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ESTIMATING THE VALUE OF OIL CAPITAL IN A SMALL OPEN ECONOMY: THE VENEZUELA'S EXAMPLE

Property rights, capital gains and exploration costs in a country's oil capital

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Abstract

The only kind of capital traditionally included in the accounting systems of most countries around the world is the manufactured capital (also sometimes called real or physical). In the search for greener accounts or for estimating the sign of sustainability criteria, other forms of capital must be measured and valued. The paper focuses in the estimation of the oil capital, as part of the natural capital, in a small open economy depending on oil rents. The Venezuelan case is used as an example, and the estimations are made with the help of a database of 40 years time series in reserves, production, prices and costs. A definition of oil capital is given, and the stock of oil is first measured in physical units. The changes in the volume of the oil capital are presented and explained in terms of changes occurred in property rights, technology and market conditions. In a second step, the oil capital is valued. In the valuation process, several difficulties appeared when trying to apply the theory of wealth accounting to the oil valuation. The theoretically sound accounting price is very difficult to calculate and was not possible to do at this step of the study. Instead the net price is used, that is the international average price for the Venezuelan oil net

of the operational cost. Two other difficulties are discussed in the paper: how to threat exploration costs and capital gains. The value of the Venezuelan oil capital is measured under different assumptions, regarding the treatment of exploration costs and capital gains. It is shown that the oil capital value varies significantly from one to another set of assumptions and that it matters significantly which assumptions about the functioning of the economy are made. United Nations (1993) recommendations, which are followed by the World Bank when estimating the genuine savings indicator, are a special case and it does not apply to Venezuela. For the Venezuelan case it is argued that the value of the oil capital has increased faster than the population, during the studied period, which is the result obtained when accepting the following two assumptions: a) Venezuela is a price taker in the oil market; and b) the exploration costs do not measure the value of the additions but a contribution from the oil to the creation of geological knowledge and therefore should be considered as part of the human capital formation. Finally, the biases introduced by the quality of the data are discussed. The main contribution of the paper is to show that the assumptions on the discovery function and the allocation mechanisms are fundamental in the results obtained, which may jump from positive to negative values depending on the set of assumptions accepted. These issues have never been considered in previous studies of oil capital value.

Keywords: Venezuela, Sustainability indicator, Oil capital, Capital Gains, Exploration costs, Property rights.

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I. Introduction and paper description

Introduction

This paper is an intermediate output of an empirical research aiming at the construction of an indicator of sustainability for Venezuela: oil based, open and small economy. Sustainability is defined as a non-negative and non-declining capital per capita where capital includes not only manufactured but also natural and human capital. (Dasgupta and Mäler, 2000 and Mäler 2001) The calculation of the index requires numerical information of the country's total capital and its changes.

The Venezuela's national accounting system records the annual formation of capital but the concept of capital is restricted to manufactured[1] as is the current practice in most countries. Measures of total capital are not reported. Consequently, the task of estimating the sustainability index implies measurement of quantity and value of other kinds of capital: natural and human. Which new form of capital should one add first? Due to the primordial role that oil production has had in the Venezuelan economy (see table 1) it was obvious that one must start by adding the oil capital, as the key element of the natural capital the country possesses.

The first part of the paper (section II) includes the definition of oil capital as the oil proven reserves. It includes also the estimates of the oil capital volume, and an

analysis of driving forces for the changes in the volume of proven reserves that occurred during the studied period (1960 – 2000). It is argued that changes in the property right regime of the oil industry played a decisive role in the changes of the oil capital. The second part (section III) reports on the valuation issues. The value of the stock of oil capital and its changes are defined. The way to calculate those values depends on the assumptions made about the discovery function and the allocation mechanisms. In the section are presented the results for calculations made under different sets of assumptions. It is shown that the value of the oil capital may be very different depending on the set of assumptions chosen. For the Venezuelan case it is argued that the value of the oil capital has increased faster than the population, during the studied period, which is the result obtained when accepting the following two assumptions: a) Venezuela is a price taker in the oil market; and b) the exploration costs do not measure the value of the additions but the oil contribution to human capital. And section V is a concluding section where some of the limitations of the study are presented and discussed.

II. Oil capital, physical accounts and analysis of the changes

II.1 Definition

Oil resources are classified according to the degree of geological certainty and the technological and economic viability. Proven reserves are that part of the oil resources that are known with considerable geological certainty and that can be recovered under the current economic and technological conditions (see Annexe 1, at the end of the paper). Oil capital is defined as the amount of proven reserves. That is the amount of oil resources having a rental value. The oil capital of Venezuela is the size of the proven reserves it owns. Although it is to acknowledge that other

Venezuelan oil resources may have a positive market value (option value) the magnitude of them were unknown to me.

II.2 Proven Reserves

The changes in the volume of proven reserves (ΔS_{OK}) are the result of the combined effect of two forces: additions (see section II.4) and depletion.

$$\Delta S_{OK\,t} = \Delta \text{ Proven Reserves }_t = \text{ Additions}_t - \text{ Depletion}_t \quad (1)$$

Figure 1 shows the reserves evolution from 1960 to 2000.

II.3   The changes in proven reserves

The Venezuelan proven reserves increased during the studied period at an annual average rate of 5%. Their increase did not happen evenly over that period. In the sixties the proven reserves went slightly down, and from 1972 they started to increase in a sustained path. However is in 1986 when the reserves jumped so as to double in size and thereafter they kept slowly increasing all the time with a moderate rate. Why?

II.4   The analysis of the additions

1. Additions may occur for three reasons, namely: Discoveries, Extensions and Revisions.

$$\text{Additions} = \text{Discoveries} + \text{Extensions} + \text{Revisions} \quad (2)$$

Discoveries are those proven reserves that exploratory drilling finds in new oil fields or in new reservoirs in oil fields. That is new oil resulting from successful exploration activities. Extensions are increases in proven reserves because of subsequent drilling showing that discovered reservoirs are larger than originally estimated. They are also new oil but resulting from increasing levels of certainty. Revisions are changes in

proven reserves because oil firms acquire new information on markets conditions or new technologies.

Figure 2 shows the changes in the additions and one can see the source of the change. Most of the additions were revisions, that is, according to the definitions it must be the result of changes in market conditions.

II.5 Property rights modifications as a driving force of the changes in the proven reserves

The proven reserves of oil may increase when the prices do because some of the oil resources that were not included in the proven reserves acquire rental value. In the Venezuelan case the reserves increased when the prices did but they also rose when the prices fell. Why?

Venezuela became the world biggest oil export country in 1928, when its exports started to be greater than those from Mexico. The legal status of oil has always been that it belongs to the state, as all subsoil resources do according to laws inherited from colonial times. However the oil industry was in the hands of foreign companies that had received concessions.

Main changes in the property right system occurred during the time period of this study. In 1958 the last dictatorial government came to an end and the Venezuela's democratic period started then. Venezuela implemented at that time a new oil policy based on: a) no new concessions, b) the creation of a state oil company, c) the promotion of a producers union which led to the creation of OPEC, d) the introduction of changes in the royalties and the tax system in order to favour the nation's recovery of the oil rents, and e) the creation of a state owned oil company. To that is to be added that the major concessions were to revert to the country in 1983-1984.

No new concessions, an increased participation of the state in the rents and in the business, and decreasing prices –together with the relatively short time remaining before the existing concessions will revert- were strong negative incentives for the foreign companies. The capital investments in the end of the sixties had decreased in about 20%, and the oil employment fell to its half (Espinasa, 1997). Meanwhile the production went up reaching its maximum in 1970 (see figure 3). After 1970 the oil production declined because of the exhaustion of the old fields. That is the oil production started its fall much before OPEC decided to cut it back. The volume produced fell precisely when the price started to increase.

The new oil policy had increased the participation of the state in the oil revenues and simultaneously had created negative incentives for the oil companies; meanwhile the oil reserves from Arabic countries were rising. All these elements led to the fact that Venezuela kept its position as biggest exporter until 1970 when Saudi Arabia took over, while the relation reserves/production went down to 10.

In 1973, the international oil companies and the Venezuelan government agreed not to wait until the concession will revert to the state. The industry was nationalized in 1975. The new state oil company –PDV– started operations (1976) and a massive investment plan was carried out. In what affects the amount of reserves, the new investment policy led first to stop the field's decay and later to increases in reserves (Espinasa, 1998).

Simultaneously, resources were allocated also to technology development for the very heavy oil that had been found in the Orinoco belt. Orimulsión –the patented name - is a liquid combustible produced with this new technology, and it is used as an alternative input in electrical plants.

As a consequence, the proven reserves went up from 18 thousand million barrels 1976 (when the nationalization happened) to near 80 thousands million barrels today[2].

In the Figure 4 can be seen that when the oil prices jumped in the 70s, the reserves did not jump as much as they did in mid 80s. They increased in the 80s, with a big jump in 86, when the Orinoco belt resources started to be included in the proven reserves, and they continued to increase moderately even when the prices fell. The changes in reserves are more related to the changes in the property right system than to the changes in prices.

The property right regime had gone through major changes. That is not to say that changes in prices did not change the volume of reserves, they did; and the OPEC quota policy may also have given incentive to increases in the volume of the reserves – as quotas are related to the amount of reserves – but the main jump in reserves is more the consequence of changes in the property right system. Those changes created the incentives for exploration and technology development and for the search of markets to the extra heavy oil. These major changes in the property rights regime have also had other consequences that are not in focus here because they are not directly related to the reserves but to the fiscal revenues and in a more general way to the relations between the national oil industry and the rest of the economy.

II.6   The proven reserves increased but they changed in quality

The additions were mainly of heavy and extra heavy oil meanwhile the production was integrated mainly with light and medium oil (see figure 5 and 6). The corollary? The participation of heavy and extra heavy oil in the Venezuelan reserves of oil has increased.

III. Valuation of the oil capital

III.1 Definition

The value of oil capital in year t ($W_{OK\,t}$) is defined as the shadow price of oil (p_t) times the amount of proven reserves (S_t); and the shadow price is defined as the change in well-being[3] (V_t) derived from a unit change in the stock of oil (S_t) (see Dasgupta and Mäler 2000 and Mäler 2001)

$$W_{OK\,t} = p_t * S_{OK\,t} \tag{3}$$

$$p_t = \frac{\partial V}{\partial S_{OK\,t}} \tag{4}$$

However the shadow price, defined as above, is not available for the moment and its calculation is very difficult. Instead the international net average price of the Venezuelan oil exports is used in the paper. That introduces other bias in the calculations of the value, which will be discussed in section V. The value of the oil capital is calculated here as the international average market price for the Venezuelan oil, net of production costs, times the quantity of proven reserves.

$$P_t = \text{average oil world market price per barrel} - \text{average cost per barrel} \tag{5}$$

$$W_{OK\,t} = P_t * S_t \tag{6}$$

Two issues remain to be discussed in this section. 1) The changes in the stock of oil (S) are a function of production, discoveries and exploration costs. Explorations

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costs have been used as the value of discoveries (UN, 1983). How should we treat them when valuing oil capital? 2) The fluctuations in oil prices are notorious. Changes in prices lead to capital gain or losses. How should one account for capital gains (or losses)?

In other words, which assumptions may one make about the discovery function and the autonomy of the oil allocation mechanisms?

- The discovery function

    1. Are today's discoveries the consequence of only today's exploration costs? Or,

    2. Are they today's discoveries the consequence of only the accumulated exploration costs?

- The resource mechanism allocations.

    a. Are the oil allocation mechanisms autonomous? Or,

    b. Are they non-autonomous?

The remaining part of this section focuses in these issues. It is shown that the value of the oil capital varies significantly depending on assumptions made.

III.2   Exploration costs

In current national accounting systems has been accepted that discoveries should not be treated as an expense but as an investment, and therefore they must be incorporated as part of the year capital formation of the country. The explanation has been that exploration costs are a measure of the potential discoveries of oil. The oil capital values are to be used for adjusting the current measures of capital in the search of a more inclusive definition of the country's wealth. If when oil capital value is

measured one includes the value of the oil discovered, then one can believe that there is double accounting. Is that true? Dasgupta, Kristöm, Mäler (1997) developed a model with which they proved that if one assumes that oil resources discovered today depend only on the accumulated exploration costs then they should not be a measure of the discoveries value but instead a contribution of oil to the formation of human capital (knowledge). The value of the change in oil capital must be measured by the result of the two forces that modified the stock, additions minus depletion. In other words, both the exploration costs and the value of the discoveries must be accounted for in the year capital formation.

In the other hand, if the discoveries of this year are the consequence of the exploration cost of the year, exploration cost can not be considered oil contribution to human capital and both addition and exploration costs can not be added but only one of them.

III.3 Allocation mechanism of oil resources

This section is done following Mäler (2001) in which the author develops a model for measuring wealth in discrete time, for the proof of what follows the reader may look at that reference.

If the economy's allocation mechanisms[4] are time autonomous[5], one can express in discrete time the change in social well-being as follows

$$V_{t+1} - V_t = p_t (K_{t+1} - K_t) \qquad (7)$$

In equation 7, V stands for social well-being, p for shadow price (defined above as the change in well-being when the resource stock changes in one unit), K stands for the inclusive definition of capital, and t for the time period. That is, the change in well-being is equal to the value of the change in the capital stock. The value

of the change in capital is different from the change in the value of the capital because it excludes capital gains.

The assumption of time autonomous mechanisms in the allocation of oil resources implies that the capital gains must be excluded.

However, resource mechanism allocations may be non-autonomous. They are non-autonomous when exogenous changes influence the economy and the way this economy's resources are allocated also changes. For example, changes in the terms of trade.

When the allocation mechanisms are non-autonomous the change in well-being will be

$$V_{t+1} - V_t = p_t \varepsilon S_t - p_t R_t \qquad (8)$$

R is the production and ε is the average annual relative change in the world market price. The world market price of the produced oil is in general different to the accounting price of the stock. In the calculations made here they are assumed to be the same and that introduces a bias in the calculations as it was mentioned in section III.1.

Mäler concludes that the capital gains generated by price changes in the world market should be included when assessing the change in well-being but no those being the consequence of changes in the accounting price

III.4   Measuring the value of oil capital under different assumptions

III.4.1 Estimate 1

Here is presented the value of oil capital when one accepts the following assumptions:

Assumption 1.The discoveries reported this year depends only on this year explorations costs and not in the previous years exploration cost.

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Assumption 2 The resource allocation mechanisms for oil resources are exogenous

In this case, the value of the oil capital

- Will not include the value of the discoveries

- The oil capital for the starting year is calculated as $p_0 S_0$; and,

- To this initial value of the stock one deducts every year the oil production.

$$W_{OK\,t} = W_{OK\,t-1} - (p_t * D_t) \tag{9}$$

In figure 7 is shown the value of the oil capital for the period 1960-2000 when it is measured following this set of assumptions. The average annual growth rate for this estimate is near to minus 7% (see table 3)

This estimate may lead us to the conclusion that the country is depleting the oil resources without any compensation and may adjust down the estimations of total capital formation

The United Nations recommendation how to account for mineral reserves included in the guidelines published in 1993, correspond to this case. According to those recommendations, capital gains are to be included and the discoveries are valued by the exploration costs. (United Nations 1993, in particular pages 219, 230).

The World Bank produces and publishes the genuine saving indicator, which is meant to cope with the absence of other capitals different to the real, within the current accounting system. Genuine saving includes traditional savings less de value of resource depletion and environmental degradation plus de value of investments in human capital (Hamilton and Clemens, 1999)

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That means that both United Nations and the World Bank are using this way for valuing an asset.

III.4.2 Estimate 2

Now both previous assumptions are changed and instead the following ones are accepted

Assumption 1 The discoveries of proven reserves of oil that the country reports in year t depend only on the accumulated exploration costs

Assumption 2 The resource mechanism allocation is autonomous

These assumptions together will imply the exclusion of capital gains and the inclusion of the discovery value when valuing oil capital.

That is the value of OK in year t is given by

$$W_{OK_t} = W_{OK_0} + \sum_{\tau=0}^{t-1} p_\tau (OK_{\tau+1} - OK_\tau) \tag{10}$$

The oil capital in Venezuela has grown at an average annual rate of 10 % with this set of assumptions, under the studied period (see table 3). Figure 8 shows now the results for estimates 1 and 2

III.4 3 Estimate 3

Here W_{OK} is estimated under the following two assumptions:

Assumption 1: The discoveries of proven reserves of oil that the country reports in year t depend only on the exploration costs the companies had in the previous years

Assumption 2: The resource allocation mechanism in the economy is exogenous

The stock of oil capital in period t is given by

$$S_{OK\,t} = S_{OK\,t-1} + A_t - D_t \tag{11}$$

S $_{OK\,t}$ stands for stock of oil proven reserves in year t, A $_t$ for the additions made to the proven reserves during the year, D $_t$ for the oil produced (depleted) during the year t, all of them expressed in physical units.

The value of the oil stock in period t, W $_{OK\,t}$, is given by

$$W_{OK\,t} = W_{OK\,t\text{-}1} + P_t * (A_t - D_t) \tag{12}$$

In this estimate the value of oil capital includes the value of the net changes to proven reserves (Additions minus depletions) and the capital gains generated by changes in the world market prices

The average annual growth of the oil capital, according with this set of assumptions is 8% (see table 3). Notice that during the studied period, the changes in price gave in average losses instead of gains.

This third estimate of the oil value seems to me the one that is closest to the real conditions. The oil reserve additions do depend on the accumulated expenses in explorations. Venezuela is a price taker, even if the country has had some influence in the way OPEC may behave by itself neither Venezuela nor OPEC can fix the price of oil. The consequences of the changes in the world market prices are very much affecting the well-being of Venezuelan citizens.

IV. Population and oil capital growth

The Venezuelan population grew at an annual average rate of 3% during the period 1960 – 2000. The growth rate of a series built with the value of oil capital (estimate #3) per capita is a bit larger than 3%. Oil capital has grown at a fastest path than population. And that is true also if we made the estimations with the volume of oil instead of the value of them.

V. A review of the biases in the estimations and concluding remarks

V.1   The biases

V.1.1   The concept of oil capital

Oil resources that are different from the proven reserves are not accounted for. By definition, oil capital is the amount of proven reserves a country has, and therefore it is the value of the Venezuelan proven reserves what I have estimated as the value of oil capital. Other resources, known with less geological certainty, are not included. However those resources may have a positive market value, which should be also estimated and included, as Nordhaus and Kokkelenberg (1999) have already pointed out. How to measure the value of those other resources needs further work. In the case that other resources would have rental value, the measures given in this paper would have a bias downward.

V.1.2   Valuing remaining reserves with the price of oil sold

I am using the market price and average production costs of the oil sold to obtain the net price with which the oil capital is valued. However, in the Venezuelan case, the structure of the proven reserves is quite different from the structure of the oil being produced, in terms of the oil quality. The Venezuelan reserve composition has changed under the studied period (see figures 5 and 6 above). At the end of the period the proportion of the heavy and extra heavy oil has increased. These oils, heavy and extra heavy, have **a smaller market price** and a higher cost than the light and medium oils. Heavy oil and light oil are different goods and should be valued with different net prices. Given the composition of the remaining reserves in Venezuela, implies that the value estimated is biased upwards.

V.1.3 Average costs

According to the theory, one should use **marginal costs** in the estimation of the unit rent. Marginal costs are seldom available and I did not have access to them. Therefore the accounting price was estimated with average cost. The implication of this is a bias downward of the value of the oil capital, as the marginal cost would be higher than the average.

V.1.4 Natural gas is not yet included

The reported costs for oil are not separated form the cost of producing natural gas - a by-product.

V.2   Concluding remarks

Summarizing the findings

1. The changes in property right played an important role in the investments on exploration and in technology development leading later on to a substantial increase in the size of the oil capital

2. The volume of proven reserves grew in average at an annual rate of 5%. While the population grew at 3% annual average rate (OCEI)

3. The oil capital structure has changed to have a much bigger proportion of heavy and extra heavy oil at the end of the period

4. The estimate #1, which follows UN recommendations and the way the World Bank genuine savings indicator is calculated, gives a negative rate for the increase in capital. That happens because in this way of doing reserves are valued by the exploration costs

5. The estimate # 2, in which capital gains are excluded, shows that in the period the country had not gains but losses The growth rate for this estimate was 10%

average per year, while for the estimate # 3 –which includes the capital gains- was only 8%

6. The three different estimates for the value of the oil capital showed in the paper correspond to different assumptions on

    a. The country allocates its resources autonomously or not
    b. The additions to oil proven reserves were a function of the accumulated exploration costs or not

    I argue that the third estimate is the one that follows the theoretical principles best, because

        a. Venezuela is a price taker and
        b. The additions made are mainly the consequences of the accumulated exploration costs

7. If one accepts estimate #3 as the best, the oil capital grew fastest than population, under the period

8. The estimates will improve if

    a. It is possible to use marginal costs
    b. It is possible to divide the oil reserves in at least two categories separating heavy and extra heavy oil, and if one can find prices and marginal costs for every year for these two groups of oils.
    c. Natural gas is incorporated

9. Last remark

One should not conclude anything about sustainability with the information gathered until now. It is good news that the oil capital has increased, and even faster than population but

- Other kinds of capital must be accounted for also

- The impact of oil capital in an foreseeable degradation of other capitals, for example due to pollution, is not measured and will not because there is not information

The main contribution of this empirical study is to show how big the differences of the estimates of oil capital value are, depending on the assumptions made on exploration costs and allocation mechanism. These issues have never been taken into consideration in previous capital valuations, as far as where our information goes. The paper also reveals how changes in the economic environment of the producer affect the country's capital formation and gives and inside about the causes of changes in oil proven reserves, which in general are suspected to be only capital gains.

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Annexe1

INCREASING CERTAINTY

←⎯⎯⎯⎯⎯

Increasing Economic Viability ⎯→

	Cumulative Production	IDENTIFIED RESOURCES		UNDISCOVERED RESOURCES	
		Demonstrated	**Inferred**	**Probability Range**	
		Measured Indicated		Hypothetical	Speculative
Economic		**PROVEN RESERVES**	**INFERRED RESERVES**		
Marginally Economic		**Marginal Reserves**	**Inferred Marginal**.		
Sub-economic		**Demonstrated Sub economic Resources**	**Inferred sub economic resources**		

Other	Includes non conventional and low-grade materials

Source Mineral Commodities Summaries, US Geological Survey 1992

Table 1
Indicators of the role of Oil in the Venezuelan economy

Oil share of	GDP	X	FI
1965	27	91	65
1970	22	90	61
1975	30	91	77
1980	29	92	72
1990	28	75	77
1995	17	67	45
2000	23	78	50

GDP: Gross Domestic Product
X: Exports
FI: Fiscal Income

Source: MEM (Venezuela)

Table 2
Proven reserves growth rate

In the 60's	-1,31
In the 70's	4,07
In the 80's	15,64
In the 90's	2,85
1960 – 2000	5,10

Source: MEM. PODE. Selected years

Table 3
Oil capital estimates growth rate
1960 - 2000

		%
Estimate 1	**(used by WB)**	**- 6,98**
Estimate 2	**(without cg)**	**9,40**
Estimate 3	**(with cg + Net Ch)**	**8,05**

Figure 1
Venezuelan Proven Reserves
1960 - 2000
Million barrels
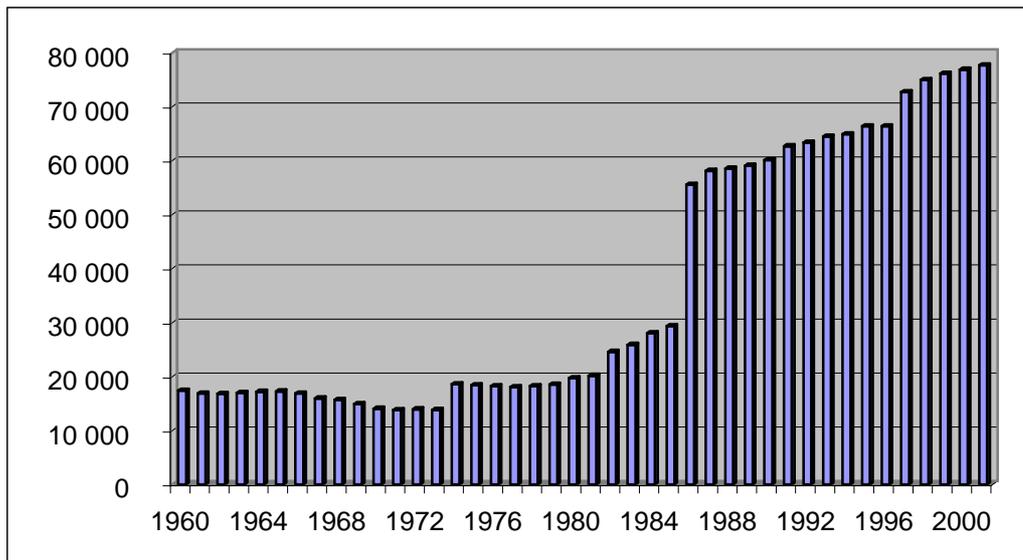

Source: MEM. PODE. Selected years

Figure 2
Structure of the additions to proven reserves
**Million barrels**
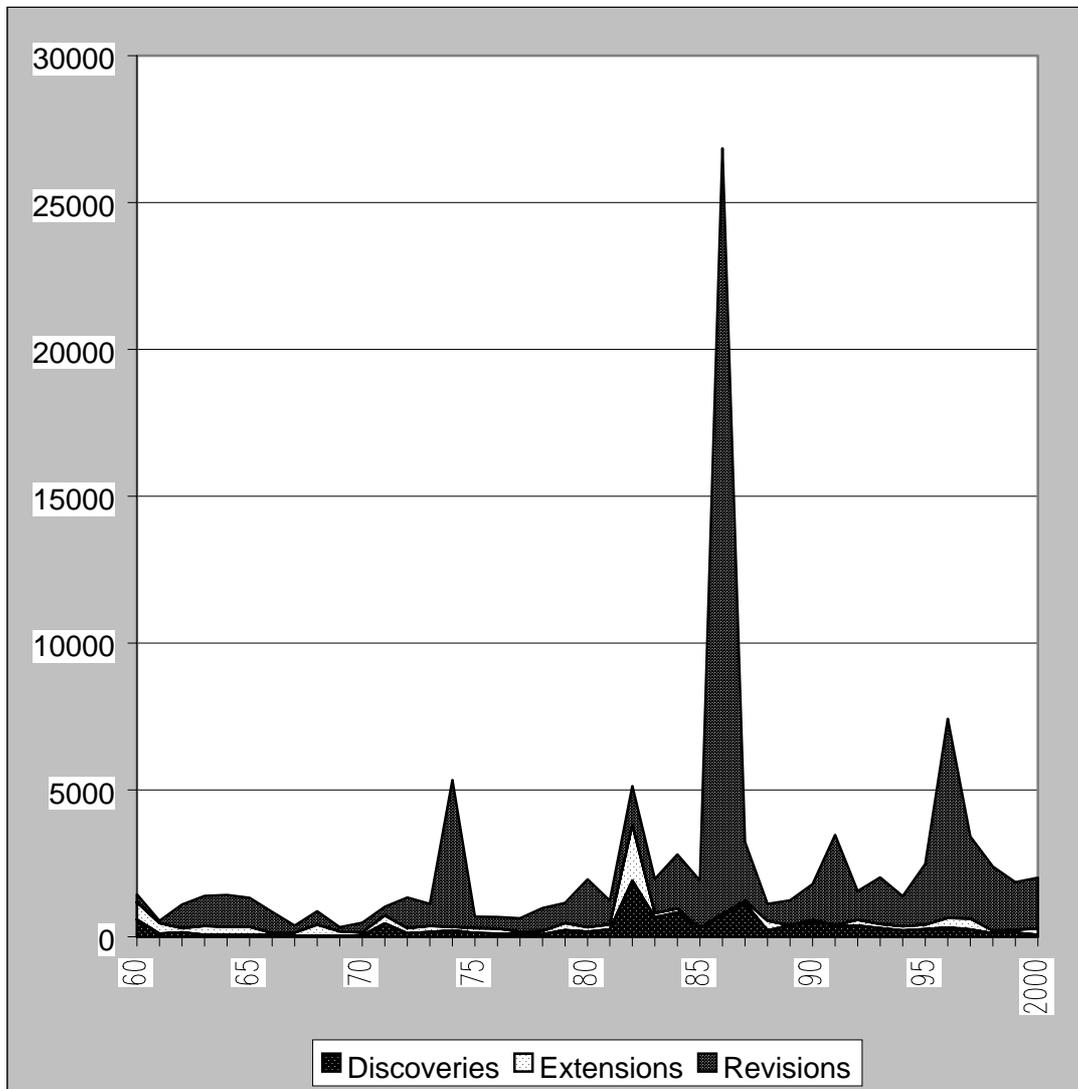
Source: MEM. PODE. Selected years

Figure 3

## Venezuela's Oil production
Million barrels
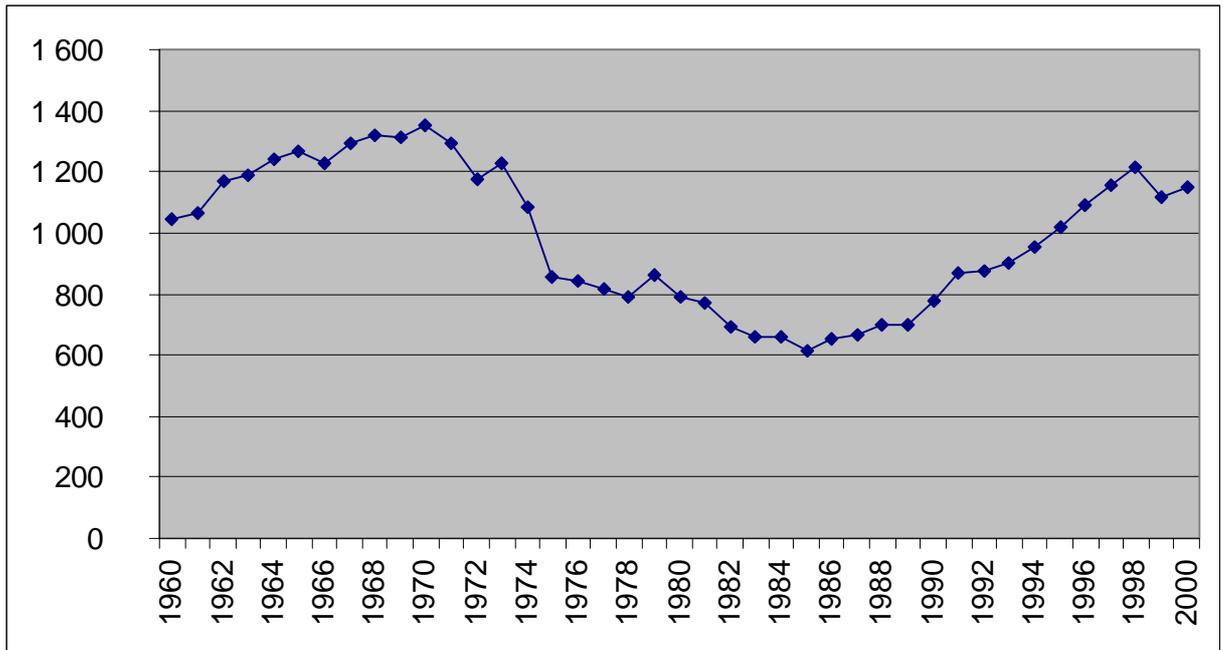
Figure 4
Reserves and price trends
Million barrels and USD
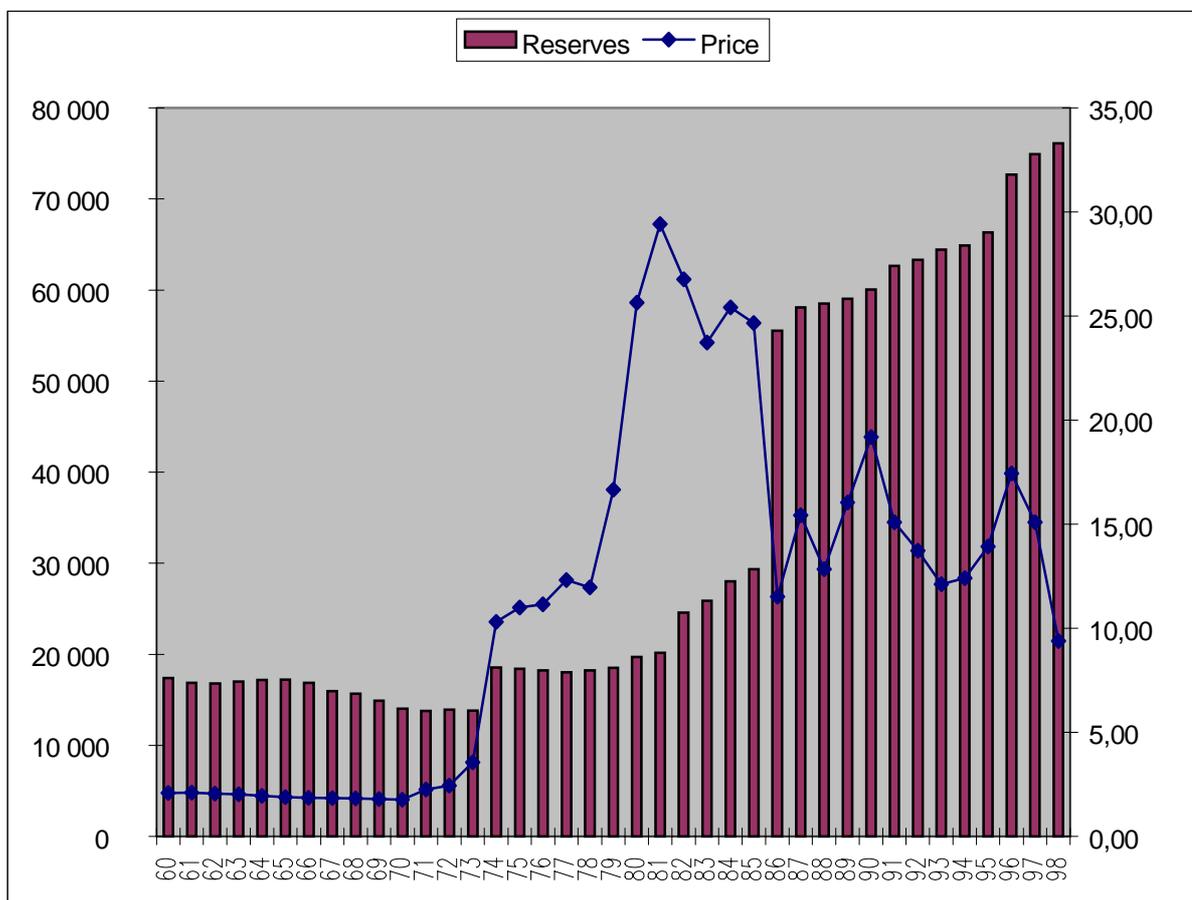
Source: MEM. PODE. Selected years

Figure 5

Venezuelan Proven Reserve Structure by grades API in miliom cubic meter

Source: MEM. PODE. Selected years

Figure 6

Oil production in Venezuela classified by grades API

Legend: Light and Medium / Heavy and Extra heavy
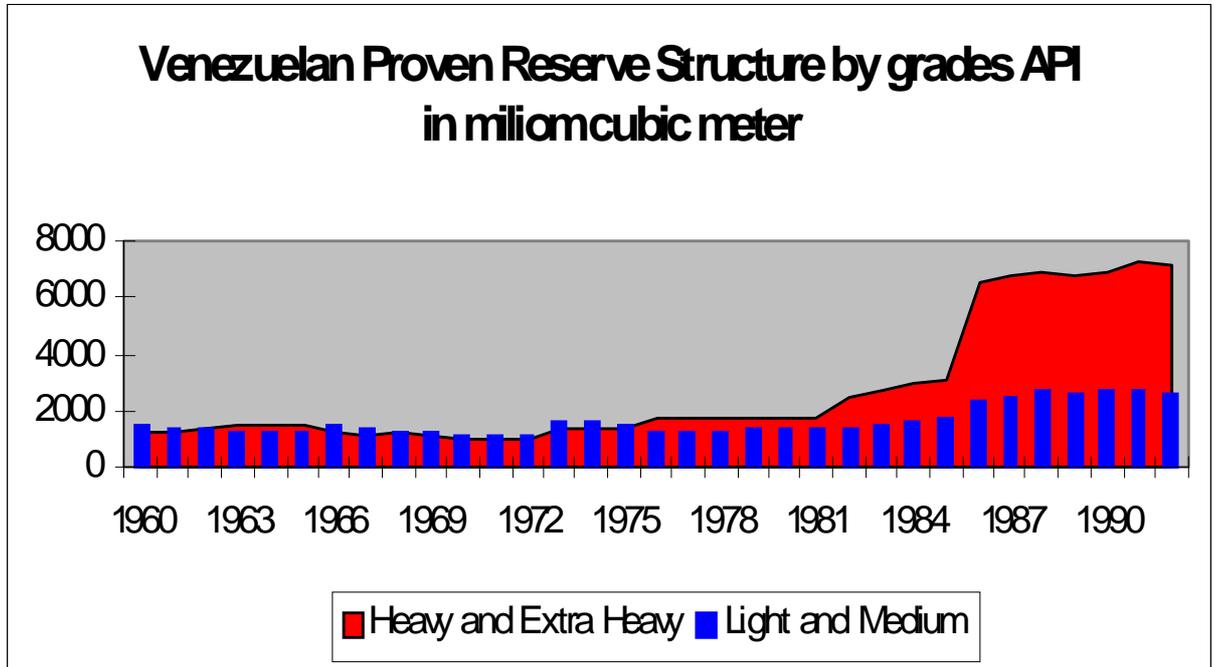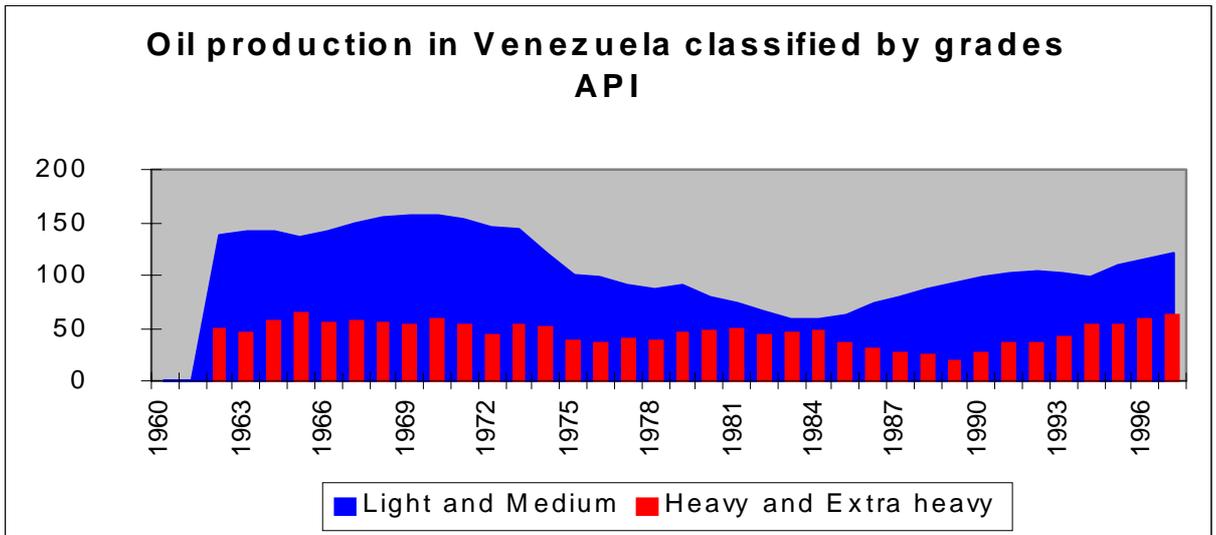
Source: MEM. PODE. Selected years

Figure 7
Value of the Venezuela's oil capital

Estimate 1 (million Bs 84)
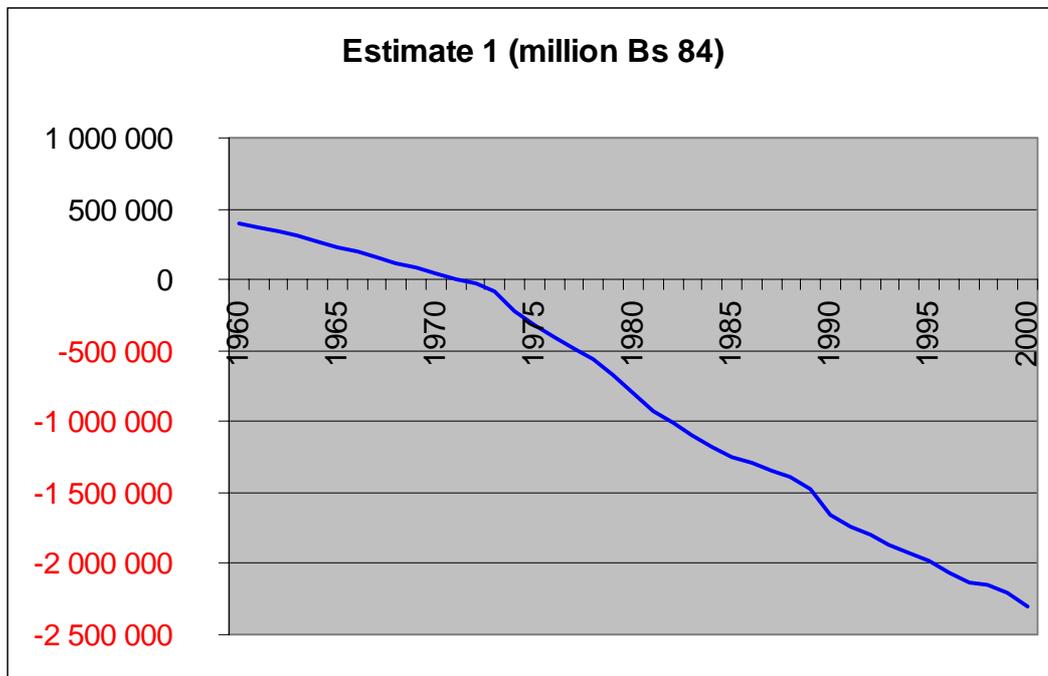
Figure 8
Venezuela's oil capital value

**Estimates 1 and 2**
**million Bs 84**
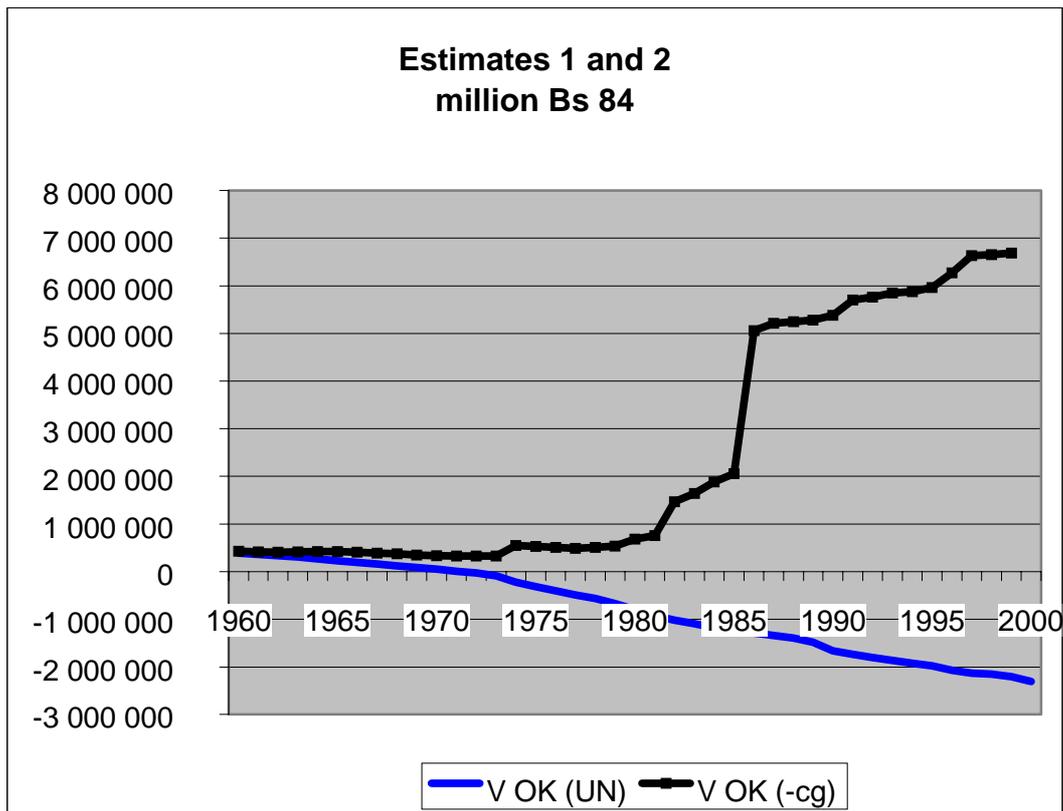
Figure 9
The three different values of Venezuelan oil capital
Million Bs. 84

Notes
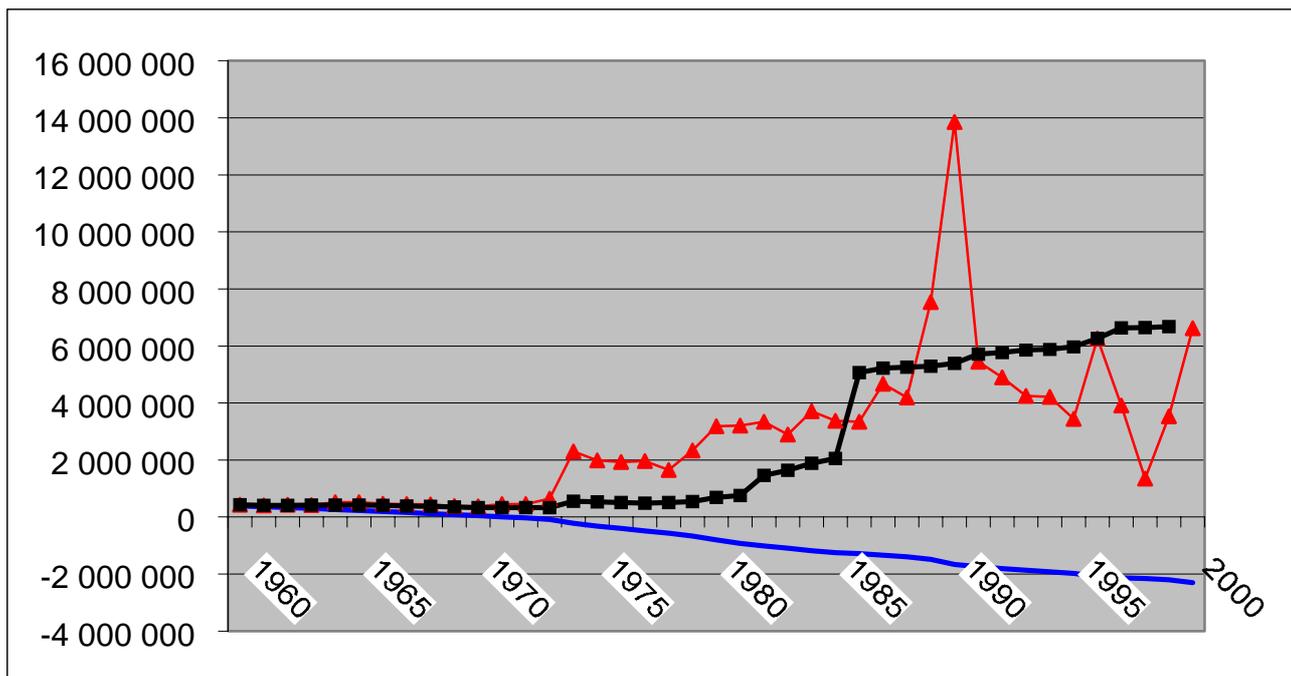
[1] Manufactured, manmade, real or physical capital are here considered as synonyms
[2] For a more detailed analysis of the changes in the relations between the oil companies and the state first as the collector of the rents and after as owner there is an huge literature. Further information on the subject can be found in Ramon Espinasa (1997), and Bernad Momer (2002)
[3] The value function – Vt- is defined as the net present value of future utilities.

$$V_t = \sum_{\tau=t}^{\infty} \frac{U(C(\tau))}{(1+\delta)^{\tau-t}}$$

[4] A resource mechanism allocation is the mapping from the initial stock of capital into a feasible time paths of consumption
[5] A resource allocation mechanism α is time autonomous when

$$\alpha(\tau+s, t+s, K) = \alpha(\tau, t, K)$$