriguez & Suslick, 2009).

The success of ANP licensing model and the political stability, fiscal incentives and low risk-country factors lead to the promotion of two auctions for mature oilfields located onshore Brazil, positively impacting competition among small and national oil companies (Rodriguez et alii, 2008). Along these ten years of acreage licensing, competition varied according to the area potentials, companies´ strategies, and the level of information available. Considering competition and the winner offers for Campos Basin, deep and shallow water areas, Furtado et alii (2008) presented a methodology to estimate the areas´ values that helps decision-makers define the bidding strategies. Focusing the same sedimentary basin, because more than 85% of Brazilian petroleum production come from oil and gas reservoirs found in both deep and shallow water areas, Rodriguez & Suslick (2008) made a comparison between Campos Basin areas´ values and US Gulf of Mexico winner offers, for the same period of time. The results achieved showed that oil companies bidding for Outer Continental Shelf areas are assigning a similar an amount of money to those spent by oil companies for deep and shallow waters acreage, while adding the total value committed as a minimum exploratory working program (PEM).

Brazilian E&P acreage auctions have a different way of defining the winner offer, while compared to a simple bonus system applied to lease sales worldwide, where the bonus is a fraction of the expected monetary value (EMV) of the area. The possibility to commit PEM and local content, besides the signature bonus allows companies to make long term investment in the area, instead of committing short term cash payment. Local content accounts for 20% of the total offer weight and was considered irrelevant for the scope of this study. However, bonus and PEM account for 40% each and therefore, are a focal point defining the most competitive offer. The whole process of ANP licensing E&P areas is presented in Rodriguez & Suslick (2009).

Dealing with both PEM and signature bonus became essential for companies´ success, and competition analyses should be precisely performed to help decision-makers develop bidding strategies. Envisaging competition evaluation a hypothetical licensing scenario was built and presented through a questionnaire for experts involved with the Brazilian licensing process. The results of this evaluation are discussed in this section and an automated expert system was built allowing users to perform their own estimation of competition level for the defined scenario. For Brazilian licensing with different assumptions from ones listed in Annex 1, the expert system could not grant reliable results. It should be, therefore, adapted.

According to experts' judgment collected from the questionnaire some relevant conclusions can be reached in two main issues: a) what impacts the participation of a petroleum company in a particular tender; and b) how competition can be estimated using experts knowledge.

Table 3 shows five parameters experts believe could impact the decision making of a company to participate or not in an auction. They were classified according to their degree of importance and will be discussed as a result of the experts' opinions. Three, out of five parameters, were selected to build the rules of the expert system: (1) basin and areas on offer; (2) number and profile of the qualified companies; and (3) information about companies' strategy (selling and buying petroleum assets). The expert system was run to yield estimation of the expected level of competition for four simulated licensing cases. Finalizing this section, some evidences confirming experts' findings about the variable that has a negative impact on competition – potential changes on game rules - will be presented.

Despite the Rodriguez et alii (2006) observation of a positive influence of the licensing period on the Brazilian 7th Licensing Round results when compared with international 2005 tenders, around 45% experts pointed out the lower relevance of the tender period for competition evaluation (Table 3). Specialists (55%) reason according to their companies' strategy, which focus Brazil for reserve replacement. These companies will bid for acreage independently of tender's period promoted around the world. On the other hand, 63% of experts mentioned the impact of the licensing period on competitor's participation on Brazilian lease, because they are not completely aware of competitor's strategy. Maybe Brazilian tender was considered to be one among some potential countries for acreage acquisition for 37% of the experts.

TABLE 3 - Degree of importance of some information about the Brazilian Petroleum Licensing

DEGREE OF IMPORTANCE	BRAZILIAN LICENSING vs WORLD LICENSING PERIOD	OIL PROCES AND R/P SCENARIOS	BASIN AND AREAS ON OFFER	NUMBER AND PROFILE OF QUALIFIED COMPANIES	COMPANIES' STRATEGIC INFORMATION
VERY IMPORTANT	20%	34.3%	94.3%	42.9%	20%
IMPORTANT	34.3%	54.3%	5.7%	48.6%	60%
LESS IMPORTANT	45.7%	11.4%	0%	8.5%	20%

Almost all experts (88.6%) do believe on world petroleum prices scenarios and reserve over production ratio (R/P) as important criteria for competition level analyses (Table 3). The majority of respondents correlated the higher bids for petroleum acreage with increasing oil prices for the same potential acreage. This is seen as consequence of oil industry needs to enhance R/P using the profit from petroleum marketing as bidding budget. Chances of winning more acreage increase with higher bids.

Regarding the areas selected by the government agency to be offered, experts were almost unanimous identifying this variable as the most important when evaluating competition. Knowing about the areas' location makes the difference for estimating competition. If they belong to a mature sedimentary basin with a proved active petroleum system or to a new frontier basin, if there is positive results such as exploration discoveries or fields under production, and if exists flowing system infra-structure, besides the hydrocarbon potential of each block itself, are critical information for all companies.

ANP always set a minimum bonus value per block offered. Previously set as a constant value according to the location of the block (onshore, offshore shallow and deep water), since 2003 it varies according to the hydrocarbon potential of each block. Generally, blocks located in High Potential (EP) or in New Frontier areas have the same minimum bonus value per area, except for those which ANP's technical and economic evaluation indicated higher EMV. However, expert's opinion can be grouped into two classes: a) those who believe on the credibility of minimum bonus information of block's geological potential (46%); and b) those that are not confident on ANP technical studies (54%). Figure 7 shows that while requested to estimate competition considering the existence of blocks with high minimum bonuses, 52% of experts stated that this information does not impact their competitive analyses if blocks are located in EP areas. Therefore, almost 63% of the experts considered that information to have a negative impact, reducing the level of competition for the blocks in new frontier areas. These results can be explained by companies´ risk aversion. When bidding for areas located on EP areas, companies are more confident on their own geologic and economic evaluation, and are aware of the petroleum system and production facilities, which may reduce their financial exposure. Contrarily, in new frontier areas where geological uncertainties and technological challenges should be first solved, companies prefer not to bid for blocks with high minimum bonuses values to avoid a winner's curse.

According to experts' opinion, mapping qualified companies' strategies and behavior are very important variables for competition estimation (see Table 3 for reference). Evaluating the bidding history of each company can help the identification of potential competitors. This is reinforced by analyzing companies' behavior of buying and selling petroleum assets in the basin, in Brazil or worldwide. For example, one company that has never bided for Campos Basin bought its geological and geophysical data or acquired working interest by faming out. This potential non-competitor (SPC) - a company that is familiar with Brazilian licensing, but have never bid for Campos Basin - has an increasing interest for the basin, according to around 90% of specialists, but only little percentage believes SPC will not present an offer (Table 4). On the other hand, if a company is a well known potential competitor (CC), meaning companies that usually bid for the basin, although 50% of experts pointed out the increasing interest for the basin, and 40% stated that CC participation on the licensing is unpredictable.

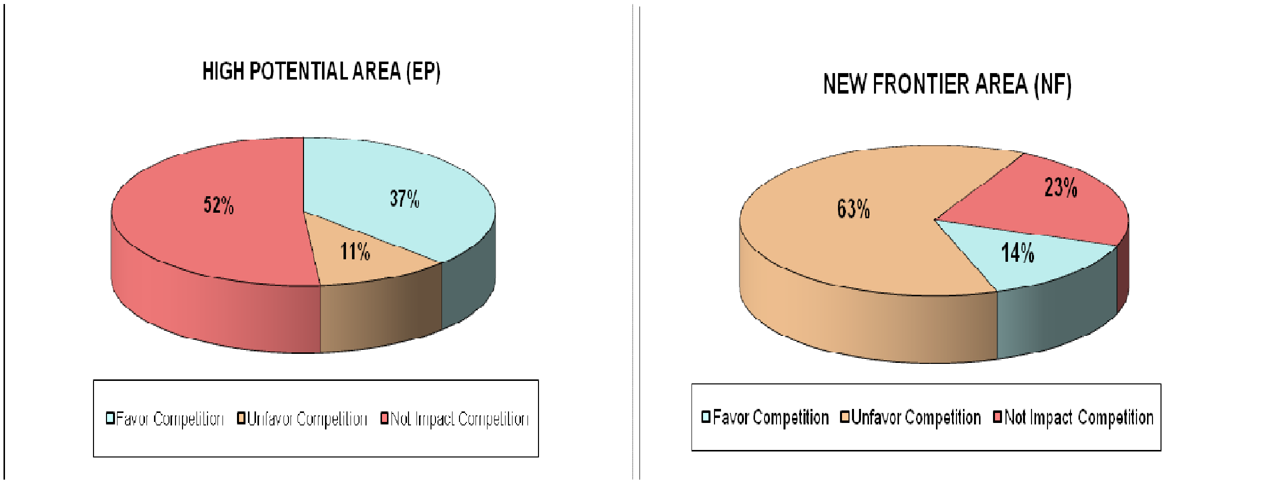


Figure 7 - Expert´s judgment on competition impact due to minimum bonus value for both High Potential and New Frontier Areas

TABLE 4 – CC and SPC working interest acquisition that could affect licensing participation

COMPANY PROFILE	EXPERTS BELIEVE ON THE RELEVANCE OF COMPANIES INFORMATION	INCREASING INTEREST	WILL NOT PRESENT OFFER	UNPREDICATBLE PARTICIPATION
CC	> 88%	48.6%	11.4%	40%
SPC	100%	54.3% (high) 37.1% (medium)	8.6%	----

Besides companies´ activities on acquiring and selling acreage previous to a bid round, it is elementary to analyze companies´ international strategies, financial health and reserve figures. The questionnaire asked specialists about three different companies SPC, CC and NE – a company that has never bided in Brazil and is not used to the Brazilian fiscal system (Table 5). Regarding SPC profile, 43% of the experts stated they prefer to monitor its behavior and they do not expect SPC as a strong competitor with aggressive offers. However, respondents consider very important mapping NE, because although not knowing its strategy, they do believe in an unexpected aggressive bidding or in a strategic alliance with a potential competitor (CC).

Companies, despite of being SPC, CC or NE, could bid alone or in consortia according to their bidding strategies. Sunnevåg (2000) and Saidi & Marsden (1992) analyzed 40 years sales data bank of Outer Continental Shelf (US-GOM) and revealed that companies associate among themselves to share information and investments. So, consortium formation reduces risk of financial loss and aggregates geological knowledge, enhancing the possibility a consortium has to win acreage.

TABLE 5 – Degree of importance of qualified companies according to their profile

QUALIFIED COMPANIES' PROFILE	LEVEL OF IMPORTANCE		
	VERY IMPORTANT	IMPORTANT	NO IMPORTANT
CC	83%	17%	0%
NE	46%	48.5%	5.5%
SPC	14%	43%	43%

When argued about this issue, 80% of experts indicated that companies also associate to avoid competition, besides the two above mentioned reasons. In Brazilian petroleum leases the number of players and the number of acreage offered differ by one order of magnitude when compared to US-GOM leases (Rodriguez & Suslick, 2008), which is a possible explanation. The low availability of acreage leads companies to jointly bid reducing the number of potential competitors, as well as enhancing their possibility to win some area.

Trying to understand how companies estimate competition in a situation where competitors associate to bid, a set of specific questions were made:

a) Specialists were argued about how they classify information on companies' strategies for a licensing. According to Figure 8, it is remarkable that information given by decision-makers is classified as very important (83%), suggesting that companies rely each other. This is reinforced by 69% experts, who consider "important" all information disclosed by companies' representatives other than decision makers. If information is obtained from newspaper, specialized magazines, among others, respondents split their opinion between "less important" (43%) to "not relevant" (34%), although 23% still grade as important. The explanation stands on the source of information, i.e., news given by a trustful person or entity should be taken into account, otherwise is rumor, as well as those coming from comments raised during the licensing period.

b) Specialists were invited to play a game for estimating competition in a scenario where information was released by newspapers, the acreage is the same for all cases, and are offered according to the same rules. Table 6 shows the outcomes for five different cases reflecting experts' judgments on competition estimation when companies bid jointly.

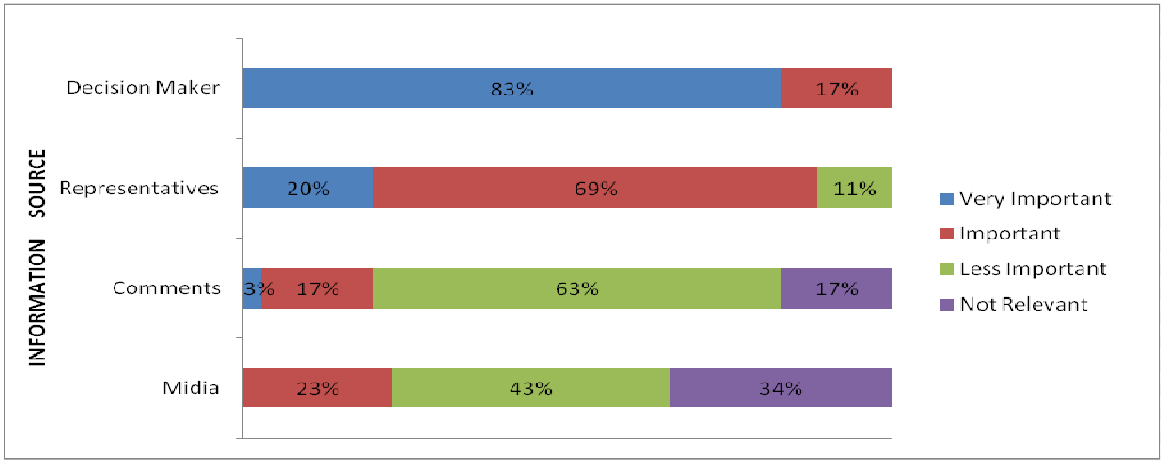


Figure 8 - Expert's evaluation by information source. An information gave by a decision-maker is very important when compared with some extracted from a newspaper, for example, which is considered irrelevant by 34% experts.

TABLE 6 **– Impact of jointly bidding on competition estimation**

CASE	CONSORTIA FORMED AMONG POTENTIAL COMPETITORS COMPANIES (CC)					
	CC	EXPERT'S COMPANY	NUMBER OF CONSORTION	TOTAL NUMBER OF COMPANIES	NUMBER OF OFFERS	COMPETITION ESTIMATION
CASE 1	5	1	2	6	4	HIGH = 22 / MD* = 11
CASE 2	4	1	3	5	2	HIGH = 15 / MD* = 14
CASE 3	3	1	2	4	2	HIGH = 19 / MD* = 13
CONSORTION FORMED WITH A NEWCOMER (NE)						
CASE 4	3	1	2	4	2	HIGH = 13 / MD* = 20
CONSORTION FORMED WITH A NON POTENTIAL COMPETITOR COMPANY (SPC)						
CASE 5	3	1	2	4	2	HIGH = 7 / MD* = 26

(*) MD – a moderate competition

Cases 1 to 3 are scenarios of high competition and specialist's company is assumed to participate in all bids. Nevertheless, Case 2 splits expert's opinion into high and moderate. This can be explained by the association of the specialist's company with another CC, reducing competition as per the experts' perception. From their point of view, as their company is jointly bidding with a CC they assess more information and enhance budget, mitigating competition and becoming a stronger competitor.

Cases 4 and 5 deal with situation where newcomers and non-competitors profile, respectively, are also players in the bidding game. Both cases present the same conditions such as number of companies, consortia and offers, differing exclusively by the presence of a NE (Case 4) and SPC (Case 5). Experts consider a consortium formed between a CC and a NE to be a stronger competitor than another formed between CC and SPC. They estimate competition as moderate to high for Case 4 (57%) and 74% of specialists indicate an essentially moderate competition for Case 5, when a SPC associates with any other company. This observation is in accordance to specialists´ opinion on SPC relevance as a player in Brazilian licensing, as previously expressed.

The game, above described, directly revealed experts' estimation of competition for a particular licensing scenario when there is information regarding consortium formation.

Another set of questions retrieved valuable data on experts' knowledge, later on treated to build the automated computer program able to infer the expected level of competition for a specific petroleum lease. The Corvid® Expert System resulting from this research, i.e., considering expert's judgment on a variety of issues concerning historical Brazilian licensing, proved to be a powerful tool for non-specialists interested in analyzing competition in tenders with characteristics similar to those mentioned in Annex 1. Software outcomes for four bidding cases are presented in Table 7.

In Case 1 user is willing to investigate competition for a lease sale with eight qualified companies competing with the user's company. Four of them are potential competitors (CC), two newcomers (NE) and two companies with non-competitor profile (SPC). User's company is interested in bidding for blocks located in high potential sector and close to areas with recent exploratory successful results (variable EXPSUC_EP = yes). Recently it was announced some hydrocarbon discoveries in the basin, then the variable DESCBAC was set as “yes”. The results achieved for CASE 1 revealed a high plus number of competitors, area of very high attractiveness, release of strategic information that stimulates competition, leading to an estimation of a High competition.

Cases 2 and 3 show two different licensing bid simulations, presenting the same estimation result - a Moderate level of competition. For Case 2, there were three potential competitors companies (CC) and one newcomer (NE), besides the user’s company, aiming to bid for blocks close to the ring fence of oilfields located in high potential areas (RFDP_EP=yes). The third variable that lead expert system to estimates a moderate competition was the information about a recent discovery in a similar play, but in another basin under evaluation by user’s company (DESCPLAY=yes). Despite the fact that the release of strategic information stimulates competition (DESCBAC=yes) in both cases, what differs Case 2 from Case 3 is the number of competitors - Medium level for Case 2 and Medium Minus for Case 3 (1 SPC, 2 NE and 2 CC), and the attractiveness of the area, which is High for Case 2 and Median for Case 3, due to the existence of recent results of exploratory success in new frontier areas (EXPSUC_NF=yes).

The last case, Case 4, presents the bidding conditions for a Low level of competition, which is reached whenever the area has low attractiveness and the number of competitors is medium minus. It means, the block user’s company is interested in evaluating competition is located in a new frontier area close to ring fences of oilfields (RFDP_NF=yes) and there is no potential competitors (CC) qualified for the licensing round, with only 1 SPC and 3 NE.

This study revealed positive aspects on a petroleum lease sale that could impact competition, and the area attractiveness was unanimously pointed out as the most impacting parameter to attract companies’ attention. Nevertheless, there was one question addressed to specialists dedicated to assess if there was any issue they recognize as of a negative impact on lease tenders.

TABLE 7 – Simulated results of expected level of competition using an expert system built from oil industry experts´ knowledge

CASE STUDY	CENARIO_PRECO (*)			TIPO_BACIA (**)				NUM_COMPETIDORES			ATRATIVIDADE_AREA				INFO_ESTRATEGICA			LEVEL OF COMPETITIO N ESTIMATION
	<25	26<$<50	>51	Onshore		Offshore		SPC	NE	CC	EP		NF		LEGISLA	DESCBAC	DESCPLAY	
				Mature	New Front.	Mature	New Front.				EXPSUC_EP	RFDP_EP	EXPSUC_NF	RFDP_NF				
CASE 1		40				x		2	2	4	YES	NO	NO	NO	NO	YES	NO	HIGH
								HIGH PLUS			VERY HIGH				ESTIMULA COMPETIÇÃO			
CASE 2		40				x		0	1	3	NO	YES	NO	NO	NO	NO	YES	MODERATE
								MEDIUM			HIGH				ESTIMULA COMPETIÇÃO			
CASE 3		40				x		1	2	2	NO	NO	YES	NO	NO	YES	NO	MODERATE
								MEDIUM MINUS			MEDIAN				ESTIMULA COMPETIÇÃO			
CASE 4		40				x		1	3	0	NO	NO	NO	YES	NO	NO	NO	LOW
								MEDIUM MINUS			LOW				NÃO AFETA PERCEPÇÃO			

Table 8 shows that, despite the attractiveness of the acreage on sale potential changes on game rules are enough to create a risky environment for exploration investment. What experts do remark as strongly impacting the participation of any oil company, more than the possible presence of potential competitors or newcomers, is the Brazilian fiscal and legal environment for performing E&P activities. Any changes made by the Government on the fiscal system, the regulatory framework, or to the licensing rules, could immediately cause a retraction on companies' intention to participate.

TABLE 8 **– Impact on companies´ participation in a licensing when the regulatory framework is subject to changes**

COMPANY PROFILE	EXPERTS TRUST ON THE IMPACT ON COMPETITION	HIGH POTENTIAL AREA (EP)	NEW FRONTIER AREA (NF)
COMPETITOR (CC)	> 91%	> 88%	> 85%
NEWCOMER (NE)	> 94%	> 86%	> 86%

The Brazilian petroleum lease history data presents unusual results regarding companies bidding for acreage on the 5th Licensing Round that could be assumed as an example of that expert perception. Rodriguez & Suslick (2009) pointed out that only three oil companies, amongst the eighties used to participate in Brazilian auctions, made offers in that licensing round characterizing a low competitive bid. These authors correlated this with: a) the changes on the fiscal system (Noel and Valentin Laws), and b) the new licensing model approved by ANP, which introduced new criteria to define the winner offer, and changed some technical concepts (PEM as biddable factor, area size, relinquishment policies, exploration phase duration, among others).

Although these changes have negatively impacted competition on the 5th Licensing Round, the oil industry reacted positively, returning to the game in the following leases. This behavior can be assigned to the success of the petroleum exploration activities observed then. Some constrains established for the 8th licensing round, so as the number of area acquired by the same operator, caused its suspension *sine die*. Just before starting the 9th Bid Round, ANP withdrew

from the auction portfolio areas with subsalt potentials after Tupi wildcatd results (Berman, 2008). These unstable procedures promoted a revision on the current auction model.
The Petroleum Law 9478/97, in force for over 10 years, proved that auctioning acreage through Concession Contract agreements is a model that stimulated high risk investments in a period when oil prices raised from US$12,00/bbl to US$130,00/bbl. This investment in petroleum exploration lead to oil and gas field discoveries, such as Tupi - a super-giant oilfield - located in deep water Santos Basin, with pre-salt reserves estimated from 5 to 8 Billion boe (Berman, 2008).

Recently, in the same geologic play and region, a series of similar potential oilfields were discovered, leading Brazilian proved reserves from 14.2 Billion boe to a total reserve estimated from 70 to 100 Billion boe. These discoveries opened a new oil frontier, motivating the Federal Government to review the petroleum regulatory policy to protect Brazilian oil and gas reserves. The proposal considers changing from Concession Contracts licensing to a Production Sharing Contracts, for all acreage to be licensed in areas where the pre-salt horizons occur.

4.2. Competition Expectation under Production Sharing Contracts

Production Sharing Contracts (PSC) is a petroleum exploration licensing system conceived by the oil industry to have the rights and obligations to explore attractive acreage in high risk countries, such as those located in Asia and Africa. Based on sharing all oil and gas produced from an area, it is a competitive licensing process as the Concession Contract.

Almost all petroleum contracts in effect worldwide provide for Government Take to be a mix of financial revenues and production entitlement. As shown in Figure 9, countries adopt different contract models the most commom being PSC and Concession Contracts. Europe and particularly USA have more open systems for the E&P activity. Middle East is the most protectionist region. One of the most common legal arrangements between a Government (or its National Oil Company - NOC) and a private company is the PSC. The main difference between Concessions and PSC Contracts is that under the former the Company is entitled to the hydrocarbons before or upon them being produced (Johnston, 1994). Table 9 presents more details on both models of contracts.

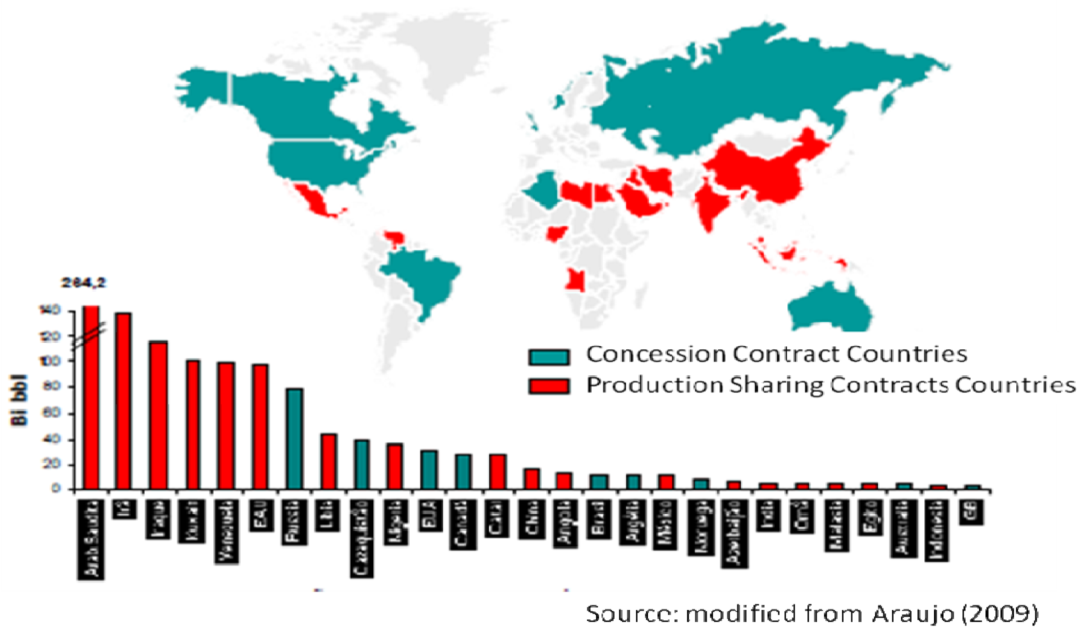


Figure 9 - Map with the countries that promote licensing of exploration acreage applying Concession Contract and Production Sharing Contract models.

Although Brazil has been successful in differentiating itself from its Latin America neighbors, a new regime is to be introduced through amendments to the existing Petroleum law (Law 9478/97), the creation of a National Oil Company (Pré Sal Petróleo S.A. - PPSA), and a Social Fund at a Federal level. This new legal framework should be applied exclusively to the pre-salt areas, being the remaining onshore and the offshore shallow or deepwater areas subject to the current regime.

As this new licensing model is still under discussion and the associated regulatory policy is essentially different from that applied for the well known Concession Contract rules, listening to the oil industry experts about their perceptions on the expected level of competition for the new licensing model was very opportune.

Table 9 – Main differences between Concession Contracts and Production Sharing Contracts

	Concession / License Contracts	Production Sharing Contracts
Parties	Grantor = Sovereign or Government Agency Grantee = Investors and possible Participating Local Companies	Principal = NOC or Government Agency Contractor = Investors and possible NOC and/or Participating Local Companies
Fiscal System	Royalty / Tax	Cost Recovery / Profit Share
Government Take	Signature and production bonuses Royalties (5% to 10%) Property taxes on assets owned Income taxes on profits from operations Special participation tax varying from 10% to 40% according to volumes and water depth of the field, among others	Signature and production bonuses Government share of production Income taxes on Grantee' s profit from sale
Asset Ownership	Grantee owns the assets and has the duty to abandon and decommission	NOC owns the assets from cost recovery Contractor has the right to use the asset until termination
Production Ownership	Grantee owns production at wellhead	Contractor is entitled to a share of production
Management and Control	Grantee manages and controls operations subject to regulations	Grantor manages and controls according to regulations and approved work program

All 36 experts were unanimous in referring to PSC as a familiar contract model that could be applied for pre-salt areas with no major effect on the contractors' side. They recognized that this licensing program, theoretically, is as competitive as the concession contracts in force.

Among the interviewees, some reported that majors and super majors are used to explore in countries with PSC licensing agreements, and are familiar to Brazilian political and economic culture - once they are concessionaires of E&P Brazilian assets – will comfortably deal with the regulatory changes, and consequently, continue to compete for the pre-salt acreage. On the other hand, independents and regional companies should bid in a more conservative way or make a tight sensitivity risk analysis indicating not to present an offer in the bid process.

The last question of the questionnaire was created to cover this subject. Although a multiple-choice question, with two "yes" and two "no" options, participants were encouraged to give their opinion regarding what is expected in terms of competition after changing the licensing policy.

The statistics obtained during this enquire is shown in Figure 10. Sixty-four percent of experts (64%) believe that this change will reduce the level of competition, but 20% do not see any impact. Both 8% figures reflect a percentage of experts that prefer not to respond the question and those which state that there are some aspects of the policy that could motivate companies to compete and others that could promote the opposite effect. It means that most part (64%) believes in a negative impact reducing the level of competition, but 20% do not see any impact. A small group of experts (8%) states that the policy could motivate companies to compete or to decline offer. The remaining eight percent (8%) represents experts that prefer not to respond the question.

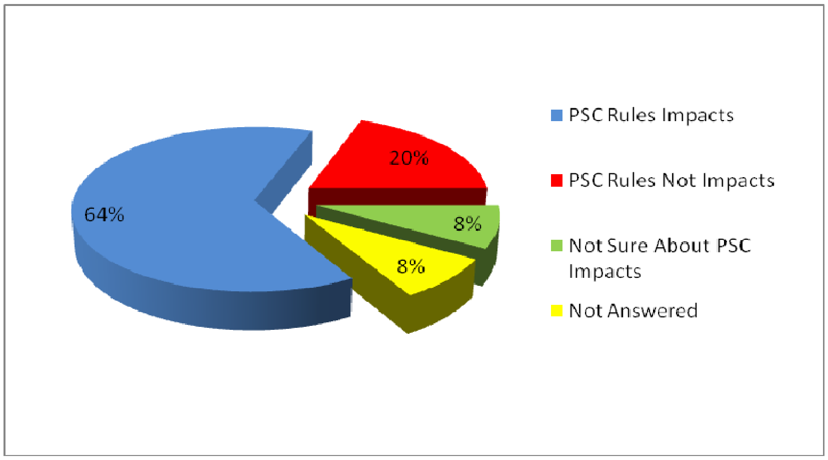


Figure 10 - Result of expert´s opinion about the possible impact on competition with the possible change on the current licensing policy.

Regarding the “no” responses (20%), all experts but one, indicate the high potential of pre-salt areas as the main factor to keep competition at similar levels of such observed in previous concession contracts bids. One expert believes in the maintenance of competition level because these changes do not significantly affect companies´ interest even when loosing rights to oil property and having a maximum working interest limited to 70%.

In respect of the “yes” answers, which account for 64%, most of the respondents expect a change on the level of competition with the approval of the amendments on the Petroleum Law currently in force, implementing the PSC as the licensing model for the pre-salt areas. Nevertheless, among these experts it is possible to group participants with different opinions.

Within 64%, only 10% of the experts believe on the reduction on competition due to restriction for hydrocarbon production entitlement to companies. Despite the majority not expects lack of transparency in the conduction of PSC licensing agreement among Brazilian Government and petroleum companies, twenty percent (20%) of the “yes” population related this negative aspect with a possible impact on competition level. Their opinion are supported by Cramtom (2005) who reported that PSCs are often associated to lack of transparency, because the negotiations between the Principal and each Contractor or Consortium while selling E&P assets are developed in different occasions. However, what reinforces the majority of participants not expecting any kind of collusion and/or corruption in the process of selling areas within the new legal framework is ANP´s ability in sale E&P acreage for the past 10 years under clear rules previously established, and Brazilian stable fiscal system.

The large majority (70%) of oil industry representatives interviewed agreed that a change from a Concession Contract model to a Production Sharing is definitely not the issue when analyzing competition. What really could impact the level of expected competition are the rules adopted for the PSC structure. They are mainly concerned with two aspects of the new regulatory policy: 1) the power delegated to PPSA, the company proposed to be the NOC in the PSC model, and 2) the designation of Petrobras, a Brazilian state company which had the monopoly to perform E&P activities in Brazil for around 45 years, as the sole operator for all acreage to be licensed under the PSC rules.

Among the four amendments seeking for congress approval, the creation of a NOC – PPSA, which has privileges on the voting procedure for both technical and operational decisions, is pointed out as the detrimental aspect of the process. Moreover, another key issue raised by experts is the establishment of Petrobras as the unique operator of all pre-salt areas to be licensed. A quick wrap-up of the judgment of the 33 experts giving opinion on such subject (Figure 11), lead to the conclusion that Brazilian Government intention to change the licensing model, envisaging strategic protection of the pre-salt high oil volumes zone, is acceptable by 77% of all upstream companies currently searching for oil and gas offshore Brazil.

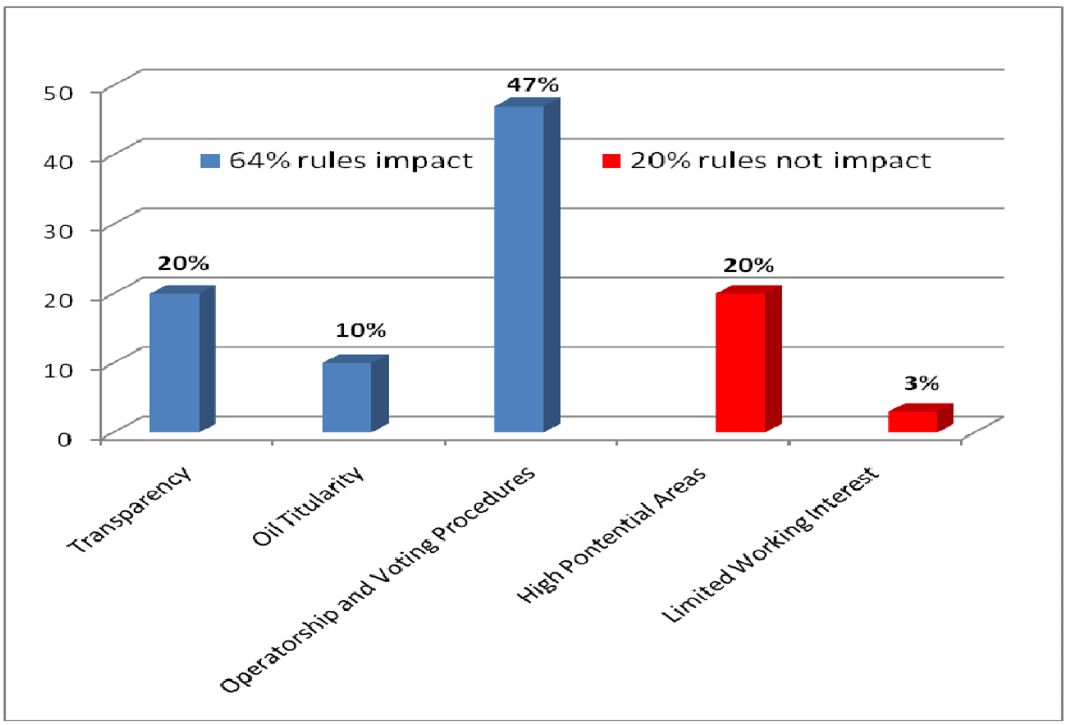


Figure 11 - Graphic showing total 33 "yes" and "no" answers on policy changes on the current licensing model. "No" answers (23%) are related to the high potential pre-salt areas and to the working interest limited to 70%, as proposed by PSC rules. The "yes" answers (77%) as per expert’s opinion are associated with hydrocarbon entitlement and lack of transparency, and mainly with the voting procedure and unique operatorship.

However, the establishment of rules that could prevent them to fully operate E&P assets and voting against or in accordance with the consortium decisions, without the interference of a purely administrative company, as PPSA is supposed to be, could significantly impact the competition level, as perceived by experts.

5. Conclusions

Analyzing competition in a petroleum lease sale is not an easy task, and this is the reason why the literature to generally consider its existence as an assumption for mathematical models developed to define optimal bids, such that maximize revenues in a simple bonus bidding system. However, Brazilian licensing model is more complex and besides bonus, deal with both working program and local content as biddable factors. So, defining the optimal bid becomes more complicated, pushing companies to do a better job while evaluating competition, and helping decision-makers find suitable bidding strategies.

This study targets to understand how oil companies' representatives, used to participate in Brazilian lease, perceive competition, and also build a practical tool that could estimate the expected level of competition in a Brazilian tender.

The first objective was reached by the development of a questionnaire applied to 36 specialists from 20 oil companies and governmental entities to investigate specialists' opinion about competition. Questions were formulated using a database built based on ANP results in the last eight licensing rounds in which Campos Basin acreage was offered. This method proved to be effective in assessing experts judgment on the main licensing variables that directly impact the decision making process. Nevertheless, it is important to keep in mind that limitations on intelligence and perception constrain the ability of decision-makers to accurately calculate the optimal choice from the available information (Bazerman, 2006). The main conclusions of the current research project are the following:

- The questionnaire successfully captured experts knowledge and is robust enough to allow a comprehensive understanding in how specialists mind deal with technical data, strategic information and licensing rules to estimate competition;
- There is no bias observed on the questionnaires answers neither per specialists business position nor for their companies profile. This can be correlated to past professionals experience of the interviewed team;
- According to 94% of the assessed experts, what grants the success of a petroleum lease sale is the quality of the auctioned asset. High potential areas attract competitors interest. Since the 80's Brazil is discovering giant to super-giant oilfields, attracting oil industry attention to Brazilian hydrocarbon potential acreage (Moraes Jr et al., 2004). This is confirmed by the high levels of competition for assets located at Campos Basin as shown by Furtado et al. (2008), exception made for the 5th Licensing Round;
- What do really cause a negative impact reducing competition are uncertainties, not those related to acreage, but to the policies, as happened during the year of the 5th tender. An unstable fiscal system or a licensing process conducted without transparency is unanimously identified by industry representatives as key that reduce the success of a bid round;
- Almost all interviewees indicated high level of competition for acreage located in high potential areas or even in new frontiers, since they are prospectively sit on a sedimentary basin with active petroleum system, and have production flowing systems available close by;
- More than 90% of respondents, the proper evaluation on qualified companies characteristics (strategies, budgets, exploration portfolio, etc), which is crucial for a calibrated competition estimation. Experts stated they should be aware of potential competitors (CC) movement, i.e., companies that usually bid in Brazil for mature basins where they already perform E&P activities and are qualified for the round. Companies that have never bided in the country, i.e. newcomers (NE), meaning not being familiar with ANP and Brazilian policies, prefer to associate with CC to avoid losing the bid if they make offers alone and based only in the symmetric information they acquired from ANP database. On the other hand, companies used to bid in Brazilian tenders, but acquired data for a mature basin where they never bid before (SPC), do not demand experts attention. They do not expect SPCs competing against CCs,

which has asymmetric information, but farming into opportunities in the basin, other than effectively participating in the licensing.

The second goal was accomplished by the development of an automated expert system, using Corvid® platform, which works with a knowledge database build from experts' judgment on competition issues that were transformed into rules. It proved to be an efficient tool, as per the findings obtained for the four theoretical cases implemented on the software. The expert system was able to properly estimate the level of competition level expected for each case, showing coherent outcomes when run by non-specialists. Users must be aware that this expert system was developed for Brazilian lease of Campos Basin acreage in a period of time when average oil price was US$40,00/bbl. Results may vary according to the assumptions adopted.

The last conclusion refers to a current discussion about the newly proposed regulatory licensing policy. As shown by this study, competition granted the success of licensing promoted by ANP under the Concession Contract model. For licensing acreage under Production Sharing Contract model, specialists (64%) expect an impact in competition level due to the rules adopted by the government and not because of the model. PSC is a well known model applied in many countries worldwide, which facilitates the bid for companies familiar with its rules. In Brazil, experts pointed out two main reasons for reducing competition: a) the decision to have PETROBRAS as the unique operator for all acreage licensed, and b) the voting procedures for the NOC (Pré-Sal) who can reject both technical and economic issues. If the regulatory changes are approved as is, then competition level may be affected.

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ANNEX 1

ASSUMPTIONS ADOPTED TO BUILD THE KNOWLEDGE BASE OF THE CORVID® EXPERT SYSTEM

Licensing

- Brazilian tender
- Competitive sealed bid
- Concession contract model
- Average petroleum price for the last two years assumed as US$40,00 / bbl

Acreage Offered

- On a mature offshore sedimentary basin (Campos basin)
- On High Potential (EP) areas to reallocate national reserve and supply the growing domestic demand
- On New Frontier (NF) areas to attract investments for regions with poor geological information or with technological barrier

Qualified Companies

- Brazil is a strategic country for experts' company investments
- A mature offshore basin with a proved petroleum system and an existing flowing system is the acreage expert's company is focusing
- All potential competitors (new comers or companies used to bid for the basin) have the same strategic focus
- All companies including expert' s one have a similar ratio reserve per production (R/P), around 10 years

Observation

- The premises above listed were stated envisaging narrowing the questionnaire and keep experts playing the same game. It means that the rules are the same for each respondent.
- From an amount of 26 questions, 36% of the total answers reflect competitor behavior under those specific premises. The other 64% of answers were used to build the knowledge base for the expert system been valid for all possible scenarios.

VARIABLES DEFINED TO BUILT THE KNOWLEDGE EXPERT SYSTEM

[CENARIO_PRECO]

Static List Variable
Prompt: CENARIO_PRECO
Static List Values:

ALTO
ALTO

MEDIO
MEDIO

BAIXO
BAIXO

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line

[EXPSUC_EP]

Static List Variable
Prompt:
Static List Values:

SIM
SIM

NAO
NAO

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Pretende realizar oferta para blocos proximos a areas com sucesso exploratorio em setor de Elevado Potencial ?"
BUTTONS: OneLine

[EXPSUC_NF]

Static List Variable
Prompt:
Static List Values:

SIM
SIM

NAO
NAO

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Pretende realizar oferta para blocos proximos a areas com sucesso exploratorio em setor de Novas Fornteiras?"
BUTTONS: OneLine

[TIPO_BACIA]

Static List Variable
Prompt:
Static List Values:

ONSHORE_MADURA
ONSHORE MADURA

ONSHORE_NOVA_FORNTEIRA
ONSHORE NOVA FORNTEIRA

OFFSHORE_MADURA
OFFSHORE MADURA

OFFSHORE_NOVA_FRONTEIRA
OFFSHORE NOVA FRONTEIRA

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Em que tipo de bacia sedimentar se quer estimar a competicao ?"
BUTTONS: OneLine

[DESCBAC]

Static List Variable
Prompt:
Static List Values:

SIM
SIM

NAO
NAO

Flags:

Always obtain a value: False
Display with results: False

Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Houve recente descoberta de hidrocaborneto na bacia ?"
BUTTONS: OneLine

[DESCPLAY]

Static List Variable
Prompt:
Static List Values:

SIM
SIM

NAO
NAO

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Houve recente descoberta de hidrocarboneto em um play especifico em bacia analoga ?"
BUTTONS: OneLine

[MUDA_LEGISLA]

Static List Variable
Prompt:
Static List Values:

SIM
SIM

NAO
NAO

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Existe alguma intencao de mudanca na legislacao (Tecnica, Juridica ou Fiscal) ?"
BUTTONS: OneLine

[TIPO_AREA]

Static List Variable
Prompt:
Static List Values:

Elevado_Potencial
Elevado Potencial

Nova_Fronteira
Nova Fronteira

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Qual e o setor da bacia que se quer estimar a competicao ?" FORMAT:
BUTTONS: OneLine

[ATRATIVIDADE_AREA]

Static List Variable
Prompt: ATRATIVIDADE DA AREA :
Static List Values:

MUITO_ALTA
MUITO_ALTA

ALTA
ALTA

MEDIANA
MEDIANA

BAIXA
BAIXA

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line

[INFO_ESTRATEGICA]

Static List Variable
Prompt: EXISTENCIA DE INFORMACAO ESTRATEGICA :
Static List Values:

ESTIMULA_COMPETICAO
ESTIMULA COMPETICAO

NAO_AFETA_PERCEPCAO
NAO AFETA PERCEPCAO

DESESTIMULA_COMPETICAO
DESESTIMULA COMPETICAO

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:

TEXT "Existe alguma informacao sobre a movimentacao das companhias com perfil de competidora ?"
BUTTONS: OneLine

[PRECO_BBL]
Numeric Variable
Prompt:

[RFDP_EP]
Static List Variable
Prompt:
Static List Values:
SIM
SIM

NAO
NAO

Flags:
Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:
Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Sua companhia pretende realizar oferta para blocos proximos a ring fences em setor de Elevado Potencial ?"
BUTTONS: OneLine

[RFDP_NF]
Static List Variable
Prompt:
Static List Values:
SIM
SIM

NAO
NAO

Flags:
Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:
Ask with: Radio Buttons
Arrange: One item per line
Before Ask, display:
TEXT "Sua companhia pretende realizar oferta para blocos proximos a ring fences em setor de Novas Fronteiras ?"
BUTTONS: OneLine

[NUM_CIAS_COMPETIDORAS]
Numeric Variable
Prompt:

[NUM_CIAS_SEMPERFILCOMPET]
Numeric Variable
Prompt:

[NUM_COMPETIDORES]
Static List Variable
Prompt: NUMERO DE COMPETIDORES :
Static List Values:

ALTO
ALTO

MEDIO
MEDIO

BAIXO
BAIXO

ALTO_MAIS
ALTO MAIS

MEDIO_MAIS
MEDIO MAIS

MEDIO_MENOS
MEDIO MENOS

Flags:
Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:
Ask with: Radio Buttons
Arrange: One item per line

[NUM_NOVAS_ENTRANTES]
Numeric Variable
Prompt:

[ESTIMA_COMPET]

Static List Variable
Prompt: ESTIMATIVA DO NIVEL DE COMPETICAO ESPERADO :
Static List Values:

MODERADA
MODERADA

BAIXA
BAIXA

ALTA
ALTA

Flags:

Always obtain a value: False
Display with results: False
Never Ask User: False
Display with results: False
Initialize: False
Check for PARAM data passed in Applet call: False
In backward chaining, stop after first value is set: False
In backward chaining, skip redundant rules: False
Use backward chaining to derive value: True
Use External Source to get value: False
Any number of values can be assigned

Display:

Ask with: Radio Buttons
Arrange: One item per line

LOGIC BLOCKS BUILT AS PART OF THE KNOWLEDGE EXPERT SYSTEM PROCEDURES

Logic Block: CENARIO_PRECO_BBL

```
|  [PRECO_BBL] <= 25
       --> CENARIO_PRECO = BAIXO
|- [PRECO_BBL] >= 26
   |  [PRECO_BBL] <= 50
          --> CENARIO_PRECO = MEDIO
|  [PRECO_BBL] >= 51
       --> CENARIO_PRECO = ALTO
```

Logic Block: NUM_COMPETIDORES

```
├─ TIPO_BACIA = OFFSHORE_MADURA
    ├─ [NUM_CIAS_SEMPERFILCOMPET] <= 7
        ├─ [NUM_NOVAS_ENTRANTES] <= 1
            │ [NUM_CIAS_COMPETIDORAS] >= 4
                --> NUM_COMPETIDORES = ALTO
            │ [NUM_CIAS_COMPETIDORAS] = 3
                --> NUM_COMPETIDORES = MEDIO
            │ [NUM_CIAS_COMPETIDORAS] <= 2
                --> NUM_COMPETIDORES = BAIXO
        ├─ [NUM_NOVAS_ENTRANTES] = 2
            │ [NUM_CIAS_COMPETIDORAS] <= 2
                --> NUM_COMPETIDORES = MEDIO_MENOS
        ├─ [NUM_NOVAS_ENTRANTES] = 3
            │ [NUM_CIAS_COMPETIDORAS] <= 2
                --> NUM_COMPETIDORES = MEDIO_MENOS
        ├─ [NUM_NOVAS_ENTRANTES] >= 2
            │ [NUM_CIAS_COMPETIDORAS] >= 3
                --> NUM_COMPETIDORES = ALTO_MAIS
        ├─ [NUM_NOVAS_ENTRANTES] >= 4
            │ [NUM_CIAS_COMPETIDORAS] <= 2
                --> NUM_COMPETIDORES = MEDIO_MAIS
```

Logic Block: INFO_ESTRATEGICA

```
├─ MUDA_LEGISLA = NAO
    │ DESCBAC = SIM
        --> INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
    │ DESCBAC = NAO
        --> INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
    │ DESCPLAY = SIM
        --> INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
    │ DESCPLAY = NAO
        --> INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
│ MUDA_LEGISLA = SIM
    --> INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
```

Logic Block: ATRATIVIDADE_AREA

```
├ TIPO_AREA = Nova_Fronteira
   ├ EXPSUC_NF = SIM
      │ RFDP_NF = NAO
            --> ATRATIVIDADE_AREA = MEDIANA
   ├ EXPSUC_NF = NAO
      │ RFDP_NF = SIM
            --> ATRATIVIDADE_AREA = BAIXA
   ├ RFDP_NF = SIM
      │ EXPSUC_NF = SIM
            --> ATRATIVIDADE_AREA = MEDIANA
   ├ RFDP_NF = NAO
      │ EXPSUC_NF = NAO
            --> ATRATIVIDADE_AREA = BAIXA
├ TIPO_AREA = Elevado_Potencial
   ├ EXPSUC_EP = SIM
      │ RFDP_EP = SIM
            --> ATRATIVIDADE_AREA = MUITO_ALTA
      ├ RFDP_EP = NAO
         │ [NUM_CIAS_SEMPERFILCOMPET] >= 1
               --> ATRATIVIDADE_AREA = MUITO_ALTA
         │ [NUM_CIAS_COMPETIDORAS] >= 1
               --> ATRATIVIDADE_AREA = MUITO_ALTA
         │ [NUM_NOVAS_ENTRANTES] >= 1
               --> ATRATIVIDADE_AREA = MUITO_ALTA
   ├ EXPSUC_EP = NAO
      │ RFDP_EP = NAO
            --> ATRATIVIDADE_AREA = ALTA
      ├ RFDP_EP = SIM
         ├ [NUM_NOVAS_ENTRANTES] >= 1
            │ [NUM_CIAS_COMPETIDORAS] = 0
                  --> ATRATIVIDADE_AREA = MEDIANA
         │ [NUM_CIAS_COMPETIDORAS] >= 1
               --> ATRATIVIDADE_AREA = ALTA
         ├ [NUM_CIAS_SEMPERFILCOMPET] >= 1
            │ [NUM_CIAS_COMPETIDORAS] = 0
                  --> ATRATIVIDADE_AREA = MEDIANA
```

ANNEX 2

CRITERIA USED TO DEFINE CUT-OFFS FOR DIFFERENT LEVELS OF COMEPTITION ACCORDING TO ALL POSSIBLE ARRANGEMENTS BETWEEN NUM_COMPETIDORES, ATRATIVIDADE_AREA AND INFO_ESTARTEGICA VARIABLES

The questionnaire first answer was used to classify and prioritize the variables that should be applied to estimate the level of competition. Three variables, among the five listed on Table 10 and, as suggested by the literature, were selected to perform competition analyses. Setting values to: a) the degree of importance of basin and area on offer; b) number and profile of qualified companies; and c) to companies' strategic information variables, was possible to calculate weights for these variables. The next step consisted in giving notes for each variable value, as seen on Table 11. A competition scale was defined multiplying weights per grades for each of the 72 licensing cases (possibilities to combine the three variables), as shown on Table 12.

TABLE 10 - Weight calculation for the variables to be used in competition estimation

Degree of Importance	Experts judgment on variables degree of relevance for competition estimation					
	Licensing Period	Petroleum price scenario and R/P	Number and profile of qualified companies	Basin and areas on offer	Companies´ Strategic Information	Value
Very Important	7	12	15	33	7	9
Important	12	19	17	2	21	3
Less Important	16	4	3	0	7	1
Total	115	169	189	303	112	-----
Rounded weight	-----	-----	1.9	3.0	1.1	----

TABLE 11 – Grades attributed to each of the three selected variable value for competition estimation

NUM_COMPETIDORES		ATRATIVIDADE_AREA		INFO_ESTRATEGICA	
Grade	Variable Value	Grade	Variable Value	Grade	Variable Value
6	High Plus	5	Very high	3	Stimulate
5	High	4	High	2	Do not affect perception
4	Medium Plus	3	Median	1	Do not stimulate
3	Medium	1	Low		
2	Medium Minus				
1	Low				

Figure 12 shows the level of competition scale obtained from the data presented on Table D. Values of 6.0 and 29.7 define the lower and upper limits of the competition level scale, respectively. The cut-off parameters that limit low competition level situation to moderate and from moderate to high are 15.5 and 22.5, respectively. These cut-offs, when applied to each licensing case, allow the estimation of the level of competition (Table C).

Figure 12 – Level of competition scale built to determine cut-off parameters defining low, moderate and high ranges.

TABLE 12 – Worksheet with all possible arrangements with the three selected variables, weights and grades, results and the estimation of level of competition

Licensing Case	Rounded Weights			Competition Sacle	Expected Level of Competition
	1.90	3.00	1.10		
	NUM_COMPETIDORES	ATRATIVIDADE_AREA	INFO_ESTRATEGICA		
	Notes				
1	6	5	3	29.70	HIGH
2	6	5	2	28.60	HIGH
3	6	5	1	27.50	HIGH
4	6	4	3	26.70	HIGH
5	6	4	2	25.60	HIGH

6	6	4	1	24.50	HIGH
7	6	3	3	23.70	HIGH
8	6	3	2	22.60	MODERATE
9	6	3	1	21.50	MODERATE
10	6	1	3	17.70	MODERATE
11	6	1	2	16.60	MODERATE
12	6	1	1	15.50	MODERATE
13	5	5	3	27.80	HIGH
14	5	5	2	26.70	HIGH
15	5	5	1	25.60	HIGH
16	5	4	3	24.80	HIGH
17	5	4	2	23.70	HIGH
18	5	4	1	22.60	MODERATE
19	5	3	3	21.80	MODERATE
20	5	3	2	20.70	MODERATE
21	5	3	1	19.60	MODERATE
22	5	1	3	15.80	MODERATE
23	5	1	2	14.70	LOW
24	5	1	1	13.60	LOW
25	4	5	3	25.90	HIGH
26	4	5	2	24.80	HIGH
27	4	5	1	23.70	HIGH
28	4	4	3	22.90	HIGH
29	4	4	2	21.80	MODERATE
30	4	4	1	20.70	MODERATE
31	4	3	3	19.90	MODERATE
32	4	3	2	18.80	MODERATE
33	4	3	1	17.70	MODERATE
34	4	1	3	13.90	LOW
35	4	1	2	12.80	LOW
36	4	1	1	11.70	LOW
37	3	5	3	24.00	HIGH
38	3	5	2	22.90	HIGH
39	3	5	1	21.80	MODERATE
40	3	4	3	21.00	MODERATE
41	3	4	2	19.90	MODERATE
42	3	4	1	18.80	MODERATE
43	3	3	3	18.00	MODERATE
44	3	3	2	16.90	MODERATE
45	3	3	1	15.80	MODERATE
46	3	1	3	12.00	LOW
47	3	1	2	10.90	LOW

48	3	1	1	9.80	LOW
49	2	5	3	22.10	MODERATE
50	2	5	2	21.00	MODERATE
51	2	5	1	19.90	MODERATE
52	2	4	3	19.10	MODERATE
53	2	4	2	18.00	MODERATE
54	2	4	1	16.90	MODERATE
55	2	3	3	16.10	MODERATE
56	2	3	2	15.00	MODERATE
57	2	3	1	13.90	LOW
58	2	1	3	10.1	LOW
59	2	1	2	9.00	LOW
60	2	1	1	7.90	LOW
61	1	5	3	20.20	MODERATE
62	1	5	2	19.10	MODERATE
63	1	5	1	18.00	MODERATE
64	1	4	3	17.20	MODERATE
65	1	4	2	16.10	MODERATE
66	1	4	1	15.00	MODERATE
67	1	3	3	14.20	LOW
68	1	3	2	13.10	LOW
69	1	3	1	12.00	LOW
70	1	1	3	8.20	LOW
71	1	1	2	7.10	LOW
72	1	1	1	6.00	LOW

These ranges of competition supported mapping the viable licensing cases reducing knowledge developer work when building knowledge base rules on CORVID® expert system. Combination such as NUM_COMPET = high, ATRAT_AREA = high and INFO_ESTRAT = stimulate, do not affect perception and do not stimulate (5 – 4 – 3/2/1), presents the same expected level of competition, independent on the value of INFO_ESTRAT. Then, whenever a variable does not contribute for changing the result of expected level of competition, the combination was written as a single rule on the logic block ESTIMA_COMPET.

Some theoretical licensing cases do not represent real situation, as per experts judgments, such as NUM_COMPET = Plus high, ATRAT_AREA = median and INFO_ESTRAT = stimulate (6 – 3 – 3). In this specific example, a situation of ATRAT_AREA = median can only occur when

NUM_COMPET is equal to Low, Medium Minus or Medium Plus (1 – 3 – 3 or 2 – 3- 3 or 4 – 3 – 3). Once identified these cases, the corresponding rules were cut from the logic block ESTIMA_COMPET. The final structure and rules of the logic block are presented next.

Logic Block: ESTIMA_COMPETICAO

```
|- NUM_COMPETIDORES = ALTO_MAIS
   |  ATRATIVIDADE_AREA = MUITO_ALTA
         --> ESTIMA_COMPET = ALTA
   |  ATRATIVIDADE_AREA = ALTA
         --> ESTIMA_COMPET = ALTA
   |- ATRATIVIDADE_AREA = MEDIANA
      |  INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = ALTA
      |  INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
            --> ESTIMA_COMPET = MODERADA
      |  INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = BAIXA
         --> ESTIMA_COMPET = MODERADA
|- NUM_COMPETIDORES = ALTO
   |  ATRATIVIDADE_AREA = MUITO_ALTA
         --> ESTIMA_COMPET = ALTA
   |- ATRATIVIDADE_AREA = ALTA
      |  INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = ALTA
      |  INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
            --> ESTIMA_COMPET = ALTA
      |  INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = MEDIANA
         --> ESTIMA_COMPET = MODERADA
   |- ATRATIVIDADE_AREA = BAIXA
      |  INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
            --> ESTIMA_COMPET = BAIXA
      |  INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = BAIXA
|- NUM_COMPETIDORES = MEDIO_MAIS
   |  ATRATIVIDADE_AREA = MUITO_ALTA
         --> ESTIMA_COMPET = ALTA
   |- ATRATIVIDADE_AREA = ALTA
      |  INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = ALTA
      |  INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
            --> ESTIMA_COMPET = MODERADA
      |  INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = MEDIANA
         --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = BAIXA
         --> ESTIMA_COMPET = BAIXA
|- NUM_COMPETIDORES = MEDIO
   |- ATRATIVIDADE_AREA = MUITO_ALTA
      |  INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = ALTA
      |  INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
            --> ESTIMA_COMPET = ALTA
      |  INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = ALTA
         --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = MEDIANA
         --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = BAIXA
         --> ESTIMA_COMPET = BAIXA
|- NUM_COMPETIDORES = MEDIO_MENOS
   |  ATRATIVIDADE_AREA = MUITO_ALTA
         --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = ALTA
         --> ESTIMA_COMPET = MODERADA
   |- ATRATIVIDADE_AREA = MEDIANA
      |  INFO_ESTRATEGICA = ESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = MODERADA
      |  INFO_ESTRATEGICA = NAO_AFETA_PERCEPCAO
            --> ESTIMA_COMPET = MODERADA
      |  INFO_ESTRATEGICA = DESESTIMULA_COMPETICAO
            --> ESTIMA_COMPET = BAIXA
   |  ATRATIVIDADE_AREA = BAIXA
         --> ESTIMA_COMPET = BAIXA
|- NUM_COMPETIDORES = BAIXO
   |  ATRATIVIDADE_AREA = MUITO_ALTA
         --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = ALTA
         --> ESTIMA_COMPET = MODERADA
   |  ATRATIVIDADE_AREA = MEDIANA
         --> ESTIMA_COMPET = BAIXA
   |  ATRATIVIDADE_AREA = BAIXA
         --> ESTIMA_COMPET = BAIXA
```

7. CONCLUSÕES E RECOMENDAÇÕES

Dentre os fatores que atestam o sucesso das licitações de áreas para exploração e produção (E&P) de petróleo no Brasil destacam-se a qualificação de um número elevado de companhias, que implica em competição pelas áreas, e a qualidade do portfólio exploratório ofertado que, com suas conseqüentes descobertas de hidrocarbonetos, atrai o interesse dessas companhias. Aliados a esses fatores, o baixo risco-país, a existência de um regime fiscal estável e a clareza nas regras das licitações promovidas pela ANP, propiciaram um ambiente mais seguro para os investimentos das empresas de petróleo de pequeno, médio e grande porte, gerando benefícios ao País, tais como o desenvolvimento de setores da indústria do petróleo e o recolhimento de participações governamentais, dentre outros tributos.

O modelo de licitação competitivo selado adotado pela ANP é considerado eficiente e difere da maioria das licitações internacionais por prover ao governo: a) receitas “upfront” decorrentes do pagamento de bônus para aquisição de área; b) informações sobre as características geológicas das áreas e seu potencial petrolífero, resultante das atividades exploratórias, e comprometidas pelas companhias, como o Programa Exploratório Mínimo (PEM); e c) o desenvolvimento da indústria nacional a partir da oferta de um percentual de contratação de bens e serviços domésticos para a execução das atividades de E&P.

Em todas as dez licitações de áreas exploratórias e nas duas licitações de áreas inativas com acumulações marginais observam-se movimentos de cooperação, com a formação de parcerias para dividir os riscos técnicos e financeiros, reduzindo, assim, o número de competidores – e movimentos de competição entre as firmas - onde a companhia detentora de informação assimétrica possui uma vantagem competitiva em relação às demais na disputa pela aquisição de uma área.

Historicamente, analisando as ofertas para as áreas da Bacia de Campos, é possível observar os comportamentos de cooperação e competição entre as companhias. Nas áreas de maior potencial geológico e nas chamadas de "*golden blocks*", as companhias tendem a realizar ofertas associadas entre si e a oferecer valores próximos a um (1,0), que são muito maiores que as frações do valor monetário esperado (VME) que a literatura recomenda como oferta ótima (0,3) para enfrentar a competição. Para essas áreas, quantificar o "dinheiro deixado sobre a mesa" ou considerar a possível "maldição do vencedor" são dados sem valor para as próprias empresas e para a ANP, sendo apenas uma informação que revela o grau de aversão ao risco das empresas: alto risco x alto prêmio x alto investimento. Entretanto, para ofertas realizadas para as áreas de potencial geológico médio e baixo, o modelo de simulação estocástico construído mostrou ser uma ferramenta robusta para auxiliar os decisores na definição do bônus ótimo. A estimativa do valor de VME/km^2 permite as firmas elaborarem ofertas competitivas para o bloco de seu interesse, em um cenário de alta volatilidade de preços de petróleo e incertezas nos determinantes do mercado. De acordo com a simetria entre os valores de VME/km^2 efetivamente realizados e os estocasticamente simulados pode-se concluir que quanto maior o número de competidores, maiores os valores de VME/km^2 ofertados pelas companhias, em situações em que há simetria de informações. Quando há assimetria, apesar de não ter sido objeto desta pesquisa, observou-se que as companhias menos informadas, em geral, realizam poucas ofertas, porém são mais agressivas nos valores apresentados. Esta metodologia pode revelar a expectativa exploratória das companhias, como verificado nas licitações da Bacia de Campos, tornando visível seu comportamento em termos de estratégias de oferta, alocação financeira de recursos e formação de consórcios com suas preferências. O modelo estocástico proposto pode ser aplicado para áreas em outras bacias, mesmo que localizadas fora do Brasil, desde que licitadas sob um modelo competitivo selado.

Observando-se que os valores pagos pelas firmas para as áreas da Bacia de Campos eram, por vezes, elevados, efetuou-se uma análise comparativa entre estas ofertas e as realizadas pelas empresas para áreas do Golfo do México Americano (US-GOM), com o intuito de quantificar o interesse das empresas no Brasil. As licitações escolhidas para análise, realizadas em 2004 e 2005, consideraram a existência de um mesmo cenário de preços de petróleo e potencial geológico das áreas. Mesmo o US-GOM, atraindo o interesse de um número de companhias de três a quatro vezes maior que no Brasil, e tendo um número de áreas ofertadas entre 200 e 400% maior que o montante de áreas ofertadas no Brasil, identificou-se que as empresas oferecem o dobro do valor por unidade de área para as áreas de águas profundas brasileiras. Em 2004, as empresas pagaram US$55.000,00/km^2 para as áreas localizadas em lâmina d´água superior a 400m de profundidade e US$25.000,00/km^2 em áreas semelhantes do US-GOM. Em 2005 estes valores foram US$160.000,00/km^2 contra US$80.000,00/km^2, respectivamente. Ressalta-se que, para as áreas do US-GOM os valores são obtidos dividindo o bônus de assinatura pelo total de área arrematada com esses bônus. Para as ofertas brasileiras esses números foram calculados adicionando ao bônus, o montante comprometido como PEM, após converter as unidades de trabalho (UT) em valores monetários. Tais números confirmam a atratividade da Bacia de Campos, e do Brasil, no cenário mundial de oportunidades exploratórias, atraindo assim, os investimentos da indústria do petróleo.

Entretanto, para as companhias realizarem esses investimentos e adquirirem as áreas que atendem ao seu portfólio exploratório, ou seja, aquelas que podem maximizar suas receitas, além da valoração técnica e econômica da área, se faz necessária uma avaliação rigorosa do nível de competição esperado.

Para estimar o nível de competição, construiu-se um sistema especialista cujo insumo foi um questionário desenvolvido para capturar o conhecimento de 36 especialistas que atuam como técnicos, gerentes, consultores, diretores e presidentes em 20 companhias de petróleo de pequeno, médio e grande porte. Tal questionário propiciou ainda, conhecer como as companhias lidam com as informações técnicas, regulatórias e estratégicas para estimar a competição, além de permitir a quantificação das variáveis que impactam a competição nos modelos licitatórios de concessão e de partilha de produção.

Para 94% dos entrevistados o que mais estimula a competição é a qualidade das áreas oferecidas pela ANP, ou seja, a oferta de áreas de elevado potencial geológico localizadas em bacias sedimentares com sistema petrolífero ativo e dispondo de infraestrutura para escoamento da produção de petróleo e gás natural sugere elevada competição. Por unanimidade, o que negativamente impacta a competição são incertezas do tipo regime fiscal instável e/ou falta de transparência nas regras da licitação.

O perfil estratégico, financeiro e exploratório das companhias qualificadas nas licitações, bem como seu histórico de atuação no Brasil (compra e venda de ativos de E&P) foi identificado por 90% dos especialistas como sendo a segunda mais importante variável de impacto na estimativa de competição. Ao se analisar a competição para as áreas de elevado potencial e de novas fronteiras da Bacia de Campos, 83% dos especialistas indicaram como potenciais competidoras (CC) as companhias qualificadas atuantes no país e que já possuem exposição exploratória na bacia. Entretanto, companhias qualificadas que atuam no Brasil, mas que nunca apresentaram oferta para esta bacia, foram consideradas por 46% dos especialistas como sem perfil de competidoras (SPC) por disporem apenas de informações simétricas, ou seja, aquelas que qualquer empresa pode adquirir do banco de dados da ANP. Segundo 14% dos especialistas, as companhias conhecidas como novas entrantes (NE), i.e., aquelas que nunca participaram de uma licitação brasileira, preferem competir em associação com as CC para terem acesso a informações privilegiadas (assimétricas) sobre a bacia, que lhes garanta uma vantagem competitiva.

Essas percepções, adquiridas através do questionário, foram transformados em regras para a construção de um sistema especialista, utilizando a plataforma Exsys Corvid®, capaz de estimar o nível de competição para áreas da Bacia de Campos em um cenário de preço de petróleo pré-estabelecido a US$40,00/bbl.

A simulação de quatro casos teóricos em que se variou: 1) o tipo de área em oferta, 2) o número e o tipo de companhias qualificadas, 3) a existência ou não de informações sobre campos em produção, descobertas de petróleo na bacia ou em plays análogos, e 4) a estabilidade do sistema fiscal e regulatório, mostrou resultados coerentes. Além da estimativa robusta do nível de competição, outra vantagem da ferramenta desenvolvida é sua interatividade que permite a qualquer usuário não especialista nas licitações brasileiras, através de respostas a perguntas pré-estabelecidas, conhecer o nível de competição para a área que deseja avaliar.

Por fim, questionados sobre o impacto da nova regulamentação do setor petróleo na competição pelas áreas do pré-sal, 64% dos especialistas acreditam em uma diminuição na competição, não pelo modelo de Partilha de Produção adotado, pois este é mundialmente reconhecido como válido, apesar de ser considerado pouco transparente, mas sim pelas regras estipuladas que conferem à Petrobras a operação exclusiva das áreas licitadas, e o poder de veto à companhia estatal - Pré Sal Petróleo S.A..

Como recomendações para trabalhos futuros sugere-se: a) desenvolver novos questionários que possam capturar o julgamento dos especialistas em licitações brasileiras com relação ao cenário de preço de petróleo variável e a competição em bacias terrestres, por exemplo; b) incorporar as consequentes respostas desses novos questionários ao sistema especialista existente, ampliando seu escopo, de forma a estimar o nível de competição em outras bacias brasileiras, ou outras licitações mundiais, ou sob quaisquer modelos regulatórios onde exista a competição; e c) desenvolver modelos com base na teoria dos jogos visando definir estratégias de oferta mais competitivas que usam bônus e PEM, para as licitações brasileiras considerando as metodologias aqui desenvolvidas de valoração da área e de estimativa de competição.

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