EXTENDED ABSTRACT

Preliminary/Incomplete paper, please don't quote it.

Tax Effects on Timing, Scale, and Learning Options in Petroleum Upstream

First Version: January 2nd, 2008. Current Version: February 21th, 2008.

By: Marco Antonio Guimarães Dias (*)

Abstract

The escalation of oil prices in the last years has motivated a debate about natural resources taxation. This paper uses real options approach to discuss different taxation devices for exploration & production (E&P) with focus in Brazilian petroleum sector. The concept of tax neutrality under uncertainty is established when both the project value and investment follows correlated stochastic processes, analyzing the option to delay a project considering corporate income tax and royalties. Other issues like tax efficiency, risk exposition and simplicity, are also considered. The paper discusses the taxation effect on optimal investment timing when exists discrete mutually exclusive alternatives to develop an oilfield, that is, consider the scale option issue on taxation. Next, the paper analyzes the special participation tax for high productive oilfields when there is technical uncertainty about the size and quality of the oilfield considering the learning option before developing the field. The paper suggests a more efficient and win-win design for this special participation tax.

JEL classification: G38; H21; G31; G11.

Keywords: real options, taxation, petroleum exploration & production, taxation under uncertainty, defer option, scale option, learning option, investment under uncertainty.

(*) Adjunct Professor (part-time) at the Industrial Engineering Department, PUC-Rio; and (internal) Senior Consultant at Petrobras. E-mail: marcoagd@pobox.com. Address: Petrobras/E&P-ENGP/DP/EEP. Av. Chile 65, sala 1701 – Rio de Janeiro, RJ, Brazil, 20035-900. Phone: +55 (21) 32242164. Fax: +55 (21) 32241579.

1 – Introduction

In the last years the high prices of commodities in general and the high oil prices in particular, have fomented the public debate on taxation of commodity projects. In the upstream (exploration and production – E&P) petroleum sector some countries have announced higher taxation for new exploratory rights auctions and others have removed some areas from exploratory bids in order to study new taxes.

Some examples: (a) US Government in January 10, 2007, raised the royalties rates (from 12.5 % to 16.7 %) for new oil and gas exploratory blocks lease sales in Gulf of Mexico[1]; (b) The Canadian Government announced in October 2007 new royalties rules for the Alberta's oil and gas resources, starting in 2009[2]; (c) The Brazilian Government in November 2007 removed 41 tracts from the 2007 lease sales in order to study new taxation for the areas with high potential for oil and gas[3].

The US case is a return to 1980´s royalty rates (the 1/6th royalty rate), which was lowered to 1/8th during the 1990´s cheap oil prices years. Canadian new rules can hurt small producers according some critics[4], even more with the jumps in the petroleum equipment costs since 2005. For example, the typical break-even price for oil sands in Canada was US$25/bbl five years ago, jumped to US$ 50/bbl in 2007 and, with the new royalty rules, is estimated to reach US$ 65/bbl[5]. Although the current oil price is near US$ 90/bbl, most oil companies don't believe that this price level is sustainable in the long-run. Most petroleum E&P projects depend on *long-term* oil prices, not short-term oil prices, while the (very expensive) investments are performed upfront, before the production. In addition, almost all new attractive E&P projects are placed in high cost offshore areas like ultra-deep waters and/or sub-salt. These issues suggest that the government countries shall be cautious when proposing new taxation rules, in order to provide sufficient incentives for new investments.

The aim of this paper is to contribute to this debate on E&P projects taxation using the real options framework. With this approach, the paper considers the effect of market uncertainty on the decision to invest or delay (*timing option*) as well as other relevant E&P real options like the *scale option* (investment intensity) and *learning option*. In the last case the paper considers the technical

---

[1] See www.nytimes.com/2007/01/10/washington/10royalty.html
[2] See http://www.cbc.ca/canada/edmonton/story/2007/10/25/stelmach-response.html
[3] See http://www.ft.com/cms/s/0/9ed89916-960a-11dc-b7ec-0000779fd2ac.html?nclick_check=1
[4] See http://oil-gas-news.blogspot.com/2007/10/alberta-royalty-increase-seen-hurting.html ("Alberta Royalty Increase Seen Hurting Small Producers").
[5] See http://seekingalpha.com/article/53987-full-impact-of-albertas-new-royalty-framework-still-years-away and http://seekingalpha.com/article/41128-petro-canada-announces-new-oil-sands-breakeven-50-a-barrel

uncertainties about the size and quality of oil reserves. The paper shows that some taxation instruments or design could hurt investments or can be distortionary inducing oil firms to postpone or to adopt less efficient development alternatives. In this way the paper discusses classical taxation themes like neutral taxation and other related themes.

This paper is organized as follow. Second section makes a literature review on taxation of projects, discusses some theoretical issues like tax neutrality, tax uncertainty and efficiency concepts, and discusses some assumptions for the models used in this paper. Section 3 presents the real options approach for E&P taxation under uncertainty focusing the timing option and two taxation instruments, income tax and royalties. Section 4 studies the effect of discrete mutually exclusive alternatives for oilfield development in the previous timing model, but with a parametric payoff model. Section 5 discusses another tax instrument, the special participation tax for highly productive oilfields, from the perspective of learning options, and suggests another design for this instrument. Section 6 sets some concluding remarks and suggestions for future research.

2 – Taxation and Real Options: Literature Review, Concepts, and Model Assumptions

2.1 – Literature Review

Nowadays real options approach is a well established framework for the modern valuation of projects under uncertainty. However, the real options literature on taxation of projects is still incipient and most real options textbooks don't work this theme or give a very secondary treatment. For example, Trigeorgis (1996) and Copeland & Antikarov (2000) don't analyze this theme. Dixit & Pindyck (1994) give some suggestions, e.g., recommend the use of Poisson process to model *tax uncertainty* instead Brownian process (p. 304) and provides one model of tax policy uncertainty (p. 304-309). But even this more economically oriented textbook recognizes the relative low importance given to this theme: "*we largely ignore the implications of taxes in this book*" (p. 54).

The first real options textbook focusing taxation is very recent: Panteghini (2007). This book is a nice and very important addition to the literature, even being not complete. The book discusses both theoretical themes like tax neutrality and some applications. The book analyzes the taxation effects on entrepreneurship and on firms' decisions, considering the organizational form, capital structure, option to delay, optimal location in foreign direct investment, tax policy uncertainty and alternative tax schemes with emphasis on imputation methods. However, the book doesn't analyze natural

resource taxation or the typical tax instruments in this sector such as royalties and special taxation for high productive projects. But some insights of this book are applicable to natural resource industry.

The classical concept of *tax neutrality* was established and discussed in Brown (1948), Samuelson (1964) and Johansson (1969). This is discussed in the section 2.2.

Postali (2007) .

Pennings (2000) .

Fraser (1993) .

Zhang (1997) .

.

2.2 – Neutrality and Other Taxation Concepts

There is a classical discussion about the desirable properties of taxation schemes. The most popular is the tax neutrality concept. Others are tax efficiency, low risk exposition (or risk sharing) and simplicity. The last one is related with auditing and agency costs, which is important due to the asymmetric information between firms and government about project profitability and costs.

In the traditional literature the tax neutral concept is summarized as follow. Let GT the present value of the *government tax* of one project if the investment is performed now (t = 0). The net present values (NPV) before taxes and after taxes are given respectively by NPV_{bt} and NPV_{at}. So, with these definitions we can write the following equation:

$$\mathbf{NPV_{at} = NPV_{bt} - GT} \qquad \mathbf{(1)}$$

A sufficient condition to tax neutrality is when exists a relevant tax rate τ so that the after tax NPV is $(1 - \tau)$ times the before tax NPV, i.e.,

$$\mathbf{NPV_{at} = (1 - \tau)\, NPV_{bt}} \qquad \mathbf{(2)}$$

The idea is simple. In this way if the NPV_{bt} is positive, the NPV_{at} will be positive irrespective of how high is the tax rate τ, since $\tau \in (0, 1)$. If this rate exists and it is the same for a set of mutually exclusive investments, we get a neutral taxation in the sense that *the ranking of alternative investments* calculated before tax *doesn't change* with the inclusion of this neutral taxation. In this way, tax neutrality means government income tax without changing or distorting the investor decisions.

Many practical issues arise from this neutral tax idea. Is it possible for a single project? If yes, is the same for a set of mutually exclusive alternatives? What happen if we consider the richer real option framework (inclusion of uncertainty and flexibility)?

First, let us consider the case of a single alternative for oilfield development. Assume that the project NPV is the value of operating project V less the investment I, which we´ll assume that follow correlated stochastic processes. That is,

$$\mathbf{NPV = V - I} \tag{3}$$

By the MAD (market asset disclaimer) hypothesis (see Copeland & Antikarov, 2001), the best market estimate for V is the present value of the revenues net of operational costs and taxes, without considering any flexibility. In the same way, the investment is the present value of the investment flow net of tax benefits. In this way, we can define the before tax NPV and the after tax NPV respectively as:

$$\mathbf{NPV_{bt} = V_{bt} - I_{bt}} \tag{3a}$$

$$\mathbf{NPV_{at} = V_{at} - I_{at}} \tag{3b}$$

The difference between equations 3a and 3b is the government tax, as pointed out in the equation 1. The threshold for optimal immediate investment is denoted by (V/I)* and is homogeneous of degree zero in V and I if both V and I follow correlated geometric Brownian motions (McDonald & Siegel, 1986). In this case the weak tax neutrality conditions in the real option context are:

$$\mathbf{V_{bt}/I_{bt} \geq (V_{bt}/I_{bt})^* \quad \Rightarrow \quad V_{at}/I_{at} \geq (V_{at}/I_{at})^*} \tag{4a}$$

$$\mathbf{V_{bt}/I_{bt} < (V_{bt}/I_{bt})^* \quad \Rightarrow \quad V_{at}/I_{at} < (V_{at}/I_{at})^*} \tag{4b}$$

Govern risk exposition with tax systems is a less explored issue by the taxation literature. All tax systems bring some risk exposition to the government. When the economy is in recession, the tax revenue is lower, etc., and this is the moment that government more need to spend money to reactivate the economy or has more social costs like employment insurance. In another context, the risk exposition with specific fiscal policy was analyzed by Auerbach (2004), which recommended the no adoption of systems that could increases even more the risk exposition to the economy movements (see also Panteghini, 2007, p.15).

Tax uncertainty and its effects on investment decisions is another theme studied in the real options literature. As pointed out by Dixit & Pindyck (1994, p.309) and by Hassett & Metcalf (1999), policy uncertainty generally raises the investment threshold and lowers the scale of this investment. The tax effect on optimal scale of the investment is studied in section 3. However, the tax uncertainty effect on investment threshold has been controversial. Dixit & Pindyck (1994, p.307), following an earlier version of Hassett & Metcalf (1999) model, show that increasing tax uncertainty can lower the threshold, speeding up the investment. However, Dixit & Pindyck wrote that "the effect is quantitatively negligible". In this model the uncertainty is modeled as Poisson processes with a frequency λ_0 that the fiscal benefit will be removed (given that it exists) and a frequency λ_1 that the fiscal benefit will be enacted (given that it does not exist). So, the switches between the two tax regimes (with and without fiscal benefits) are governed by Poisson processes. In this case, increasing the frequency λ_0 (and so the Poisson process variance) of benefit removal decreases the waiting value (and so the investment threshold), even when the benefit is not in place. However, they show that the effect of frequency λ_1 is much more relevant and increasing this frequency, increases the threshold, depressing the investment. The intuition is as follow: (a) if the benefit is not currently in place, waiting for a lower investment cost (due to the benefit) is valuable; and (b) if the benefit is currently in place, even if the benefit currently in effect is removed, with high frequency λ_1 it is probable to be restored soon, so the necessity to invest immediately is less important.

Despite these typical trade-off effects caused by tax policy uncertainty over the investment decisions, if quantitatively the depressing effect is more important as pointed out above, frequent changes in tax policy for the E&P sector, is not a recommendable policy if the country wants more investment in this sector. So, again, the country governments shall be cautious in this subject, avoiding the temptation of frequent changes in the tax system due to the "low" or "high" oil prices.

Fiscal Regime for E&P sector is another related issue. The two main fiscal regimes are the *concession* or lease sales system (e.g., Brazil, USA, Norway and other European countries) and *production sharing* contracts (PSC), used mainly in Africa (like Nigeria) and some Asia countries (like Indonesia). Other regime, less used, is the service contract, when the government pays a fee for an oil company to invest and produce oil and gas. Mead (1994) studied these regimes (see also Dias, 1996, cap. 4), concluding that the lease/concession regime is more adequate and efficient mainly in terms of allocation of resources in the economy. Countries with efficient income tax system over corporate profits has preferred the simpler concessions system, regulating the desired rent to be

extracted in specific projects with its typical devices, royalties and special tax, in addition to corporate income tax. These devices are studied here.

Concessions or leases of exploratory areas are generally disputed by oil companies in first-price sealed auctions. In this fiscal system the government earns cash in advance (the bonus paid in the bid) and transfer both exploratory risk (existence, size and quality of a reserve) and market risk (mainly due to the oil price, but not only). Production sharing is an agreement between the oil firms and the host country government regarding the percentage of production each party will receive after the investors have recovered a specified amount of investment costs and other expenses. In this system the government is much more like a partner of the project, typically sharing more risk than the concession regime. It is a more complex system, with more agency costs (e.g., auditing costs) mainly due to the asymmetric information between oil company and govern, and with more transaction costs – typically is created a Government firm as an intermediary between the oil sector and the governmental treasury, with the consequent costs and complexity. The concession regime using income tax plus royalties provides more incentive for cost reduction and for more efficiency in resources allocation than PSC because in the latter these costs are almost all deducted before the oilfield starts paying significant taxes.

Perhaps because it is both more dramatic (a negative signal for the investors) and politically costly, it is rare a change in fiscal regime: once adopted countries have calibrating only the tax devices in each regime. But there is a significant risk of expropriation from radical political changes, as in Venezuela, which depresses much more the oil firms' willingness to invest.

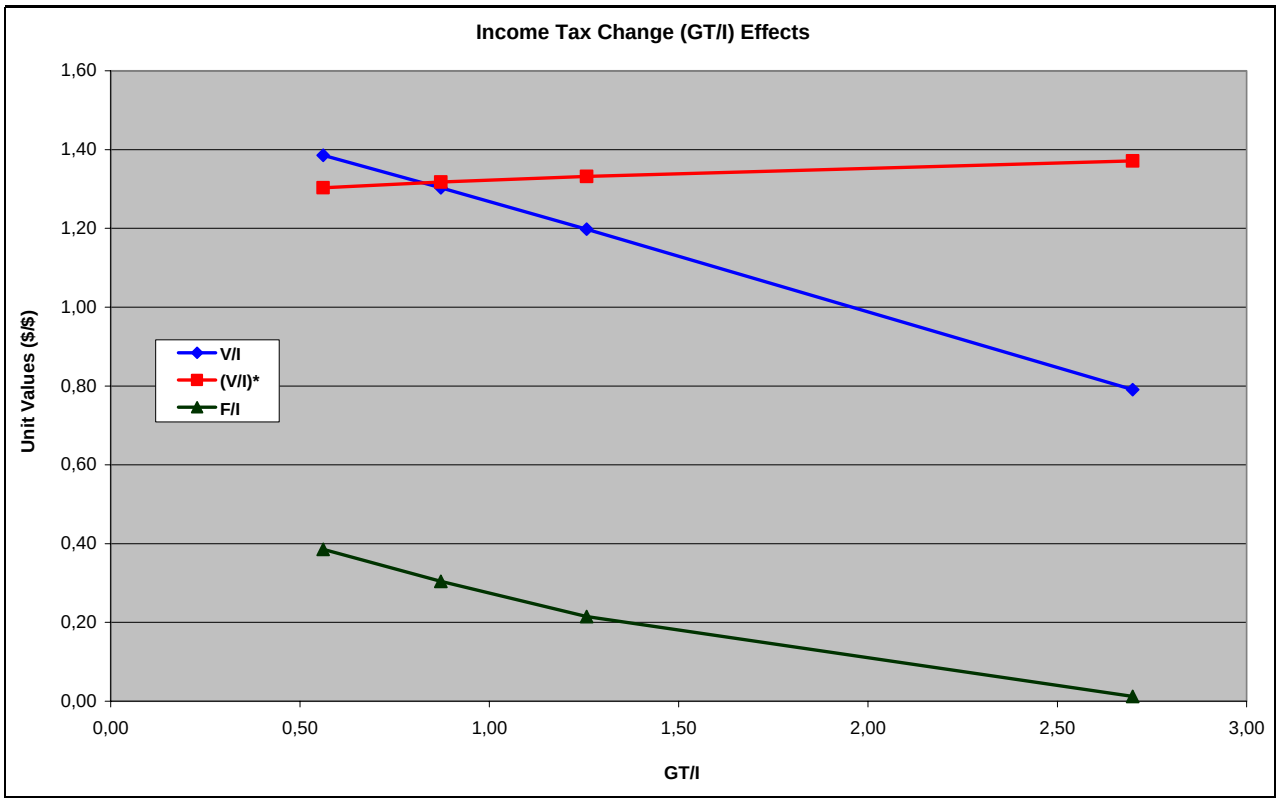
2.3 – Some Modeling Assumptions

3 – Timing Options and Taxation in Upstream Petroleum: Results

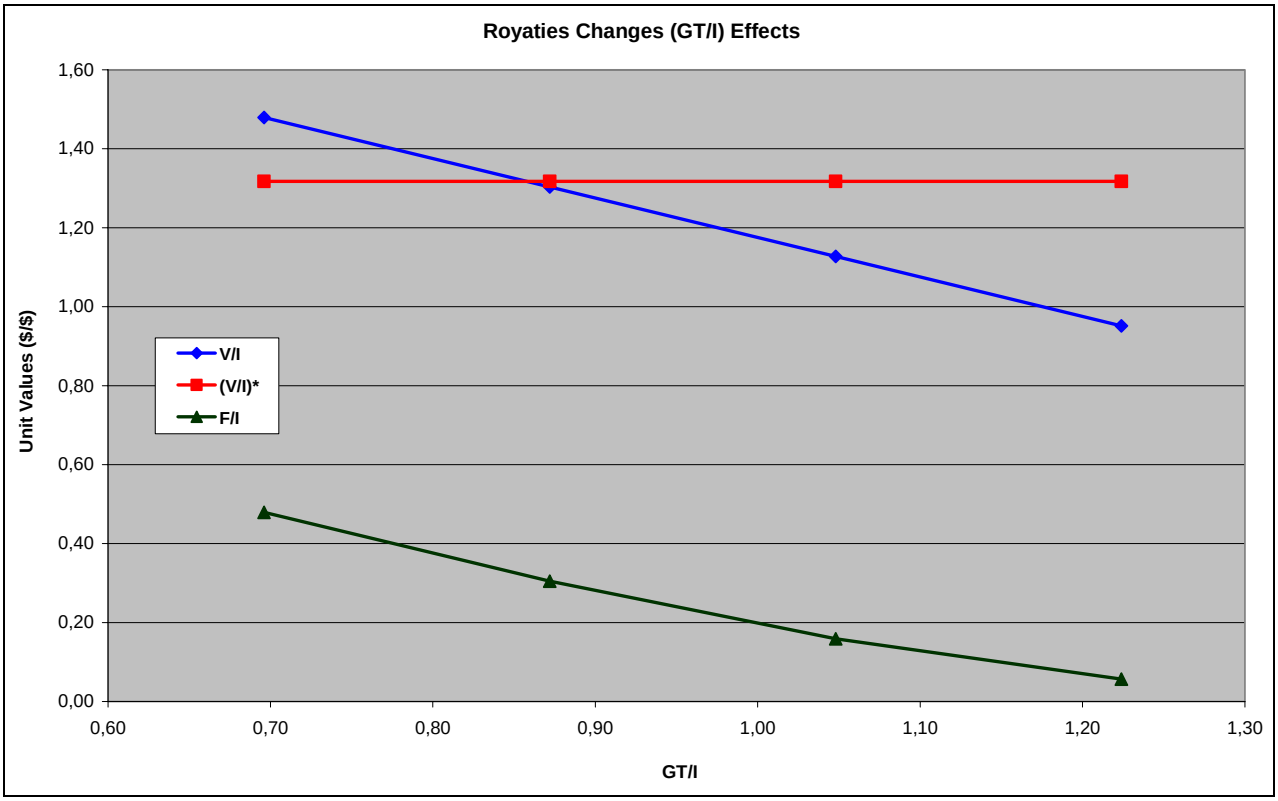
In this section is shown the effect of typical concession tax devices (income tax and royalties) in the investment decisions focusing the timing real option. Here is considered some cash flow tax details such as the depreciation of part of investments and how the income tax effect on both, risk free

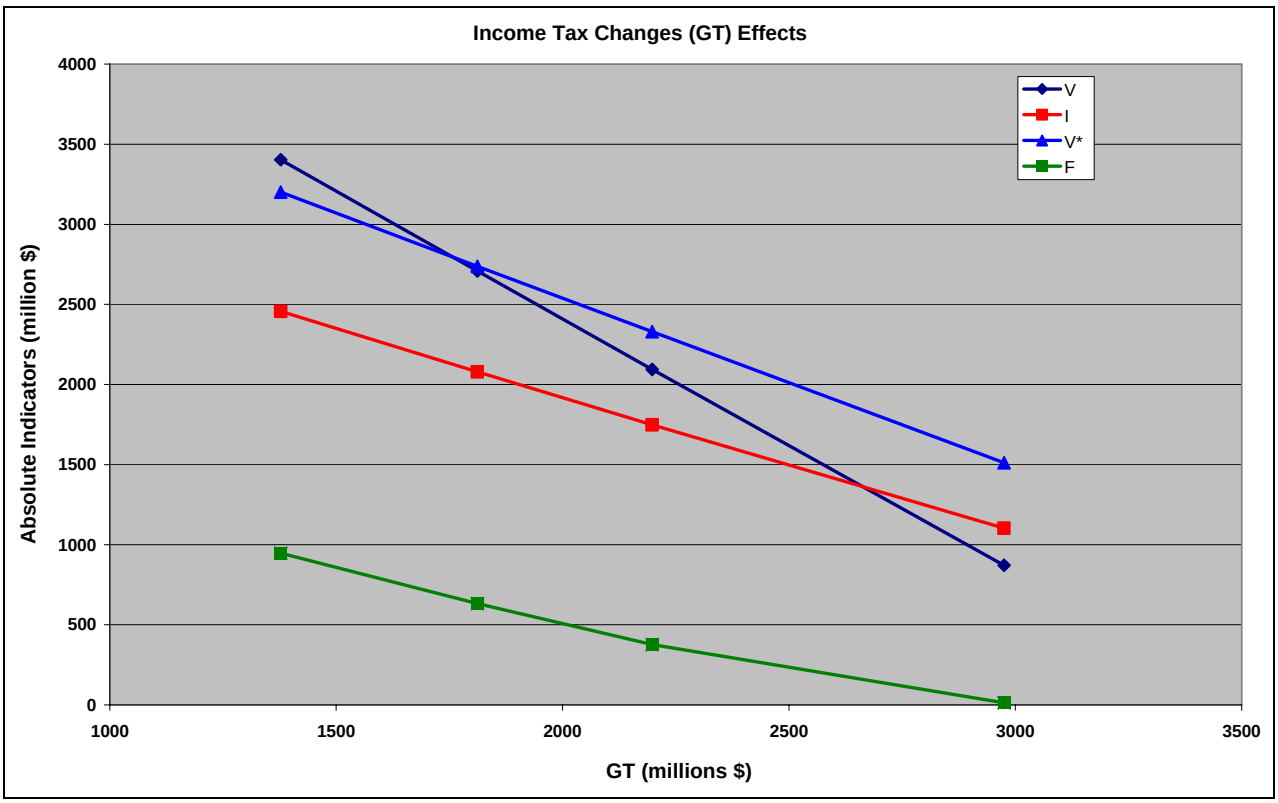
interest rate and the corporate (risk-adjusted) discount rate, affects the option threshold. In this way, the paper goes deeper in terms of combined effects than previous taxation real options literature.

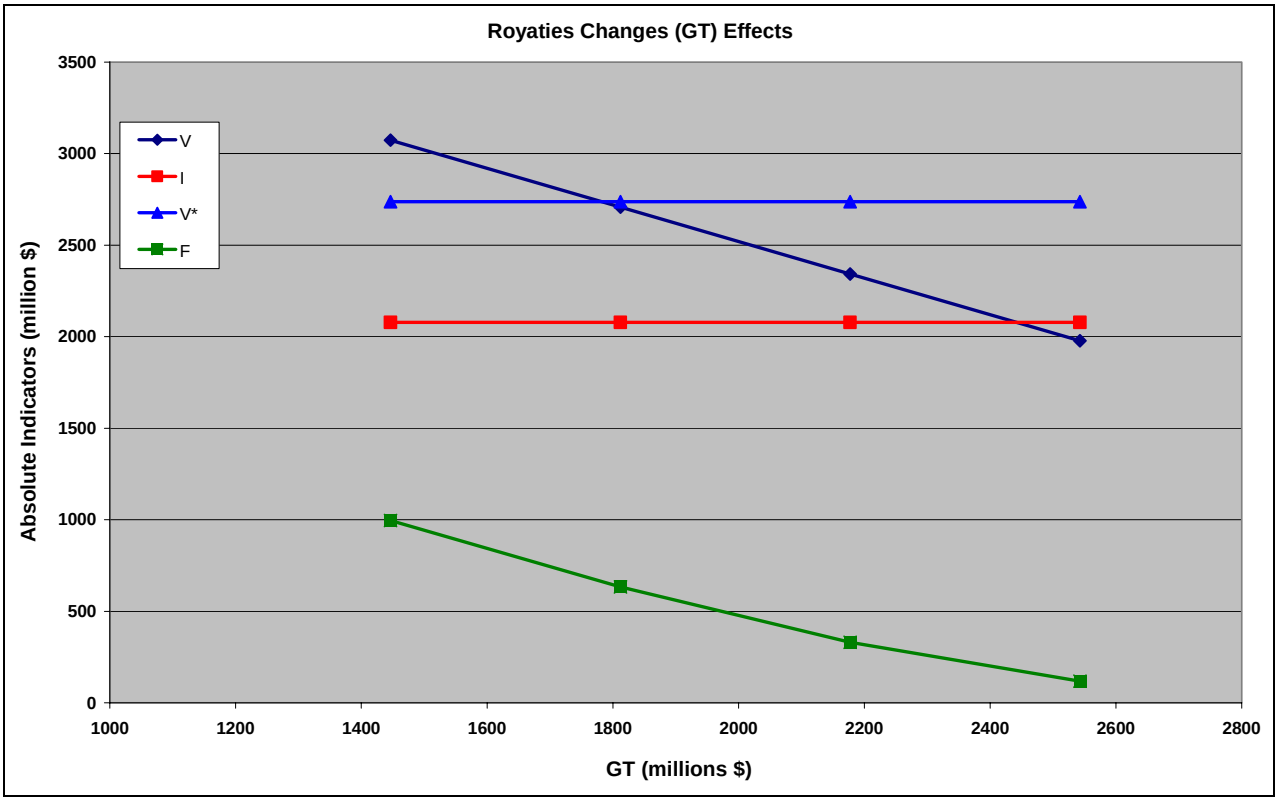
.



.


Royaties Changes (GT/I) Effects
Unit Values ($/$)
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
V/I
(V/I)*
F/I
0,60
0,70
0,80
0,90
1,00
1,10
1,20
1,30
GT/I

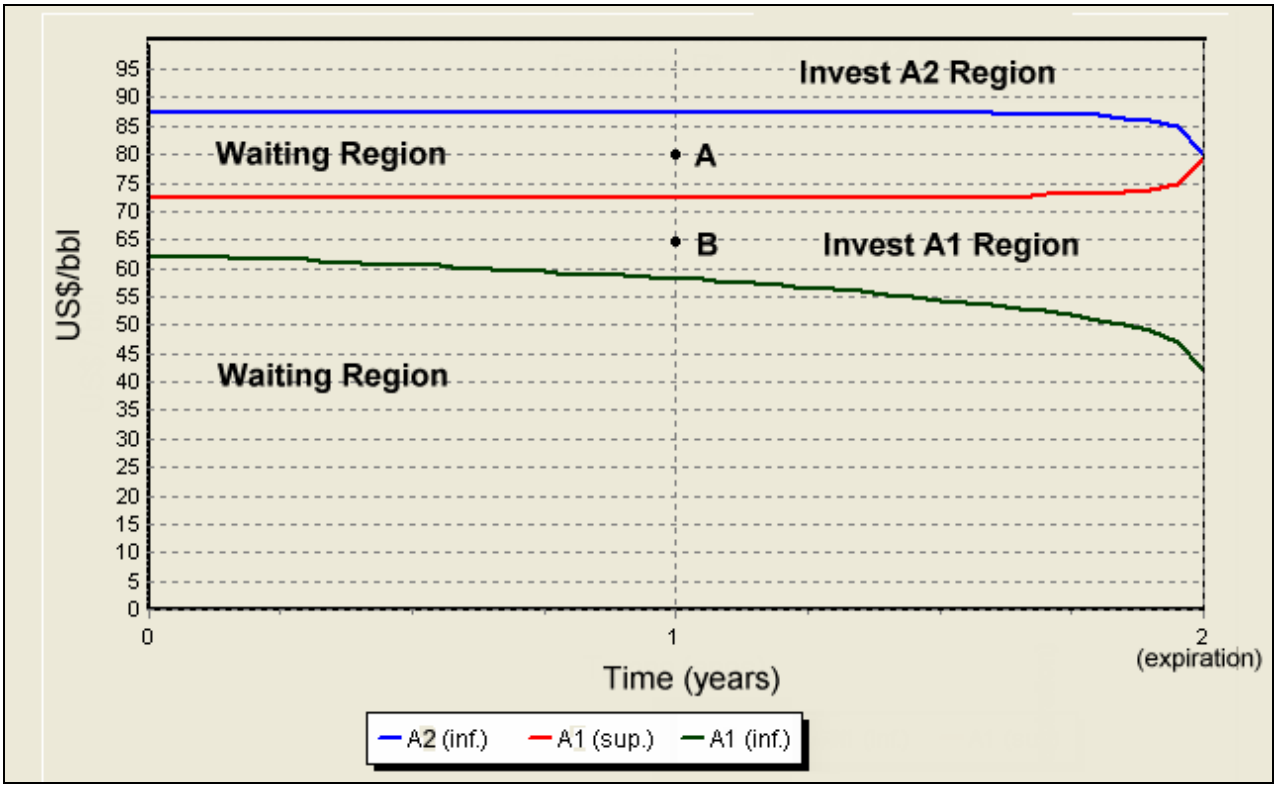

Income Tax Changes (GT) Effects
Absolute Indicators (million $)
4000
3500
3000
2500
2000
1500
1000
500
0
V
I
V*
F
1000
1500
2000
2500
3000
3500
GT (millions $)


Royaties Changes (GT) Effects
Absolute Indicators (million $)
GT (millions $)
V
I
V*
F
3500
3000
2500
2000
1500
1000
500
0
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

4 – The Effect of Multiple Discrete Mutually Exclusive Alternatives

In the section 2 was mentioned that Dixit & Pindyck (1994, p.309) and Hassett & Metcalf (1999) found that policy uncertainty generally lowers the scale of the investment. Using a different model, this paper shows that if the income tax raises, investors generally reduce the investment scale, but other less intuitive feature can arises: if waiting is optimal, increasing the income tax could speed up the investment.

.



5 – Learning Options and the Special Tax Design

In this section is analyzed the special tax design used in Brazilian oil sector since 1997 (also known as “special participation”). The paper proposes another design for the progressive tax system that is much more efficient and win-win for oil companies and government.

.

6 – Conclusion

In this paper we.

.

.

APPENDIXES

A)

.

Bibliographical References

Auerbach, A.J. (2004). *How Much Equity Does the Government Hold?* American Economic Review, vol.94, pp. 211-216

Brown, E.C. (1948). *Business-Income Taxation and Investment Incentives*. In L.A. Metzler et al., eds., *Income, Employment and Public Policy – Essays in Honor of Alvin H. Hansen*. W.W. Norton & Company, Inc., New York, pp. 300-316

Copeland, T. & V. Antikarov (2001). *Real Options – A Practitioner's Guide*. Texere LLC Publishing, New York.

Dias, M.A.G. (1996): *Investimento sob Incerteza em Exploração e Produção de Petróleo* (*Investment under Uncertainty in Exploration & Production of Petroleum*). Dept. of Industrial Engineering, PUC-RJ, Master's Dissertation (in Portuguese).

Dias, M.A.G. (2002). *Investment in Information in Petroleum: Real Options and Revelation*. Working Paper, PUC-Rio, presented at MIT seminar *Real Options in Real Life*, May 2002 and at *6th Annual International Conference on Real Options*, Cyprus, July 2002.

Dias, M.A.G. (2004). *Valuation of Exploration & Production Assets: An Overview of Real Options Models*. Journal of Petroleum Science and Engineering, vol. 44(1-2), October, pp.93-114.

Dias, M.A.G. (2005a). *Opções Reais Híbridas com Aplicações em Petróleo* (*Hybrid Real Options with Petroleum Applications*). Doctoral Thesis, PUC-Rio, Rio de Janeiro, January. (in Portuguese).

Dias, M.A.G. (2005b). *Real Options, Learning Measures, and Bernoulli Revelation Processes.* Working Paper presented at the 9th Annual International Conference on Real Options, Paris, June.

Dixit, A.K. & Pindyck, R.S. (1994). *Investment under Uncertainty*. Princeton: Princeton University Press.

Fraser, R. (1993). *On Neutrality of Resource Rent Tax*. Economic Record, vol. 69 (204), March, pp. 56-60.

Hassett, K.A. & G.E. Metcalf (1999). *Investment with Uncertain Tax Policy: Does Random Tax Policy Discourage Investment?* Economic Journal, vol. 109 (457), July, pgs. 372–393.

McDonald, R. & D. Siegel (1986). *The Value of Waiting to Invest*. Quarterly Journal of Economics, November, pp.707-727.

Mead, W.J. (1994). *Toward an Optimal Oil and Gas Leasing System*. Energy Journal, vol.15 (4), pp.1-18.

Panteghini, P.M. (2007). *Corporate Taxation in a Dynamic World*. Springer-Verlag Berlin Heidelberg.

Pennings, E. (2000). *Taxes and Stimuli of Investment under Uncertainty*. European Economic Review, vol. 44, pp. 383-391.

Postali, F.A.S. (2007). *The Brazilian Fiscal System and the Decision to Invest in Petroleum Reserves: A Real Options Approach*. Working Paper, USP, presented at the 11th Annual International Conference on Real Options, Berkeley, June, 31 pp.

Samuelson, P.A. (1964). *Tax Deductibility of Economic Depreciation to Insure Invariant Valuations*. Journal of Political Economy, vol. 72 (6), December, pp. 604-606.

Trigeorgis, L. (1996). *Real Options – Managerial Flexibility and Strategy In Resource Allocation*. MIT Press, Cambridge (USA).

Zhang, L. (1997). *Neutrality and Efficiency of Petroleum Revenue Tax: A Theoretical Assessment*. Economic Journal, vol. 107, July, pp. 1106-1120.