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A decision model for financial assurance instruments in the upstream petroleum sector

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Abstract

The main objective of this paper is to deepen the discussion regarding the application of financial assurance instruments, bonds, in the upstream oil sector. This paper will also attempt to explain the current choice of instruments within the sector. The concepts of environmental damages and internalization of environmental and regulatory costs will be briefly explored. Bonding mechanisms are presently being adopted by several governments with the objective of guaranteeing the availability of funds for end-of-leasing operations. Regulators are mainly concerned with the prospect of inheriting liabilities from lessees. Several forms of bonding instruments currently available were identified and a new instrument classification was proposed. Ten commonly used instruments were selected and analyzed under the perspective of both regulators and industry (surety, paid-in and periodic-payment collateral accounts, letters of credit, self-guarantees, investment grade securities, real estate collaterals, insurance policies, pools, and special funds). A multiattribute value function model was then proposed to examine current instrument preferences. Preliminary simulations confirm the current scenario where regulators are likely to require surety bonds, letters of credit, and periodic payment collateral account tools.

Keywords: Financial assurance; Performance bonds; Economic modeling

1. Introduction

Due to current world developments and to the ever-increasing demand for nonrenewable fossil fuels, governments are likely to intensify exploration and production (E & P) efforts, including small and marginal fields. In fact, several traditional and non-traditional producing nations have already established tax incentive policies and royalty relief programs. These policies and programs are based on the perception that oil imports carry profound economic and political costs, which are intensified during times of international instability. Even though governments are interested in maintaining (and improving) investment flow and competitiveness within the sector, safeguarding tax-payers against industry's environmental noncompliance costs is becoming a critical issue.

The scenario described above calls for a number of considerations regarding a desirable balance between the public outcry for environmental accountability and the industry pressure for regulatory flexibility. Regulators are mainly concerned with the noncompliance risk offered by the increasing interest of newly formed and small companies in small and marginal fields (MMS—Minerals Management Services, 2001; ANP-Brazilian Petroleum Agency, 2001; DTI—UK Department of Trade and Industry, 2001; BLM—US Bureau of Land Management, 2000; NPD—Norwegian Petroleum Directorate, 2000). In addition, without protection mechanisms, large companies could open small, spurious companies to evade closure liabilities.

Owing to the evolution of social consciousness and pressure from interest groups, regulators are being compelled to establish stringent environmental policy requirements, including incentive mechanisms aimed at safeguarding society against environmental degradation and related financial liabilities (Ferreira and Suslick, 2001). Financial assurance requirements (bonds) come as a response to environmental compliance concerns in

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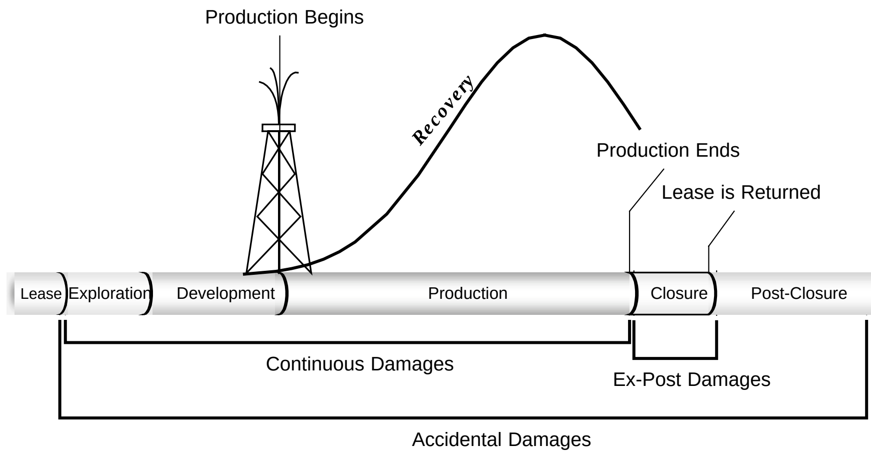

Fig. 1. The life of an oil project, its phases, and potential for environmental damages (Ferreira and Suslick, 2001).

the oil sector, where it is being used to reduce the risk of noncompliance on end-of-leasing contractual obligations[1]. Bonds have been adopted by several countries in order to cope with these ex post liabilities in the petroleum sector; among them, Canada, United States, United Kingdom, Australia, and Brazil.

The application of bonding mechanisms is a complex subject involving a great deal of controversy. The scope of this paper is limited and solely directed to the application of bonding instruments within the upstream petroleum sector aimed at ensuring compliance with closure obligations (reclamation, abandonment and decommissioning operations). As will be explained, these activities are specifically associated with the process of mitigating ex post environmental damages, providing and enforcing conditions of negligible health and safety risk to local inhabitants, and ensuring safety for navigation and the environment.

The present work does not focus on the nature or scale of potential environmental impacts; instead, it provides elements in a systematic effort to broaden the current discussion involving the application of bonding instruments in the E & P sector. This paper is divided into three sections. The first section describes different forms of environmental damages and presents an overview of environmental costs. It discusses some important concepts, such as assessment of monetary value of environmental damages and internalization of environmental costs. Section 2 briefly describes the main forms of regulatory approaches, explains the application of bonding mechanisms in the upstream petroleum sector, identifies and analyzes a number of bonding instruments currently being used in the sector, and proposes a systematic instrument classification. The last section offers a decision model to explain the current instrument choice among regulators and the industry.

2. Forms of environmental damages

Upstream petroleum activities have the potential of generating a wide range of environmental impacts (chemical, physical and biological disturbances). Such impacts may be manifested in the surface and subsurface, in the water and water bottoms, and in the atmosphere.

In order to better assess potential environmental impacts, Patin (1999) suggests a special classification for the development phases, taking into consideration the respective sequence of operations: (1) geological and geophysical survey (seismic surveys, test drilling, etc.); (2) exploration (rig emplacement, exploratory drilling, etc.); (3) development and production (platform emplacement, pipe laying, drilling, extraction, separation, transport, well and pipeline maintenance, etc.); (4) closure and decommissioning (disassembling, structure removal, well plugging, site clearance, land reclamation, etc.).

Ferreira and Suslick (2001) propose three broad categories of environmental damages within the specific context of hydrocarbon recovery: ex post, accidental and continuous environmental damages (Fig. 1). ;This classification helps to organize our discussion, assisting in the optimum application of bonding mechanisms.

[1] Recent events tend to significantly affect the political behavior among larger fuel consuming nations. At least initially, a regressive trend may be perceived on environmental policies. This may occur because in order to reduce fuel dependency from unreliable and hostile foreign sources governments may be tempted to relax environmental regulations for the upstream sector. However, in due course, domestic and international pressure should force them back on track towards more stringent environmental regulations, including the adoption of bonding requirements.

2.1. Accidental damages

This category includes environmental impacts caused by oil companies in unforeseen events during the course of daily operations. Levels of risk are assigned according to the availability of statistical data on specific events. For instance, an oil company may have control over some contingencies, making it possible to reduce the risk and intensity of accidental damages. In other cases, there is no control over events and no possibility of risk reduction. Examples of accidental damages: blowouts, accidental spillage, accidental discharge of drilling muds or produced waters, sinking of offshore installations, vessels or helicopters, etc.

2.2. Continuous damages

This category includes environmental damages resulting from on-going processes during the life of a project. Examples of continuous damages are: discharge of drilling muds and cuttings, emissions and discharge of pollutants, deforestation and other physical disturbances, generation of solid waste, emission of waste in streams, sediment resuspension, interference with humans, fisheries and other users, etc.

2.3. Ex post damages

This category includes environmental damages that are anticipated as a result of upstream oil activities. In this case, provisions for the remediation or mitigation of such damages are arranged before leases are granted for a specific project. For instance, companies conducting offshore operations are required to reclaim the site by plugging and abandoning all wells, decommissioning all offshore installations and clearing the site of all obstructions. These operations take place at the end of a project, phase or specific activity. The emphasis lies on achieving proper closure rather than on the closure process. In this case, regulators are not interested in monetary compensations, but rather in the fulfillment of all closure obligations. In order to maximize project value, oil companies are motivated to avoid costs of repairing damages, and pursuing less costly closure alternatives.

Some examples of ex post mitigating activities: plugging and abandonment of wells, removal and disposal of offshore platforms, removal and disposal of debris and obstructions on the ocean floor, site reclamation, revegetation, removal of constructions and access roads, etc.

Ex post is perhaps the best-suited category to be covered by bonds. Some of the corroborating factors are: (1) oil projects have limited time horizons (a defined beginning and a defined end); (2) operations require a lease (or license) before they are undertaken; and (3) in most circumstances, costs for mitigating ex post damages caused by upstream activities can be easily estimated (i.e. cost for plugging wells). This issue is also discussed by Cornwell (1997).

Some of the arguments that make the oil sector more convenient for the application of bonding regulations include:

- Petroleum E & P operations involve significantly smaller areas than other extractive activities.
- In most circumstances, because of the potential for significant government revenue earnings, oil projects are subjected to more scrutiny and more rigorous licensing processes.
- Currently, due to the costs involved in the licensing, exploration and development phases, in most cases, oil and gas projects attract fewer risky parties when compared to the mining sector.
- The potential for ex post environmental damages in petroleum projects is significantly small when compared to potential ex post damages in mining projects.

Nevertheless, a number of emerging issues are likely to introduce some complexity in estimating costs of ex post damages in the oil sector:

- Decommissioning of large, fixed offshore installations: the industry does not have real experience in the decommissioning of large fixed platforms. Consequently, due to technological uncertainties, estimating decommissioning costs is a very controversial issue;
- Decommissioning of pipelines: so far, regulators do not require the removal of pipelines. However, this scenario may change, bringing significant environmental and financial uncertainties to the closure process;
- Cleanup of offshore sites: currently, there is significant discussion involving requirements for the removal and disposal of drill cuttings generated in offshore operations. As regulatory standards for offshore site cleanup toughen, uncertainties will be introduced to the cost estimation of ex post damages;
- Natural-occurring radioactive material (NORMs): the presence of NORMs in waste, fluids and gases brought to the surface from producing subsurface oil and gas formations has become a great concern for the oil industry (McFadding, 1996). Long-overdue handling and disposal requirements for NORM-bearing waste and contaminated equipment will significantly impact ex post costs;
- Residual liability: the discussion on potential residual liability is also expected to add significant uncertainty to this debate: "when can a company walk away" or "when is liability over".

Although the application of bonds is mostly suitable for providing protection against ex post damages, it may indirectly generate incentives for the reduction of continuous and accidental damages. Bonds may be appropriate to cover accidental damages if the probabilities for contingencies are known and if potential damages are not catastrophic or irreversible. There is a wide spectrum of possible continuous damages, and the applicability of bonding mechanisms depends on the nature and extent of the damage.

3. Financial assurance systems and instruments

The main approaches to environmental policies are command and control (CAC, direct regulation) and economic incentive mechanisms (EIM, market alternatives). Both CAC and EIM have been exhaustively discussed in the literature, including their characteristics, applications, and efficiencies (Bohm, 1981; Stollery, 1985; Webber and Webber, 1985; Conrad, 1987; Baumal and Oates, 1988; Perrings, 1989; Cornwell, 1997).

Cornwell and Costanza (1994) compare CAC and EIM approaches, and some aspects are here adapted to the offshore oil sector: The CAC approach consists of establishing and enforcing laws and regulations, and of setting objectives, standards and technologies with which agents must comply. The EIM provides incentives that encourage the desired behavior while allowing firms the flexibility to act on their unique knowledge of their own production and mitigation costs. This decentralizes the decision-making process to protect lease areas; and it relies on performance objectives rather than on a pre-established course of action. Economic analysis indicates that present methods of environmental protection, mostly based on CAC strategies, are inefficient and often provide disincentives for directing resources toward abatement. The main causes are: (1) great uncertainties in calculating closure costs; (2) costly and lengthy litigious processes; (3) homogeneous treatment of oil companies[2] (no record-based assessment); (4) great information burden on the regulatory agency (selecting the best technology and enforcing penalties for noncompliance); (5) little incentive for development of innovations that can result in improvements and cost reductions; (6) regulatory evasion rather than regulatory compliance; and (7) vague regulatory language allowing companies to build persuasive cases by showing that requirements are unachievable.

[2] The designation "oil companies" includes other parties that may be responsible for the performance of closure activities (i.e. operators, individuals, lessees).

3.1. Environmental costs

The feasibility of bonding mechanisms will require that regulators and/or third party insurers possess a reasonable estimate of the costs that the mechanisms will need to cover. If costs are underestimated, the assurance is incomplete, and the regulator may be forced to cover the shortfall. If the costs are overestimated, desirable investment may be deterred, or companies may move their operations to countries with lower regulatory standards. What types of costs are relevant, and how they are measured, depends on the type cost under consideration, as mentioned above.

In the case of closure obligations, companies are required to meet a set of standards determined by the regulatory agency. What is far more complicated is the process of deciding on those standards. Once standards are defined, the costs for achieving those standards are fairly simple to calculate, and will determine the amount that must be provided by the bonding mechanism.

Intuitively, it would seem that the standard should be set so that there are no lingering damages (i.e. costs), environmental or otherwise, after closure operations. In the extreme case, this might require returning the site to the condition it was in prior to the start of the extractive activity. However, closure operations entail considerable costs, and the more stringent the standards set by the regulator, the higher these costs. In fact, it is likely that each step taken towards site rehabilitation costs more than the previous one—eliminating the first 10% of the damages may be fairly inexpensive, the second 10% may cost more, and the final 10% required to return the system to its pristine state may be very expensive indeed. A hypothetical marginal cost of closure operation curve is shown in Fig. 2. In contrast, the benefits to restoration may be falling as the site approaches the 'pristine' state. Plugging a well is likely to have enormous benefits in terms of preventing pollution, environmental degradation and accidents. Removing offshore infrastructures also has important benefits, though less than those of

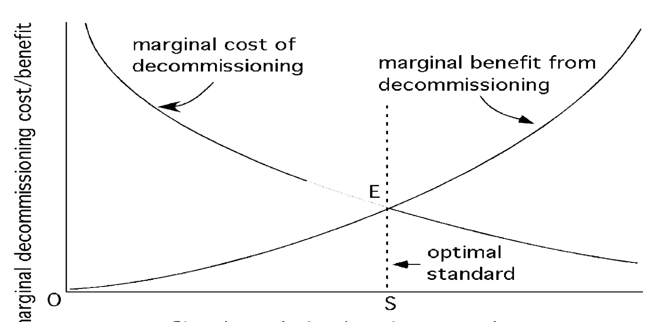

Fig. 2. Marginal costs and benefits of decommissioning operations. Intersection E indicates the point of optimum standard. Area OES indicates a low efficiency scenario, where costs outweigh decommissioning benefits.

plugging the well. Keeping offshore platforms in place or transporting them to artificial reef locations raise a series of issues, including residual liability. However, the presence of offshore structures does improve ecosystem services. Besides, the decision regarding the complete removal of offshore structures should consider the internalization of all decommissioning costs including emissions, energy consumption, safety risks, etc. As increasingly on-site contamination is cleaned up, marginal benefits are likely to fall even further. This is shown by the marginal benefits to closure operation curve in Fig. 2.

If the assumption is correct that the costs of restoration increase as we move towards recreating a pristine system, and the benefits decrease, then at some point the costs will outweigh the benefits (all points to the left of E in Fig. 2). From the efficiency perspective, this is entirely undesirable. To achieve the most efficient allocation of society's resources, the regulator should strive to set the standard at the point of intersection of the marginal cost and marginal benefit curves. This, of course, is much easier said than done, as we shall explain below.

On the other hand, what right does an oil company have to externalize costs transferring the financial burden to society? Should not polluters have to pay for the pollution they cause? Even from the viewpoint of economics, efficient market outcomes require that producers pay all of the costs associated with their production. Consider tax deductions, which imply cost sharing between companies and government/taxpayers (Ferreira and Suslick, 2001). In Fig. 2, these costs are depicted by area OES, and are substantial. While PPP should apply, closure standards are not the most efficient way to achieve this goal. The resources that a petroleum company would require to completely restore a site are resources that would become unavailable for society to apply towards other desirable activities, such as plugging of orphan wells and sites that were literally abandoned before bonds were required. To enforce Polluters Pay Principle (PPP), one option could involve a 'degradation' fee (equal to area OES) added to the costs of meeting the closure standard. Such a fee, if adjusted ex post to reflect actual degradation, could greatly increase the extent to which financial assurance instruments help internalize externalities.

Most types of ex post bonding instruments are a hybrid of market mechanisms and CAC regulations. The ideal market mechanism would allow a firm flexibility in the extent to which it performs closure operations, but force it to pay for all social costs it imposes. Such a system takes advantage of the firm's internal knowledge of production costs, clean up costs and profits. When closure is more expensive than social costs, the firm pays its social costs. When closure is less expensive, the firm performs closure operations. Most important in the dynamic setting, there is always an incentive to seek new technologies and techniques that minimize environmental costs. In the case of bonds, the regulator must determine the closure standard and is therefore less able to rely on the firm's internal knowledge. However, in a number of ways, financial assurance does help improve market function. Bonds force all firms to pay for at least some of the environmental costs they impose on society, without risk of bankruptcy or non-compliance. Bonds force firms to incorporate environmental liabilities directly into their cash flow accounting, and the costs are made explicit to shareholders. As careful management of all phases of a project can substantially reduce ex post liabilities, firms have more incentive to minimize damage and avoid accidents throughout the life cycle of the investment. Perhaps most important, firms cannot avoid these liabilities through bankruptcy or refusal to comply. Firms have incentives to develop new technologies for reducing environmental costs as long as the regulator and/or third party insurers take these into account when determining bond requirements (consider that, in practice, regulatory agencies are not very open to unproven technologies, reducing the incentive for the development of technological innovations). Third party insurers are also likely to monitor projects, potentially reducing regulatory costs in this regard (Apogee/-Hagler Bailly with D.R. Anderson Associates, 1998).

A serious problem with this analysis is that while closure operation costs are fairly simple to estimate, the benefits of such operations are dramatically less so when the impacts include damage to environmental services. There are a number or economic methodologies for estimating the values of environmental services, including contingent valuation, hedonic pricing, travel cost methodology, replacement costs and others (Pearce and Turner, 1990). All of these methodologies are inexact, and rely on a greater knowledge of ecosystem functions, the way those functions benefit humans, and the impacts human activities have on those functions than currently exists. Ecosystems are extremely complex systems, characterized by non-linearity, emergent properties, and non-reversibility beyond often-unknown thresholds (Odum, 1997). The nascent science of complexity theory offers some insights into ecosystem function, but is still inadequate to explain it (Kaufmann, 1995). Instead of the fine line depicted in Fig. 2, marginal benefits of closure operations are better illustrated by a thick smear. With so much uncertainty, the industry will pressure regulators to make the standards as vague as possible, while the public may push for stricter standards. In keeping with the precautionary principle, it is safer to err on the side of caution, and standards should be set closer to complete restoration (Costanza et al., 1997).

Bonding may help reduce the difficulty for regulators to estimate closure costs. If standards are set for closure without bonding mechanisms to back them up, firms will have incentives to overestimate closure costs so that regulators will require less complete closure operations. With bonds however, firms have to pay in advance for closure costs, and lose the incentive to overestimate. The question still remains whose costs should form the basis of the estimate. The firm is likely to be able to meet closure costs more cheaply than the regulator, because it will be able to use its own resources and avoid overhead. The government, in contrast, will have to hire outside contractors, possibly at higher cost. However, as it is the regulator that will have to bear the costs in the event of default, the more likely the firm is to default, the more appropriate it becomes to use government costs (usually, estimations are based on project plans provided by operators and confirmed by the regulator's database, and an additional amount is included, usually 15% to 30%, to internalize indirect costs such as overhead and third-party costs).

3.2. Bonding systems

There are five main stakeholders involved in the bonding process: regulators, industry, society, project financing agents, and bonding agents/third party insurers. The focus of this paper is on regulators and industry. Some key concerns associated with each stakeholder are summarized on Table 1.

Bonds may reduce liability risks by (1) providing financial incentive for contractual compliance; (2) safeguarding government and taxpayers by attaining reasonable protection from default at a minimum increase in project costs; and (3) protecting the environment from potential harm resulting from failure to carry out proper closure operations in a timely fashion. Therefore, oil companies wishing to explore and produce hydrocarbon resources would be required to post a bond in advance equal to the best estimate to cover all closure costs.

Table 1
Main stakeholders

Stakeholders	Main concerns
Regulators (government agencies)	Financial and environmental liabilities Investment flow within the sector
Industry (oil companies)	Profitability Corporate image
Society (public in general and interest groups)	Environmental protection Development
Project financing agents (investors, banks, international development institutions)	Investment returns Image
Financial assurance agents (insurance and surety companies, banks, etc.)	New business opportunities Risk reduction

As mentioned, setting the appropriate bond requirement may be one of the greatest predicaments within a bonding system. It is not always possible to calculate the total monetary value of complex non-market goods such as ecosystem functions and services, though many methodologies currently exist to calculate partial values (for instance, Costanza et al., 1997).

Another predicament within bonding regimes is tax treatment. For most tax regimes, closure obligations are ordinary and necessary expenses. In general, closure expenditures are tax-deductible only when services have been performed and payments have been made. The same rule applies when progressive closure (the phased approach) is adopted.

Under most bonding regimes, there is no deduction available for companies allocating funds as collateral until the company loses ownership of funds. However, if a company pays fees or premiums to keep surety bonds or environmental insurance policies, expenditures would be amortized over the period covered by the bond. The basic rule is that only an ordinary and necessary business expense is deductible; capital expenditure is not. Being contractually liable for closure operations and emitting bonds (in anticipation) to guarantee such operations, does not entitle companies to deduct cost of services before they are actually performed (Ferreira and Suslick, 2000).

3.3. Bonding instruments

Traditionally, bonding instruments have been used to provide different forms of guarantees as shown below (Rowe, 1987; Johnson, 1986; Cornwell, 1997; Miller, 2000): fidelity bonds (guarantee honesty); fiduciary bonds (guarantee the proper management of assets); judicial bonds (guarantee the compliance with judicial decisions); and contractual bonds (guarantee the fulfillment of contractual obligations). The category "Contractual Bonds" includes several subcategories including: performance bonds; construction bonds; bid bonds; service and materials bonds; advanced payment bonds; retention bonds; maintenance bonds; transport bonds; government regulatory bonds; customs bonds; financial bonds; and license and authorization bonds.

Within the E & P sector, two major bond categories can be identified in terms of specific purpose: (1) financial bond, a bond that guarantees the payment of a specific amount determined by the agency in case of noncompliance; and (2) performance bond, a bond that guarantees the performance of a contractual obligation.

Bonds may be used several times within a single contract. Under some regimes, companies acquiring oil or gas leases are required to post a preliminary financial bond (a fixed and relatively small bond) guaranteeing financial aspects of the lease contract (regular payments of rents and royalties, civil penalties, fines, etc.). Usually, companies holding more than one lease may opt for an "Areawide Bond", or "Blanket Bond", in which case, a single bond would cover multiple leases.

In addition to financial bonds, some regulatory agencies require a performance bond, which is usually based on the best-cost estimate for completing closure operations under the established lease contract. Performance bonds serve individual projects and individual wells. Multiple performance bonds may be found within a lease, but a single performance bond cannot be used to cover multiple projects.

Bonds must be maintained until the leases are terminated or transferred and until closure obligations are satisfactorily met. If closure activities are being conducted concomitantly during the life of the project, the phased approach, authorities may authorize proportional releases of the bond.

A bond may be subject to forfeiture for different reasons: (1) if a well or installation has been abandoned or temporarily closed without initiating required procedures; (2) if a company fails to meet closure obligations in accordance with the approved plan; or (3) if a company fails to maintain the amount bonded.

Financial instruments used to meet financial or performance bonding requirements may come in several forms with unique attributes and requirements: some are the pledged assets of a company (cash, securities, real estate, escrow accounts, salvage, etc.); others represent a guarantee for a company's performance, fulfillment of obligations (surety bonds), or the transferring of potential financial liabilities to other agents (e.g. insurance policies); others are securities issued by bonding or insurance companies, banks or other financial institutions; and still others are instruments that indicate the deposit of cash (certificates of deposit) or the existence of a line of credit (letters of credit) (Bryan, 1998).

Definitions and descriptions of currently used bonding instruments can be found in several publications including Anderson and Lohof (1997), Ferreira and Suslick (2000), ANP-Brazilian Petroleum Agency (2001), OSM—Office of Surface Mining (2000), NWF—National Wildlife Federation (2000), and Cornwell (1997).

Some complexities are involved in assessing bonding instruments: (1) a specific instrument may be known by a variety of names; (2) a single instrument may comprise a number of significant variations and still carry the same name; and (3) some instruments can be personalized with contractual clauses altering their behavior, but keeping the same name.

Table 2
Instrument options

A_n	Short name	Bonding instrument option
A_1	SURE	Corporate surety bond
A_2	PIACC	Paid-in cash collateral account
A_3	PPACC	Periodic payment collateral account
A_4	LOC	Letter of credit
A_5	SELF	Self-bond
A_6	IGS	Investment grade security bond
A_7	RE	Real estate collateral bond
A_8	INSP	Insurance policy bond
A_9	POOL	Pool guarantee fund
A_{10}	SFUND	Designated state fund

Bonding instruments are classified in several ways, but a comprehensive classification that could systematically embrace most instruments was not found. Some authors use a general "soft" and "hard" classification (i.e. Miller, 1998). "Hard" for instruments that cause significant direct costs[3], and "soft" for instruments that cause less significant direct costs. Despite less significant direct costs, soft instruments may cause some indirect costs, which may include reduction of credit capacity and increase of loan costs. Table 2 shows some financial tools currently being used as bonding instruments to provide guarantee for end-of-leasing and reclamation operations. This classification was designed to facilitate the systematic evaluation and optimum applicability of each instrument.

4. Decision model

This model is an attempt to explain the current instrument choice by both regulators and industry. It is also intended to systematize the decision-making process to help in the selection an optimum portfolio of bonding instruments. Such portfolio should offer at same time adequate protection for regulators and an acceptable level of cost and flexibility for the industry.

Due to public pressure, regulators must impose bonding requirements; however, such requirements generate significant negative impacts on the industry, which in turn, demands flexibility. Regulators must respond in order to keep the market competitive and maintain the investment flow in the sector. Closing the cycle, some of the flexibility allowed may increase the risk for regulators, triggering further pressure from taxpayers and interest groups, as demonstrated in Fig. 3.

For this comparison exercise, this paper simulates the application of ten different financial instruments identified by Ferreira and Suslick (2001) that are commonly

[3] Direct costs usually refer to opportunity costs and liquidity constraints caused by the allocation of large amounts of money at "startup".

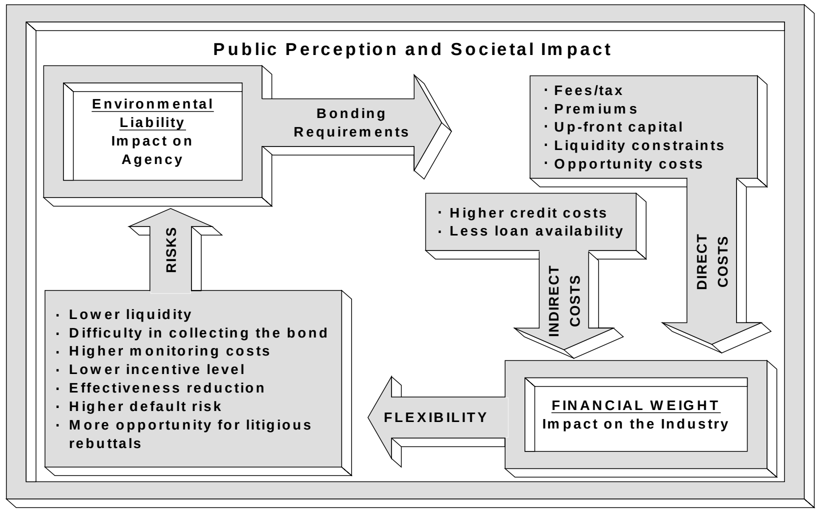

Fig. 3. The dynamics of the bonding cycle: due to public pressure, bonding requirements are adopted. Bonds cause direct and indirect economic impacts on the industry, which pressures for flexibility. Flexibility may increase liability risk, forcing regulators to review requirements.

used in the oil and mining sectors: Corporate surety bonds, paid-in cash collateral accounts, periodic payment collateral accounts, letters of credit, self bonds, investment grade security bonds, real estate collateral bond, pool guarantee funds, designated state funds. These instruments were chosen based on a study done for the Brazilian National Petroleum Agency where several forms of bonding instruments were being considered to provide ex post performance guarantee for petroleum projects (ANP-Brazilian Petroleum Agency, 2001). Currently, ANP requires financial bonds for the bidding process, where letters of credit and cash are accepted. Studies are on the way aiming at requiring performance bonds for all phases of petroleum projects. Among the instruments being studied are collateral cash (paid-in and leasing specific accounts), ex post insurance policies, and letters of credit.

The methodology used in this process was the identification of the most significant attributes according to the perspective of key stakeholders. In addition, a questionnaire was prepared and sent to a number of bond specialists who were asked to rank several bonding instruments under several categories (attributes), according to their own experience. Although subjective, personal experiences of bonding professionals have been particularly helpful to explain the current behavior and trends of regulatory systems. This process has also provided data for the decision model explained below.

The Multiple Criteria Decision Analysis (MCDA) was used to balance the conflicting objectives in the decision model. The main steps can be defined as follows according to Hwang and Yoon (1981), Starr and Zeleny (1977), and Keeney (1992): (1) definition of the main problem; (2) definition of the main attributes/criteria; (3) establishment of the relative importance of each criteria; (4) identification of a set of available alternatives; (5) performance assessment of all alternatives according to each criteria; and (6) selection of best alternatives. This model was developed using the Stella®-software (Fig. 4).

Which of the identified financial instruments (Table 3) are more likely to be accepted as bonding tools for both regulators and the industry? In order to identify the instrument with the highest performance, a process consisting of three parts must be undertaken: part 1, definition of a preferable instrument alternative for regulators; part 2, definition of a preferable instrument alternative for the industry; and part 3, cross-evaluation of results from parts one and two, and the identification of a consensual best alternative.

Regulators and industry view the identified attributes with different degrees of importance (weight) (Table 4). A choice of a certain instrument may be appealing for regulators, but may be severely opposed by the industry. In addition, the degree of flexibility demanded by the industry may pose unacceptable risks to regulators. Costs to meet technical and bonding requirements for closure obligations will impact companies differently. Usually large and financially healthy companies are not significantly affected by bonding requirements, though marginal projects operated by any company (large or small) may be severely impacted. Small companies operating small and marginal fields tend to be the most affected parties.

A comprehensive set of objectives that reflect all concerns relevant to the decision problem are defined at this point (definition of the main attributes). Regulators and the industry do not share the same priorities, but, at same time, do not necessarily have conflicting interests. Regulators are primarily interested in an efficient guarantee (protection), and the industry is primarily interested in reducing economic impacts of bonding

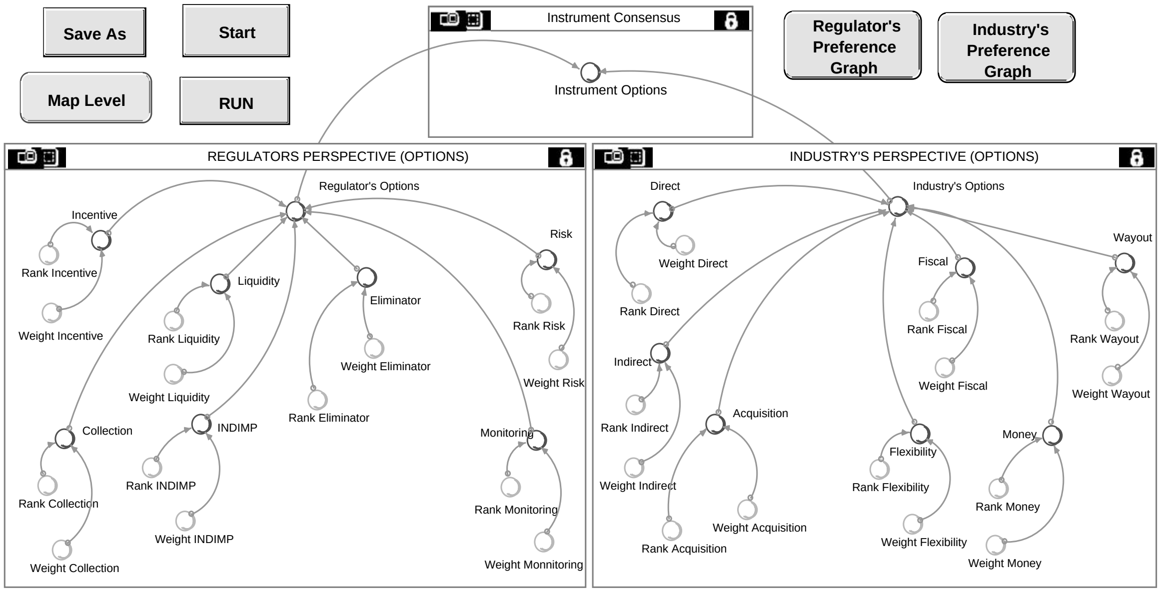

Fig. 4. Diagram of the Stella Model, including the steps of the decision model: U_{reg}, U_{ind} and U_{cons}.

Table 3
Instruments and proposed classification

Proposed classification	Instruments
Credit guarantees	Corporate surety bonds
Collateral Negotiable	Certificates of deposit, cash equivalents, government-issued treasury securities (T-bonds, investment grade securities, etc.)
Collateral Non-negotiable	Letters of credit, real estate, salvage, cash accounts, escrow accounts, paid-in trust funds, trust funds with periodic payments, standby trust funds, external sinking funds, lines of credit bank, etc.
Self-guarantees	Balance sheet tests, corporate guarantees, third-party guarantees, set-aside revenues and self-funding through financial reserves
Liability transfer	Environmental insurance, finite insurance, life insurance, annuities
Risk spreading consortiums (for low-rating participants)	Pool bonds
Risk spreading special funds (for all participants)	State funds

regulations (flexibility). The measures for achieving these objectives are expressed in terms of key attributes identified by both regulators and industry. Two sets of attributes were suggested reflecting the needs and preoccupations of key stakeholders. Each set contains seven attributes. As illustrated in Table 4, the degree to which objectives are met as measured by the attributes is the basis for comparing the sets of bond alternatives: $X_{\text{reg}} = \{x_1, x_2, ..., x_7\}$; $X_{\text{ind}} = \{x_8, x_9, ..., x_{14}\}$.

The decision maker's perception with respect to the evaluation criteria must be incorporated into the decision model. Each attribute has a certain degree of importance for a specific decision-maker. Therefore, a weight, which reflects the relative degree of importance of criteria, is assigned to all evaluation attributes, as shown on Table 4. The derivation of weights is a central step in eliciting the decision maker's preference. Weights reflect the preferences of key stakeholders and hence depend on the choice of individuals. The importance of the attribute x_i could be specified by the weight w_i, where the sum of each set of weights should be equal to 1 (one), as shown below:

$$W_{reg} = \{W_1, W_2, \ldots, W_7\},$$

$$\sum_{i=1}^{7} w_i = 1,$$

$$w_{ind} = \{w_8, w_9, \ldots, w_{14}\},$$

$$\sum_{i=8}^{14} w_i = 1,$$

$$w_{\text{cons}} = \{w'_1, w'_2, \ldots, w'_{14}\},$$

$$\sum_{i=1}^{14} w'_i = 1.$$

In order to assess all alternatives according to each attribute, a finite set of possible bond options $A_j = \{A_1, A_2, \ldots, A_{10}\}$ is provided, as indicated in Table 3. This selection corresponds to the group of most common financial instruments currently being used as bonding instruments in the United States, Canada and

Table 4
Attributes/criteria

Rank	X_{reg}	Short name	Regulator perspective	W_i	W_i'
7	X_1	LIQUIDITY	Level of liquidity offered by the instrument in case of bond forfeit	0.225	0.113
6	X_2	RISK	Overall risk offered by the instrument	0.200	0.100
5	X_3	COLLECTION	Level of difficulty in collecting funds in case of bond forfeit	0.175	0.088
4	X_4	INDIMP	Regulator's concern with impact of instrument on the industry	0.125	0.063
3	X_5	MONITORING	Level of monitoring required in order to ensure instrument integrity	0.100	0.050
2	X_6	INCENTIVE	Level of incentive for contractual compliance offered by the instrument	0.100	0.050
1	X_7	ELIMINATOR	Does the instrument target primarily risky parties?	0.075	0.038
				Total	0.500
	X_{ind}		Industry perspective		
7	X_8	DIRECT	Level of liquidity constraints and opportunity costs (direct costs)	0.275	0.138
6	X_9	FLEXIBILITY	Overall flexibility offered by the instrument	0.200	0.100
5	X_{10}	FISCAL	Level of fiscal advantages offered by the instrument	0.175	0.088
4	X_{11}	WAYOUT	Level of opportunity for an easy way out (legal, etc.)	0.150	0.075
3	X_{12}	MONEY	Level of money value protection for allocated funds offered	0.100	0.050
2	X_{13}	INDIRECT	Impact on credit and loan capacity (Indirect Impact)	0.050	0.025
1	X_{14}	ACQUISITION	Level of difficulty in instrument acquisition (underwriting process)	0.050	0.025
				Total	0.500

UK. The process of evaluating the bond alternatives is based on the value structure and related to the set of evaluation criteria.

This process is intended to specify the performance of each alternative for every evaluation criteria, allowing the identification of the best options. The performance of the bond alternative A_j on attribute x_i is indicated by x_{ij}. The values x_{ij} reflect the performance of alternative A_j according to the criteria x_i. Thus, an alternative is completely specified by its performance score profile, as seen on Table 5. These scores also reflect the personal opinion of key stakeholders from the industry, regulatory agencies, financial institutions and members of the academia involved in the research of market mechanisms.

Table 5
Matrix X_{ij}: performance of bonding alternatives on attributes[a]

Options		Regulators							Industry						
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
A_1	SURE	4	5	4	4	5	5	4	5	4	5	1	1	4	1
A_2	PIACC	5	5	5	1	3	5	2	1	1	1	1	3	4	4
A_3	PPACC	4	4	4	3	2	4	2	2	3	1	1	3	4	4
A_4	LOC	3	2	2	4	2	3	3	3	3	4	3	3	2	2
A_5	SELF	1	1	1	5	1	1	3	5	5	1	5	1	1	3
A_6	IGS	3	4	4	2	4	5	2	1	1	2	1	4	4	4
A_7	RE	1	1	1	5	1	2	1	5	4	2	5	1	2	5
A_8	INSP	4	2	2	4	2	2	2	4	4	5	3	1	5	3
A_9	POOL	3	1	2	4	1	1	1	3	4	1	3	1	4	5
A_{10}	SFUND	3	2	3	3	2	1	1	3	4	1	2	1	4	4

[a] Scores: (1) least favorable through (5) most favorable.

A decision-making rule provides an ordering of all bond alternatives according to their performance with respect to the set of attributes. Choosing the most favorable bonding instruments depends on the selection of the best outcome and the identification of the decision alternative yielding this outcome. The performance of alternative A_j on the set of attributes $(x_1, x_2, \ldots, x_n)$ is associated with vector $(x_{1j}, x_{2j}, \ldots, x_{nj})$ where a component of the vector x_{ij} gives the numerical value of the performance of alternative A_j on criteria x_i.

The multiattribute value function provides an integrated performance score for each bond alternative taking into account all attributes. In the simplest case, value functions can be combined with an additive weighed. Thus the overall value attached to a bond alternative is the weighted sum of its attribute values: $v(a_j) = w_1 \times_{1j} + w_2 \times_{2j} + \cdots w_n x_{nj}$. The components $w_1, w_2, \ldots, w_n$ are the weights which indicate the overall importance of each attribute. Since our problem involves three sub-problems, three different functions will provide the means for the selection of the best alternatives for the regulators, the industry, and for a consensual decision. The three parts of the performance evaluation are shown below (Eqs. (1)–(3)):

Performance of bond alternative a_j for regulators:

$$u_{reg}(a_j) = \sum_{i=1}^{7} w_i x_{ij}. \tag{1}$$

Performance of bond alternative a_j for industry:

$$u_{ind}(a_j) = \sum_{i=1}^{14} w_i x_{ij}. \tag{2}$$

Consensus for decision rule:

$$u_{cons}(a_j) = \left[\tfrac{1}{2} u_{reg}(a_j) + \tfrac{1}{2} u_{Ind}(a_j)\right] = \sum w_i' x_{ij}'. \tag{3}$$

5. Results and discussion

Table 6 indicates the results of the decision rule (Eqs. (1)–(3)). Columns I and II indicate the final scores for the preferences of regulators and industry, respectively, U_{Reg} and U_{Ind}. Column III results from the sum of columns I and II (U_{cons}). Higher scores indicate instruments with agreeable feedback from both parties. Column IV indicates the positive difference between columns I and II ($|\Delta u|$). High U_{cons} values must be compared against $|\Delta u|$ values, which indicate high degree of antagonism between the two parties. The combination high U_{cons} and low $|\Delta u|$ indicates the preferable scenario, where the instrument encounters less resistance from both regulators and the industry, allowing a smoother implementation of bonding requirements.

Preliminary simulations suggest that surety bonds allow the highest U_{cons}. These results are in agreement actual bonding regimes. Insurance policies also reach high scores, however, in actual scenarios; insurance policies are not well accepted by some regulators. They claim the instrument simply transfer liabilities from producers to third party insurers without generating reasonable incentives for compliance. In fact, agents from the insurance sector agree that insurance policies provide an easier way out for lessees when compared to surety bonds. Letters of credit also reach high U_{cons} values, but are not welcomed by some regulators who claim that the instrument is as good as its issuer.

A set of new parameters should be included in the model in order to account for these discrepancies. In addition, since the preference of regulators overcomes the preference of the industry, a factor should be generated to account for this gain allowing a more realistic scenario.

When stakeholders are analyzed separately, the simulations yield a more realistic set of outputs. According to the proposed model, the industry shows preference for insurance policies, self and surety bonds. The same model indicates that regulators tend towards surety bonds and cash collateral accounts.

Table 6
Total utility

	Instruments	I (Regulators)	II (Industry)	III (Consensus)	IV $\|\Delta u\|$[a]
A_1	SURE	2.200	1.775	3.975	0.425
A_2	PIACC	2.038	0.750	2.788	1.288
A_3	PPACC	1.763	1.088	2.850	0.675
A_4	LOC	1.325	1.538	2.863	0.213
A_5	SELF	0.825	1.800	2.625	0.975
A_6	IGS	1.738	0.888	2.625	0.850
A_7	RE	0.800	1.863	2.663	1.063
A_8	INSP	1.350	1.863	3.213	0.513
A_9	POOL	1.000	1.400	2.400	0.400
A_{10}	SFUND	1.175	1.300	2.475	0.125

[a] Δu is the difference between columns I and II.

6. Conclusions

In the oil sector, bonds indemnify authorities against failure to comply with lease contractual obligations, safeguarding agencies against technical and financial failure, and premature or unplanned closure. Under an ideal bonding regime the financial risk is shifted from the agency to the lessees. By internalizing ex post damages and no compliance costs, oil companies are motivated to monitor the consequences of their decisions throughout the project. In case of default, funds necessary to complete all closure obligations would be promptly available avoiding complicated and costly legal processes.

Though a hybrid of market mechanisms and CAC regulations, bonds are also likely to achieve noncompliance protection objectives far more cost efficiently than non-market regulations. Bonds are best suited to cover ex post environmental damages. The main factors include cost assessment and duration of mitigating operations. Some complications are expected in the near future as emerging issues are further considered.

Preliminary results from the simulation model indicate that the surety bond is the most preferable financial instrument among regulators and the industry.

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