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## The Peruvian petroleum industry: Analysis of contract and tax systems

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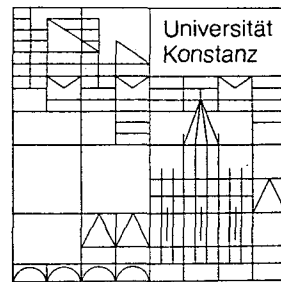
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**Sonderforschungsbereich 178**  
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Diskussionsbeiträge



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Anke Meyer

**The Peruvian Petroleum Industry:  
Analysis of Contract and Tax Systems**

**THE PERUVIAN PETROLEUM INDUSTRY:  
ANALYSIS OF CONTRACT AND TAX SYSTEMS**

Anke Meyer  
✓

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THE PERUVIAN PETROLEUM INDUSTRY:  
ANALYSIS OF CONTRACT AND TAX SYSTEMS \*

Abstract

*The main features of the Peruvian petroleum sector are described with special reference to the development of the institutional regulation of the industry since the early sixties.*

*An econometric model has been developed to study the determinants of historical investment and production patterns of foreign, mainly U.S. oil companies. This model seems to capture one of the main characteristics of crude oil operations. Given the field size, there exists an optimal, technically determined production profile which mainly determines production and investment levels.*

*A detailed analysis of various tax systems was performed with a simulation model based on Peruvian geological and cost conditions. Here, a variation of the resource rent tax seems to be a compromise between too generous tax systems and tax systems that introduce major disincentives to reserve development in high cost areas.*

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## 1. Introduction

*From the first the Spanish conquerors were interested mainly in [Peruvian] gold and silver. Everything else tended to be ignored in the scramble to obtain as much of these metals as was possible in the shortest possible time. ...[the Spanish Crown] owned the mines, protected and favoured the workers in them, and took one fifth of all the gold and silver produced in the numerous mines dotted throughout the mountains. In 1545 the silver deposits of Potosí (now part of Bolivia) were discovered ... . From this fabulously rich deposit it has been calculated that over 60 million troy pounds of silver were mined by the end of the colonial period. In 1563 another great mineral deposit, this time of mercury, was discovered at Huancavelica, and was declared a royal monopoly. The flood of gold and silver poured back to Spain to finance the Spanish court and its wars in Europe.* (Owens (1963, 25-30))

In many respects, the picture has not changed very much since colonial times. The mining sector, including mainly copper, silver, zinc, lead, and petroleum extraction, is still one of the most important economic sectors of the Peruvian economy, since it accounts for about 65% of export earnings, though only for 10% of GNP and uses only 1.5% of the labor force. Although Peru has been an independent nation since 1821, the mining sector has remained under foreign dominance. This began to change only in the 1960s, when the foreign companies had to begin to share their influence with the Peruvian state via large state-owned mining and petroleum companies. Since then, the government does not only act as a tax collector<sup>1</sup>, but tries to set the rules of the game.

The history of the Peruvian petroleum industry in the last 25 years can serve as an example of how government regulations influence private companies' decisions. From 1960 to 1985 in Peru there can be distinguished five rather different political regimes generating rather different impacts on Peruvian society and economy.

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<sup>1</sup> About 40% of total corporate income tax, which makes up for about 20% of total tax revenue, is paid by foreign and public mining companies; cf. World Bank (1981, 93-97).

The decisions and regulations of these civil and military governments regarding the petroleum industry, i.e., treatment of foreign direct investment, contract and tax schemes, will be described in the following section. In section 3, an econometric model is developed to identify some driving forces of the historical development of the foreign owned part of the Peruvian petroleum sector. Different tax policies are investigated in section 4 with a simulation model. The final section 5 contains some conclusions.

## 2. Development and regulation of the Peruvian petroleum sector, 1960-1985

### 2.1 Trends of petroleum reserves and production

After having been a net exporter of crude oil in the first half of this century, Peru became a net importer again in the 1960s, due to rising internal demand and the inability to locate additional reserves (cf. Figure 1). The up to then most important Peruvian petroleum company, the U.S. - based "International Petroleum Company" (IPC) was nationalized in 1968 shortly after the military revolution and its oilfields and installations were taken over by the state-owned "Petróleos del Perú" (Petroperú). This company was able to locate new deposits in the northeastern jungle region in 1971, thus triggering an oilboom with 18 new exploration contracts signed mostly by foreign companies. But only the U.S. "Occidental Petroleum Company" (Oxy) discovered commercially extractable reserves in the Amazone region which it developed in subsequent years. After a transandean pipeline had been built by Petroperú (1974-78), production volumes more than tripled compared to volumes in the beginning of the 1970s (cf. Figure 2). From 1979 on, production stayed around 70 million barrel per year. In 1983 production declined due to natural disasters that destroyed part of the drilling equipment and the pipeline.

FIGURE 1: PETROLEUM RESERVES AND DEMAND

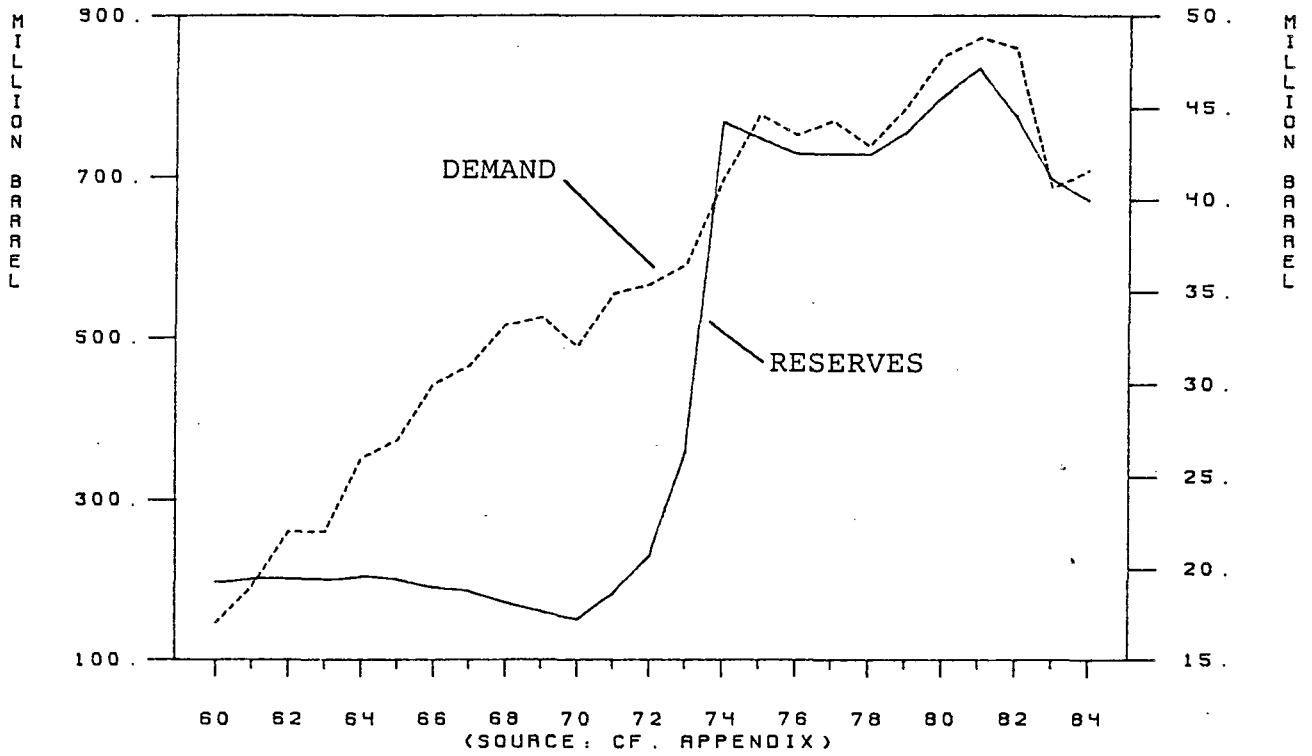
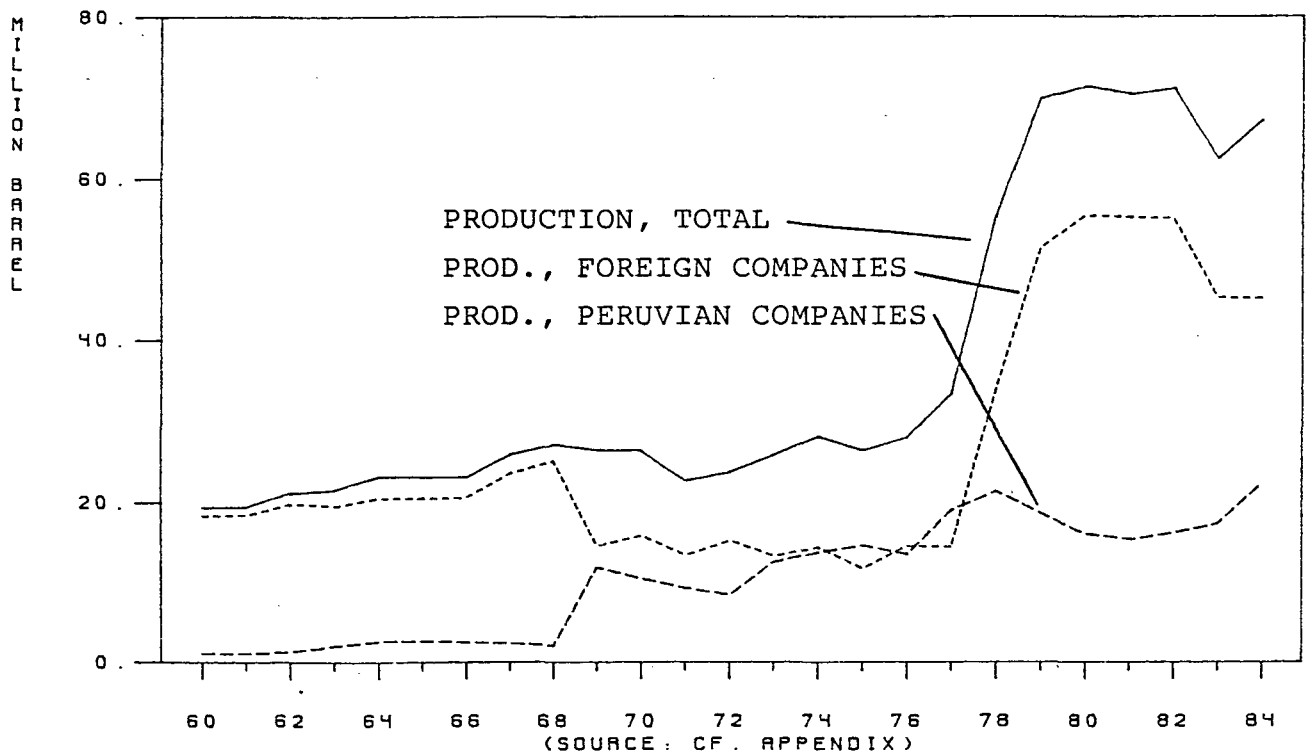


FIGURE 2: CRUDE OIL PRODUCTION



In 1978 Peru became a net exporter again. In the 1980s, crude oil and petroleum products have become the most important export commodities accounting for 20% of the total export earnings in 1984. Moreover, Peru is now exporting mainly petroleum products instead of crude oil. But current levels of investment seem much too low to maintain present production levels for more than a few years.

The regulations which influenced these developments will be described in the following.

## 2.2 Regulation of the Peruvian petroleum sector<sup>2</sup>

From 1960 to 1985, Peru has been governed by five rather different political regimes :

1960 - 1968: mainly civil government, from 1963 on under  
President Belaunde

1968 - 1975: nationalist left-wing military government

1975 - 1980: moderately right-wing military government

1980 - 1985: second civil government of Belaunde

1985 to present: nationalist left-wing civil government of  
García Perez.

### 2.2.1 1960-1968

Until 1968 the petroleum law of 1952 was in effect. It had replaced the unlimited concessions by concessions of a maximum length of 60 years. Since the concessions did not comprise any working obligations, 24 companies owned about 100 concessions, but only few of the corresponding territories had been explored and eventually been developed.

The Belaunde government enforced a major tax reform with an income tax replacing the export tax. Petroleum companies had

<sup>2</sup> For a more detailed description of the regulations cf. Pontoni 1982a,b (for 60-82), Behrman 1971 (60-68), Rose 1981 (68-80), Mikesell 1984 (68-82). For the most recent events cf., e.g., *Petroleum Economist* or *Oil and Gas Journal*.



to pay a 50% income tax, a 21% branch profits (remittance) tax and got a depletion allowance of 15% of gross production value.<sup>3</sup> Neglecting some minor taxes (exploration tax, export duties, etc.), tax payments of petroleum companies amounted to 54% of net income.

For more than 30 years IPC had been the dominant petroleum company in Peru. This company was always in conflict with the preceding government since it claimed to be the owner of the subsoil rights - in contradiction to the general legal principle inherited from the Spanish that the state was entitled to these rights - and because it had been exempted from royalty and export tax payments from 1922 on (cf. Thorp/Bertram (1978, 108ff, 168f)).<sup>4</sup> When the Belaunde government intensified efforts to deprive IPC of its preferential treatment and claimed back taxes, IPC prepared to abandon operations in Peru by increasing its amortization allowances and thus reducing its book value from \$70 million to about \$20 million from 1959 to 1967 (cf. Thorp/Bertram (1978, 226f)).

The inability of Belaunde to solve the problem IPC was a public pretext for the military seizing power in 1968.

### 2.2.2 1968-1975

The first action taken by the new revolutionary military government was the expropriation of IPC. Since the Peruvians refused to pay any compensation, the U.S. government took indirect sanctions by cutting aid authorizations and by inducing international organizations and private banks to curtail credits to

3 Terms were more favorable for companies that produced in the sierra or jungle regions and for national companies.

4 IPC production policy in the 1930s is an illustration of theories about the effects of insecure property rights and impending nationalization (cf. Long (1975) and Smith (1985)). Since from 1942 on IPC was to pay additional taxes, it produced at the highest possible level and neglected exploration. But also government was interested in high production levels, because it desperately needed higher tax revenues, cf. Thorp/Bertram (1978, 165).

Peru (cf. Olson (1975, 406f) and Stallings (1983, 164ff)).<sup>5</sup> But the revolutionary government claimed this expropriation to be an exception and that former direct dependency on foreign capital should be transformed into a "dependency by contracts". Thereby, foreign capital should be used as an instrument to overcome underdevelopment (cf. Cotler/Sonntag (1971, 66, 89-97, 165-168)).

Government declared natural resources and basic industries in general and especially the petroleum sector to be of high priority and reserved for state enterprise. But to allow for significant foreign investment the extractive industries were exempted from the famous 'decision 24' of the Andean Group which, e.g., stipulated joint ventures with domestic companies and severely restricted profit remittances of foreign companies (cf. Kampffmeyer 1977).

The government issued a new petroleum law in 1969 that abolished the concession system and replaced it by a contract system. It stated explicitly that all "resources in situ" are the property of the state and that the state-owned oil company Petroperú is the owner of all petroleum extracted. Petroperú is granted the monopoly for downstream production, marketing of crude oil and petroleum products and for secondary recovery. Furthermore, Petroperú is allowed to negotiate contracts with private companies as agent of the state. Such contracts have to match the rules of the so-called "contrato modelo Perú" that stipulates rather detailed rights and duties of both parties :

The contract's term is for 35 years with an exploration period of four (eventually seven) years. An exploration program with at least three wells to be drilled has to be fulfilled. A commercial discovery has to be developed by the contractor who also bears all production costs. In return for its investment and operating costs the private company will receive a share of the oil it has produced, specified in the specific contract.

5 The conflict was only solved in 1974, when an overall settlement of all outstanding expropriation disputes regarding U.S. companies had been agreed upon between the Peruvian and the U.S. governments; cf. Sigmund (1980, 194).

This share is net of taxes because all major taxes<sup>6</sup> will be paid by Petroperú for the account of the contractor. The private company has to contribute to domestic supply according to its share of national production. In return, it receives a price somewhat below the world market price. Petroperú has the option to let the contractor undertake marketing.

The first production sharing contract was signed in 1971 between Petroperú and Oxy for a block in the northern jungle. It provided for equal output shares. After four out of five wildcat drillings had been successful, up to 1973 17 more contracts with 31 companies were signed. The production shares of these companies were subject to a sliding scale concerning total output, going down from 50% to the minimum of 48%. Except for an offshore discovery by Tenneco/Union, none of these contractors found any commercial quantities of oil and all of the foreign companies except for Oxy and Belco - operating offshore since the sixties - left Peru until 1976.<sup>7</sup> Although the Oxy contract stated that the contractor was to build a pipeline that connected the jungle oil fields and the coast, Petroperú holding the option of a 50% participation, government decided that Petroperú would build the pipeline on its own account. It was financed with a Japanese loan of \$330 million, to be repaid in crude oil and petroleum products.

### 2.2.3 1975-1980

In 1975 the left-wing Velasco Alvarado government was replaced by the more conservative Morales Bermudez government. This government cancelled some of the reforms initiated by the

6 Income and remittance taxes, import and export duties and royalties amounted to a tax rate of 47.5% for the first ten years, 54.5% for the second ten years and 65% thereafter (cf. Mikesell (1984, 70f)).

7 The companies working under the old concessions also left since they did not fulfill the exploration and development obligations provided by a 1972 law.

first military government,<sup>8</sup> but with respect to the oil sector, it enforced more rigorous terms. This was due to several reasons:

The contracts with the 50:50 split had been signed when crude oil prices were as low as \$2 per barrel. With spot market prices rising to \$11 per barrel in 1975, the companies' profits seemed to explode. At the same time Petroperú was suffering losses, since it had to pay the contractors' income taxes<sup>9</sup>, subsidize domestic petroleum consumption<sup>10</sup> and finance the pipeline construction. New rulings of the U.S. Internal Revenue Service (IRS) regarding the extent to which foreign income taxes could be credited against U.S. taxes provided another reason for contract renegotiation. Only taxes that constitute a tax on net income and are paid directly by the contractor may be taken as a tax credit beginning in 1978. Moreover gains and losses of foreign operations have to be consolidated. The "contrato modelo Perú" obviously did not satisfy these conditions.

Therefore in 1979 a new petroleum law was enacted which established that all petroleum companies are subject to the ordinary tax regime. Still receiving only their 50% output share, companies have to pay 55% income tax and 30% branch profits (remittance) tax amounting to a total tax of 68.5% of net income. Contractors have to make tax advance payments of 40% of sales, to be paid in kind. Further important modifications of the original "contrato modelo Perú" consisted of

8 E.g., the original model of workers' participation of the industrial community law was eliminated, cf. Kampffmeyer (1977, 3, 85) and McClintock (1983, 296-298).

9 E.g. in 1979, income taxes which were paid by Petroperú for the account of Oxy, \$524 million, almost reached the value of Petroperú's 50% output share, \$570 million; cf. Roel (1983, 25).

10 Prices for petroleum products on the Peruvian market were fixed below the world market price with an increasing gap from 1978 on. In 1981, e.g., the average price on the world market was \$41.87 per barrel, on the Peruvian market only \$20.78. With a consumption of 51 million barrels this amounts to a subsidy of \$1076 million, 4.5% of Peruvian GNP (cf. World Bank (1981, 39f)).

- the obligatory use of a sliding scale for the production split;
- the introduction of an annual bonus payment;
- a different, more favorable price base for the quantities the contractor provides for internal consumption;
- the participation of Petroperú in increasing oil prices;
- a lower pipeline tariff.

The contract revisions based on this new petroleum law were valid from 1980 on and resulted in distinct disadvantages to the companies. If we transform a 50:50 production sharing formula into the corresponding tax on net income, we get a tax rate of 61% with costs assumed to be 18% of revenues (cf. Pontoni (1982a, 62)).<sup>11</sup> Production sharing plus income tax of 68.5% amounts to a tax rate of 87% of net income.

In 1978 Petroperú signed a pure production sharing contract for secondary recovery with the U.S.-Argentine consortium Oxy-Bridas. In 1980 the contract was renegotiated and transformed into a service contract. The contractors receive as a fee a base price of \$17.50 for each barrel extracted. This price will be adjusted according to the changes of the world market price, Oxy-Bridas getting 70% of a potential increase and Petroperú 30%.

#### 2.2.4 1980-1985

The extremely high tax rate of 1980 remained in effect only for this one year. The new civil government of Belaunde soon provided incentives for companies in the petroleum sector in the form of an investment tax credit. Up to 50% of income before taxes can be reinvested tax free in petroleum exploration and development. The effective tax rate was thereby reduced to 76% from 1981 on. This seemed to indicate that petroleum

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<sup>11</sup> This is nearly equivalent to the 60% tax rate that was valid for Belco, the only foreign company producing in Peru from 1968 to 1972 under the old concession regime. Only in 1973 Belco's concession was transformed into a production sharing contract.

operations in Peru became profitable again: In 1981/82 three new investors signed contracts with Petroperú with roughly the same provisions as the renegotiated Oxy and Belco contracts, except for the bonus payments.

But declining crude oil prices and the investment tax credit gave rise to new problems. Contractors complained about tax overpayments caused by the tax advance payments of 40% of sales. Although this rate was reduced several times, Oxy and Belco claimed overpayments of more than \$200 million for the period 1982 - 85 (cf. *Petroleum Economist* April 1985; Banco Central de Reserva del Perú, Memoria 1984).

At the same time there were again complaints that foreign companies' profits were exaggerated and profits remittances were too high. Policy proposals ranged from formulation of a new petroleum policy including greater participation of Petroperú and contract renegotiations to expropriation.<sup>12</sup>

#### 2.2.5 1985

The new left-wing García Perez government took action very soon and rescinded contracts with the operating companies claiming that the companies had abused the investment tax credit by increasing production capacity instead of investing in exploration.<sup>13</sup> During the renegotiations the companies had to hand over all of the oil they produced to Petroperú and received a fee that was to cover costs (cf. *Oil and Gas Journal*, Oct., 21, 1985). The investment tax credit was abolished, government demanded for new investment of more than \$600 million and offered so-called "risk contracts" which replaced output sharing by remunerating the firms with a fee for each barrel extracted. But these contracts do not differ substantially from the old

12 For the first view cf. Pontoni (1982b, Anexo II), for the second cf. various 1982 issues of *Proceso Económico*, the weekly supplement of the Lima newspaper *El Observador*.

13 In 1981, in several Peruvian newspapers the impression had been aroused that the investment tax credit was limited to exploration investment; cf. Pontoni (1982b, 43).

production sharing contracts (cf. 4.1). Since Belco did not accept the new provisions, it was expropriated at the end of the year. A compensation will be negotiated. Oxy and Oxy-Bridas accepted investment commitments of \$300 million (instead of \$440 million demanded) and entered into new contracts, the fee based on the world market price of a bundle of different qualities of crude oil. Oxy also signed a new risk contract for a block in the southern jungle. A new petroleum law is under work.

### 2.3 Peruvian petroleum policies in an international perspective

Peru was one of the first nations to try to modify the structure of the petroleum sector to its own advantage. This was due to the special combination of radical political changes and expectations of an oil boom. The corresponding policies which in a similar way gradually arose in resource-rich countries around the world, consisted of the following elements (cf., e.g., Hossain 1979):

- State-ownership of all petroleum reserves and quantities produced,
- establishment of a national petroleum company,
- reduced influence of foreign companies,
- an extensive contractual system as a basis for operations of foreign companies,
- a greater public share of revenues.

The Peruvian government had initially chosen a contract form which had just before been developed for the Indonesian petroleum sector, i.e., a production sharing system (cf., e.g., Fabrikant 1975). Foreign contractors still provided a wide range of services from exploration to possible marketing. In contrast to most of the realized production sharing systems, Peruvian contracts did not contain any cost oil provisions, i.e., no allowance for costs that, e.g., in Indonesia consisted of 40% of output. On the other hand, foreign companies did not have to pay income taxes in Peru up to 1979. Up to this year, the 50% Peruvian share on gross value of production was indeed

relatively low, compared to 56% in Ecuador, 59.5% in Columbia and 65% in Bolivia (including income taxes, c.f. Pontoni (1982a, 54-58)).

After the contract revisions the Peruvian government's share increased to 74% in 1980. This is in between the shares that the production sharing contracts of Columbia (68.4%), Indonesia (71%), Egypt (78.1%) and Malaysia (79.9%) provide (c.f. Gillis (1983, 18)).

In times of a declining world market price, and since some Latin American neighbor countries like Ecuador and Columbia have somewhat more favorable geological conditions, competitiveness with respect to contract terms seems to be necessary to attract foreign direct investment. This would not be that important if Peru could finance mining projects with international credits. But at least since the second half of the 1970s, for various reasons credit raising possibilities have been restricted (cf. Portocarrero 1982 and Stallings 1983).

### 3. Econometric analysis of production and investment of foreign oil companies in Peru

#### 3.1 Theoretical model

For the purpose of econometric estimation of the development of the Peruvian petroleum sector a simple general static neoclassical model of the profit-maximizing firm is used.<sup>14</sup>

To determine the supply of crude oil and the optimal production capacity, the firm maximizes profits  $\pi$  after income taxes with a tax rate  $\tau$  subject to a production function, assumed to be of Cobb-Douglas-type :

14 Cf. the similar approach for an econometric model of the world copper market by Wagenhals (1984).



$$(3.1) \quad \max_Q (1-\tau) \pi(V, K) = (1-\tau) (p Q(V, K) - C_v - C_k)$$

$$(3.2) \quad \text{s.t.} \quad Q(V, K) = a_0 V^{a_1} K^{a_2},$$

where  $p$  : price of crude oil  
 $Q$  : quantity of crude oil  
 $V$  : variable inputs  
 $K$  : production capacity (proportional to capital inputs)  
 $C_v = c_v * V$  : costs of variable inputs  
 $c_v$  : cost per unit of variable input  
 $C_k = c_c * K$  : cost of capacity  
 $c_c$  : user costs of capacity<sup>15</sup>  
 $\tau$  : income tax rate

From the first order conditions, optimal levels of inputs are

$$(3.3) \quad K^* = (a_2 p q) / c_c$$

$$(3.4) \quad V^* = (p / c_v * a_1 a_0 K^{a_2})^{1/(1-a_1)} = V^*(p, c_v, K)$$

Substituting  $V^*(p, c_v, K)$  into the profit function, the restricted profit function  $\pi^*(p, c_v, K)$  is obtained. From  $\pi^*$  the supply function  $Q^*(p, c_v, K)$  is derived applying Hotelling's lemma (cf., e.g., Varian (1984, 52f)):

$$\begin{aligned} (3.5) \quad Q^*(p, c_v, K) &= \partial \pi^*(p, c_v, K) / \partial p \\ &= 1/(1-a_1) * a_0^{1/(1-a_1)} * (a_1 a_1^{a_1/(1-a_1)} - a_1^{1/(1-a_1)}) * \\ &\quad * (p/c_v)^{a_1/(1-a_1)} * K^{a_2/(1-a_1)} \\ &=: e^{b_0} * (p/c_v)^{b_1} * K^{b_2} \end{aligned}$$

Taking logarithms, the profit-maximizing supply function has the form:

$$(3.6) \quad \log Q_t = b_0 + b_1 \log (p_t / c_{vt}) + b_2 \log K_t$$

Actual increases  $Z_t$  in capacity are specified by assuming that actual capacity  $K_t$  adjusts only partially to desired optimal capacity  $K_t^*$  as determined by (3.3) and that reduction in capacity due to physical wear is proportional to capacity:

<sup>15</sup> User costs of capacity are proportional to user costs of capital  $c$  that are determined by maximizing discounted net cash flow; cf. Coen (1968).

$$(3.7) \quad K_t = K_{t-1} + \alpha(K^*_t - K_{t-1})$$

$$(3.8) \quad K_t = K_{t-1} + Z_t - \beta K_{t-1} \quad ,$$

where  $\alpha$ : coefficient of adjustment

$\beta$ : rate of economic depreciation.

Inserting equations (3.3) and (3.8) into (3.7) leads to the following equation for gross capacity increases:

$$(3.9) \quad Z_t = g_1 Z_{t-1} + g_2 [(p_t/c_t)Q_t - (p_{t-1}/c_{t-1})Q_{t-1}] + \\ + g_3 (p_{t-1}/c_{t-1})Q_{t-1} \quad .$$

For real gross investment  $I_t$  (in \$ of 1980) we get an equivalent equation, if we multiply (3.9) by the price per unit of capacity in 1980:

$$(3.10) \quad I_t = g_1 I_{t-1} + \tilde{g}_2 [(p_t/c_t)Q_t - (p_{t-1}/c_{t-1})Q_{t-1}] + \\ + \tilde{g}_3 (p_{t-1}/c_{t-1})Q_{t-1} \quad .$$

To get a system of equations in  $Q_t$  and  $I_t$ ,  $K_t$  was eliminated from equation (3.6), using equations (3.3) and (3.7) and approximating  $\log(K)$  by  $vK+w$ ,  $v, w > 0$ :<sup>16</sup>

$$(3.11) \quad \log Q_t = h_0 + h_1 \log(Q_{t-1}) + h_2 \log(p_t/c_t) + \\ + h_3 \log(p_t/c_{vt}) + h_4 \log(p_{t-1}/c_{v,t-1}) \quad .$$

If income taxation is replaced by production sharing, the company's decisions will be affected by taxation (cf. Meyer 1985). But in the equations to be estimated this does not show up since the output share is constant in the relevant period. Only the computation of the user costs of capital term is affected.<sup>17</sup>

<sup>16</sup> This approximation seems to be reasonable since the values  $K$  typically lie in the far-out-part of the argument region of  $\log$ .

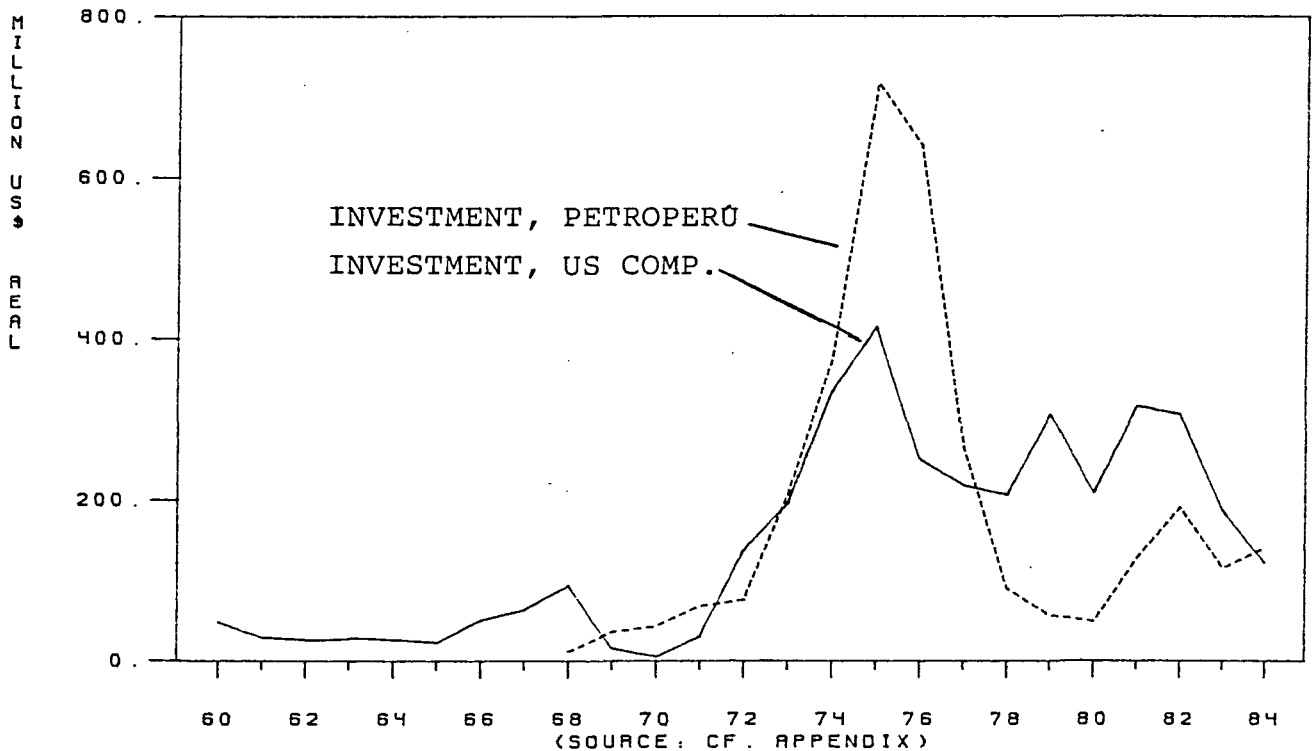
<sup>17</sup> For the computation of  $c$  cf. the appendix.

### 3.2 Results

Production and investment have been estimated only for the foreign companies operating in the Peruvian petroleum sector. National, especially state-owned companies have not been taken into account since their behavior seems to be determined at least as much by political considerations as by economic ones. This is especially illustrated by the history of the pipeline construction in Peru. Investment expenditures by Petroperú from 1974 to 1978 were mainly dedicated to the pipeline project. Investment for exploration and development outside this period accounts for only a small fraction of the 1975 peak (cf. Figure 3).

Allowing for random influences on the dependent variables, in econometrics generally an additive error process is superimposed on the theoretical deterministic model.

FIGURE 3: INVESTMENT, PETROLEUM SECTOR



Following the Ordinary-Least-Squares (OLS) - principle, the error terms of equations (3.10) and (3.11) are assumed to be independent, intertemporarily as well as contemporarily. This leads to the following OLS-estimation<sup>18</sup> of (logarithmic) production and investment:

$$(3.12) \quad \log Q_t = 1.44 + 0.40 \log(Q_{t-1}) - 0.26 \log(cvt) + 0.94 D_q$$

(5.2)      (4.1)                      (2.7)                      (6.4)

$RC^2=0.93, \quad DH=0.06$

$$(3.13) \quad I_t = 0.53 I_{t-1} + 0.17 (p_t/c_t * Q_t - p_{t-1}/c_{t-1} * Q_{t-1}) +$$

(5.5)                      (3.5)

$$+ 0.46 (R_{t-1} - R_{t-2}) + 87.52 D_I$$

(4.8)                                      (3.7)

$RC^2=0.90, \quad DH=-0.13 \quad ,$

where  $D_q$  : dummy variable ( = 1 for 1978-1984, = 0 else)  
 $R_t$  : proven petroleum reserves  
 $D_I$  : dummy variable ( = 1 for 1971-1984, = 0 else)  
 $RC^2$  : coefficient of determination, corrected for degrees of freedom  
 $DH$  : Durbin's  $h$ <sup>19</sup>.

Numbers in brackets show the values of the t-statistic corresponding to the test of parameters being equal to 0.

Durbin's  $h$  of close to zero for both equations indicates that there is no autocorrelation in the residuals so that the use of the present model does not seem inappropriate. Statements about the quality of the model can be derived from the goodness-of-fit parameter  $RC^2$  that is around 0.9 for both equations. Thus, the model explains about 90% of the variability of the data, although variables corresponding to the political environment that are not included in the model, surely had a strong influence.

18 All estimations as well as the simulations in section 4 were performed using the software product RATS (cf. RATS 1984, 1985). Data and sources are listed in the appendix.

19 Durbin's  $h$  is normally distributed with mean 0 and variance 1, also if a lagged endogenous variable is used as a regressor; cf. Judge et al. (1982, 450ff).

These two equations form a nonlinear, interdependent but recursive system in  $Q_t$  and  $I_t$ . For linear recursive systems, the OLS-estimator is known to provide the smallest uncertainty about the parameters, at least for a large number of observations of the involved variables (asymptotic efficiency), if the assumption of contemporarily independent error terms holds (cf., e.g., Schönfeld (1971, 226-231)). This result carries over to the above case as  $\log Q$  is approximately linear for the relevant range of data. But note that contemporary independence is not tested. Instead, the effect of dropping this assumption is studied (Zellner's "seemingly unrelated regression" estimator; cf. Judge et al. (1982, 115-121)). This leads to the following reestimation:

$$(3.14) \quad \log Q_t = 1.60 + 0.35 \log(Q_{t-1}) - 0.21 \log(cvt) + 0.93 D_0$$

(7.5)      (5.0)                      (2.7)                      (8.6)

$RC^2=0.92, \quad DH=0.48$

$$(3.15) \quad I_t = 0.43 I_{t-1} + 0.13 (p_t/c_t * Q_t - p_{t-1}/c_{t-1} * Q_{t-1}) +$$

(6.2)              (3.8)

$$+ 0.52 (R_{t-1} - R_{t-2}) + 110.26 D_1$$

(7.3)                      (6.3)

$RC^2=0.89, \quad DH=0.076$

The results show a remarkable stability, supporting the validity of the approach. In the discussion of the results we refer to equations (3.14) and (3.15).

In the production equation extracted quantities of the previous period have a strong influence. This is due to technical requirements that would cause high adaption costs if production levels were to be altered significantly. Among the three price-cost-terms of the theoretical model only the unlagged variable cost term is significant at a significance level of 5%. So directly, only short term cost considerations seem to have influenced the production figures, while the effect of long-term costs is covered by the lagged endogenous variable. Note that the elasticity of lagged production (0.35) is

considerably higher than the elasticity of the variable cost term (0.21). The crude oil price parameter turned out to be insignificant, indicating that price has no relevant influence on production decisions. The dummy had to be introduced since the completion of the pipeline in 1978 provided transportation facilities which allowed for a much higher level of production from then on.

In the equation for investment, again the lagged endogenous variable has an influence on present levels. This may be explained by the high capital intensity and the long gestation period of large scale petroleum projects. From the two revenue/user costs of capital - terms of the theoretical model, only the first differences term turns out to be significant. Moreover, as an additional term not being derived from the above theory, lagged first differences of petroleum reserves have been introduced. This may be justified because newly proven reserves require huge development investments in subsequent years. Lagged investment however always has the strongest influence on present investment levels. E.g. in 1979, a 1% increase in this variable leads to an increase of present investment of \$ 0.89 million (0.37%). The dummy variable was introduced to take account of the much higher investment level in the 1970s due to the searching-for-oil boom. The effect of this boom might have been superimposed by long-term expectations of a rising oil price leading to a prolongation of the dummy effect.

The tax rate has only some indirect influence in the investment equation since it is included in the user cost of capital - term. A permanent 1% increase in the tax rate leads to an increase in user costs between 1.5% (1960) and 7.5% (1980) and thereby has a negative effect on investment. This is reflected in the positive sign of the estimated coefficient of the revenue/user cost - term.

To sum up: This model seems to capture one of the main characteristics of crude oil extraction: Given the field size, there exists an optimal, technically determined production

profile so that actual production is mainly dependent on lagged production and only partially on variable costs. The resulting production level, although somewhat corrected by the relation between world market prices and capital user costs, to a considerable extent determines investment levels, apart from the structural break in the beginning of the 1970s. This causal chain is reflected in the recursive structure of the model. Moreover, taking into account the various indicators for the validity of the estimates, its reasonable data fit seems to support that the econometric model reflects a large part of the historical development of the Peruvian petroleum sector, although it ignores some characteristics of exhaustible resources.

#### 4. The simulation model

Peruvian data available do not allow for a very detailed econometric analysis of the influence of various contract formats on the private oil companies' decisions. For this purpose a simulation model was used. The model is based on Peruvian geological and cost characteristics and evaluates various contract formats, mainly their provisions for taxation that either have been in effect in Peru or the implementation of which has been discussed. The model determines the net present value of hypothetical petroleum projects under the various contracts and its allocation between the contractor and the Peruvian state.

##### 4.1 Assumptions <sup>20</sup>

The assumptions about geology and costs are based on history and on scenarios about future development of crude oil

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<sup>20</sup> These assumptions are similar to the ones used by Blitzer/Lessard/Paddock (1982) in their Ecuador study.

exploration and production in the Marañón basin in the Peruvian northern jungle region<sup>21</sup>.

The project term is 21 years: three years of exploration, three years of development, and 15 years of production.

Petroleum deposits are assumed to be log-normally distributed with the following probabilities of recoverable reserves size  $R$  (in million barrels):

$$\begin{aligned}\text{prob}(R < 10) &= 0.75 \\ \text{prob}(10 \leq R < 40) &= 0.1875 \\ \text{prob}(R \geq 40) &= 0.0625\end{aligned}$$

This gives a log-normal probability distribution with mean 1.21 and standard deviation 1.62. Since these percentages do not seem to be unrealistic,<sup>22</sup> this reflects that the structure of Peruvian petroleum deposits is rather unfavorable on international standards.<sup>23</sup>

The volume of reserves is revealed only by exploration which is assumed to cost \$10 million per year. Development costs are assumed to be dependent on reserve size with the cost function providing for economies of scale:

$$\begin{aligned}K_{dev} &= f(R) && , f' > 0, f'' < 0 \\ &= 15 * 10^6 + 24 * R^{.85}.\end{aligned}$$

In the first year of development 25% of these costs will be spent, in the second year 35% and in the last year 40%.

Production profiles are determined according to the following rule of thumb: In each of the first five years, 10% of

21 Cf. Pontoni (1982b); especially the study by Bundesanstalt für Geowissenschaft und Rohstoffe / Petroperú (1980): Evaluación del potencial petrolífero de la Cuenca Marañón, cited in Annex 1.

20 True, this log-normal distribution leads to an arithmetic mean of the reserve size of 7.5 million barrels, compared to a mean of 25 million barrels in jungle oil fields discovered in the seventies. This difference is due to the exclusion of very small, non-commercial deposits in the last figure.

23 Big and giant oil fields with a volume of more than 200 and 1000 million barrels, respectively, have an extremely low probability of occurrence in Peru.



recoverable reserves are extracted, in each of the second five years, 1/15, and in each of the last five years, 1/30.<sup>24</sup> Operating costs per barrel are constant and amount to \$3. This means that total costs per barrel range between \$4.5 for a reserve size of 200 million barrels and \$8 for reserves of 10 million barrels.

For the crude oil price there are two scenarios: a constant real oil price of \$20 and \$30, respectively.<sup>25</sup> All values are in U.S. \$ of 1980. A real discount rate of 10% has been used for both the contractor and the government.

A project is said to be acceptable if its net present value is greater than \$-24.87 million, i.e. each project that will at least lessen discounted exploration costs will be worthwhile to be undertaken.<sup>26</sup>

The taxation provisions investigated in the simulation model are the following (cf. section 2.2):

- (PS) Production sharing provisions of the original "contrato modelo Perú", i.e. a company share of 50% of extracted petroleum.
- (PI) Income taxation in addition to (PS) with a tax rate of 68.5%, straight line depreciation of 10% per year and unlimited loss carry forward.

24 Cf. the China model in Blitzer et al (1983, Appendix B). The assumption of identical time horizons for extraction independent of reserve size may be justified by adaption of the length of the extraction period to the fixed lifetime of capital goods.

25 A variable oil price has also been experimented with: It starts at \$36, declines at a rate of 5% in years 2-5, of 25% in year 6, remains constant for 4 years, and rises at 3% in years 11-17 and 6% in years 18-21. This time profile seems to capture actual price expectations. But it provided results very similar to the \$20-scenario, since in the first high-price periods there is not yet any crude oil extracted.

26 This is equivalent to a positive net present value of the project if we neglect the three year period of exploration.

(PIC) (PI) supplemented by an investment tax credit of 45% of net income before taxes.

(PIR) Introduction of a special form of excess profit taxation - a resource rent tax (cf. Garnaut/Clunies Ross 1983 and Meyer 1984) - on top of production sharing (with a company share of 75%), and income taxation (tax rate of 68.5%). Income tax is deductible, capital costs can be depreciated immediately, and losses will be carried forward and accumulated at an interest rate of 10%. Positive period cash flows will then be taxed at a rate of 75% (case (PIRH)) and 25% (case (PIRL)), respectively. The increase of the company share relative to (PS) is to compensate for the increased tax rate for very high profits.

(I) Income taxation in the absence of production sharing with a tax rate of 76% (IH) and 61% (IL), respectively.

(IR) Resource rent tax at a rate of 61% (IRH) and 45% (IRL), respectively, on top of an income tax of 61% .

The Peruvian risk contracts, introduced in 1986, do not have to be investigated separately, for, if the fee the companies get for their services increases with the same rate as the world market price, basically a risk contract does not differ from a production sharing contract. E.g., the fee Oxy gets is about 50% of the world market price. This is indeed identical to tax system (PI) except for an insecure availability of crude oil to the company.

The substitution of the investment tax credit by accelerated depreciation that is being discussed in Peru has not been investigated yet. Our model only evaluates single projects and does not take into account the performance of a project within a company setting. Only then, some form of accelerated depreciation would be profitable.

## 4.2 Results

After 500 runs the theoretical probability distribution seemed to be approximated well enough. The following tables summarize the simulation results for the two price scenarios. Column (0) of Table 1 gives the results before taxes. The other columns correspond to the taxes described in 4.1. In addition to the average net present values (avNPV) and tax revenues (av.taxes) of all 500 fields, the tables also give some key figures for the samples of developed fields: the average net present value of developed fields (avNPV, dev.fields), the average net present value of developed fields for the specific tax in relation to the average net present value of developed fields for (PS) (cor.avNPV), and tax revenues of developed fields for the specific tax in relation to tax revenues of developed fields for (PS) (cor.av.taxes). The last three rows then correspond to the rather improbable event that only fields with rather large reserve sizes will be identified by exploration.

In the figures, the density functions of the net present value and of the tax revenue, respectively, are presented. For this purpose, the 500 values have been classified. The first class includes values up to \$-24.87 million in the case of net present values and up to 0 in the case of tax revenues. This class therefore contains the net present values and tax revenues, respectively, of the non-developed fields. It is not shown in the figures, since its probability is too high to fit into the figures. Instead, the percentage is given in the upright part of each figure (prob(class no.=1)). The next 29 classes each have a width of about \$8.3 million. In the case of net present values this means that these are positive from class number 5 on. The last class contains all net present values greater than \$215.5 million and all tax revenues greater than \$240 million, respectively.

Compared to the no-tax case (0), the number of fields developed and the volume of the marginal field is reduced by the introduction of the various taxes. It is clearly shown that

petroleum reserves cannot be considered as a cake of fixed size to be shared but that the size of the cake varies dramatically with different taxes and prices.

**Table 1: Simulation results:  
Effects of Peruvian contract forms<sup>27</sup>**

	oil price \$20				oil price \$30			
	(0)	(PS)	(PI)	(PIC)	(0)	(PS)	(PI)	(PIC)
no. of fields developed	287	150	16	33	354	232	57	94
marginal field (mill b)	2.3	9.4	71.7	41.0	1.3	3.8	25.4	16.2
avNPV <sup>28</sup> (mill \$)	24.2 (2.9)	-13.8 (3.8)	-23.9 (7.2)	-21.2 (6.0)	64.2 (2.7)	4.7 (3.1)	-20.3 (6.4)	-12.3 (4.2)
av.taxes (mill \$)	--	35.3 (2.8)	21.1 (6.1)	24.7 (4.8)	--	57.6 (2.6)	55.4 (3.9)	56.5 (3.3)
avNPV, dev. fields (mill \$)	60.7	12.0	6.4	30.4	100.9	38.8	14.9	41.9
cor.avNPV <sup>29</sup> (% of (PS))	--	100	5.7	55.9	--	100	9.4	43.8
cor.av.taxes (% of (PS))	--	100	6.4	15.4	--	100	23.6	39.8

The performance of the taxes that are part of the various Peruvian contract systems as described in 2.2 is shown in Table 1. Not very surprisingly, the combination of production sharing and income taxation (PI) negatively affects project revenues as well as tax revenues. Both decline heavily since only rather large deposits which occur with a low probability can be profitably developed. The effects are not as quite as dramatic with the higher oil price. The introduction of the investment tax credit (PIC) increases the net present value as well as tax revenues, but does not compensate for all the negative effects

<sup>27</sup> Numbers in brackets show the coefficients of variation, i.e., standard deviation divided by the mean difference to \$-24.87 million and by average taxes, respectively.

<sup>28</sup> avNPV: average net present value.

<sup>29</sup> Corrected average net present value: the number of developed fields is taken into account.

FIG. 4A: NPV: PS, PI, PIC (A:P=\$20)

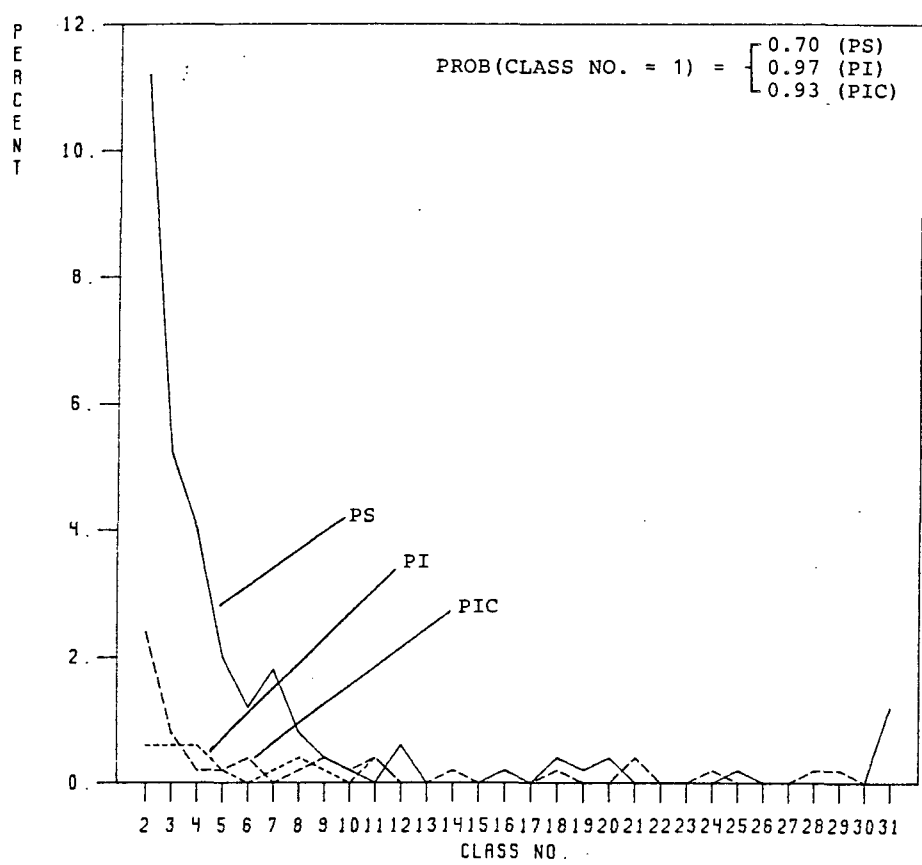


FIG. 4B: NPV: PS, PI, PIC (B:P=\$30)

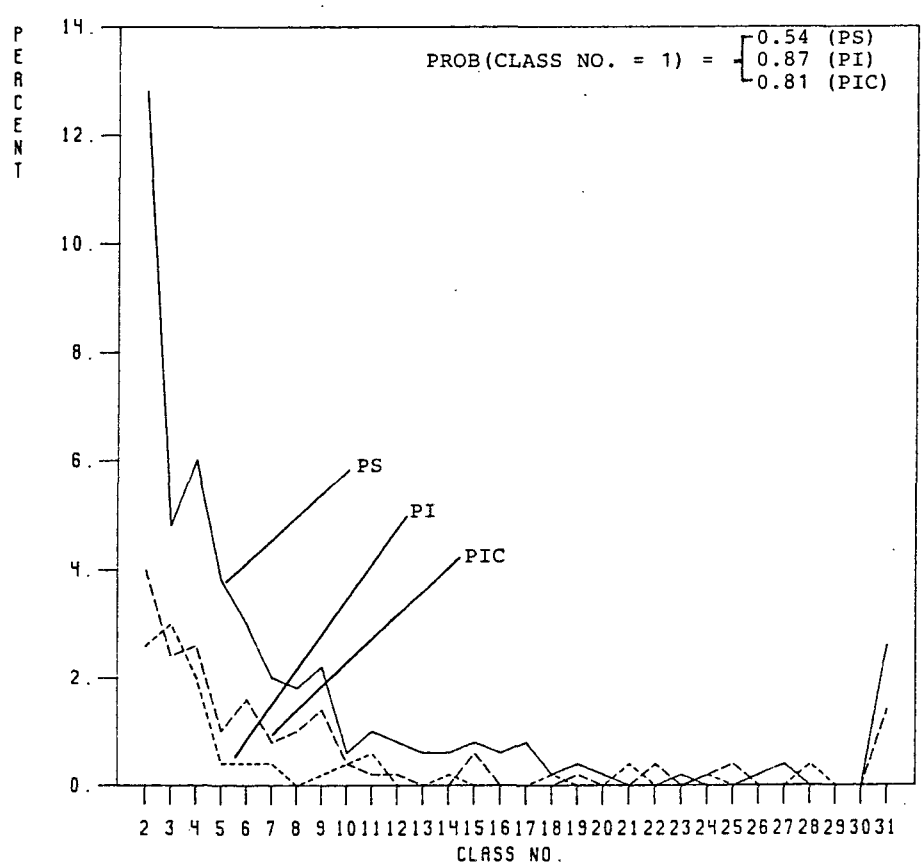


FIG. 4C: TAXES: PS,PI,PIC (A:P=\$20)

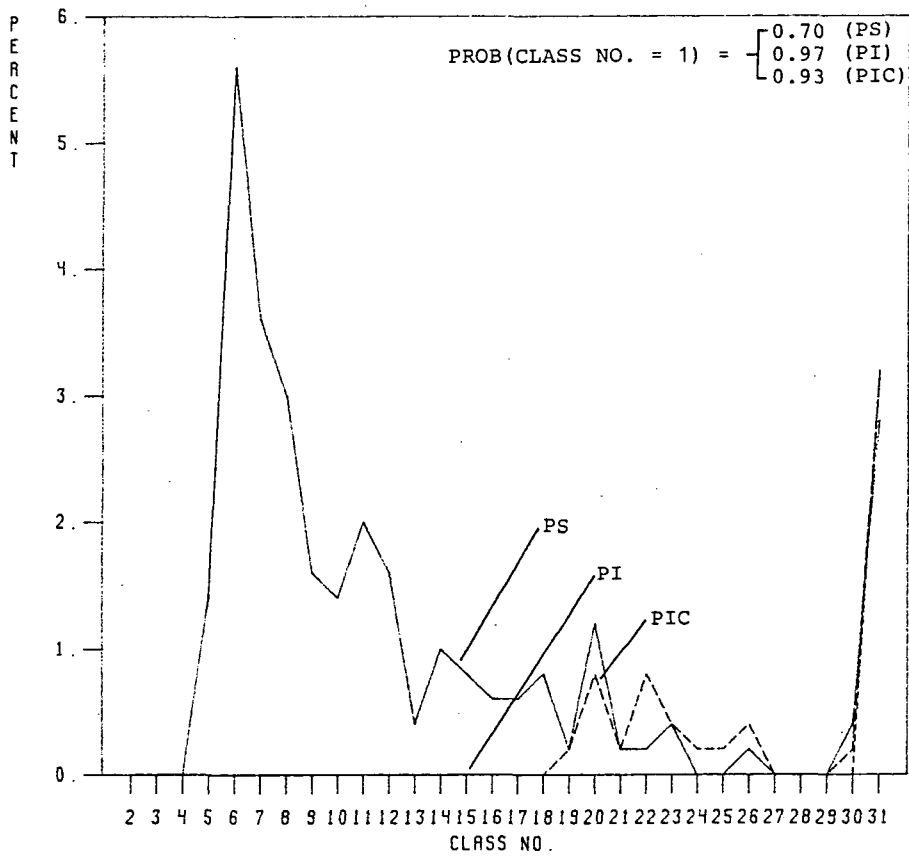
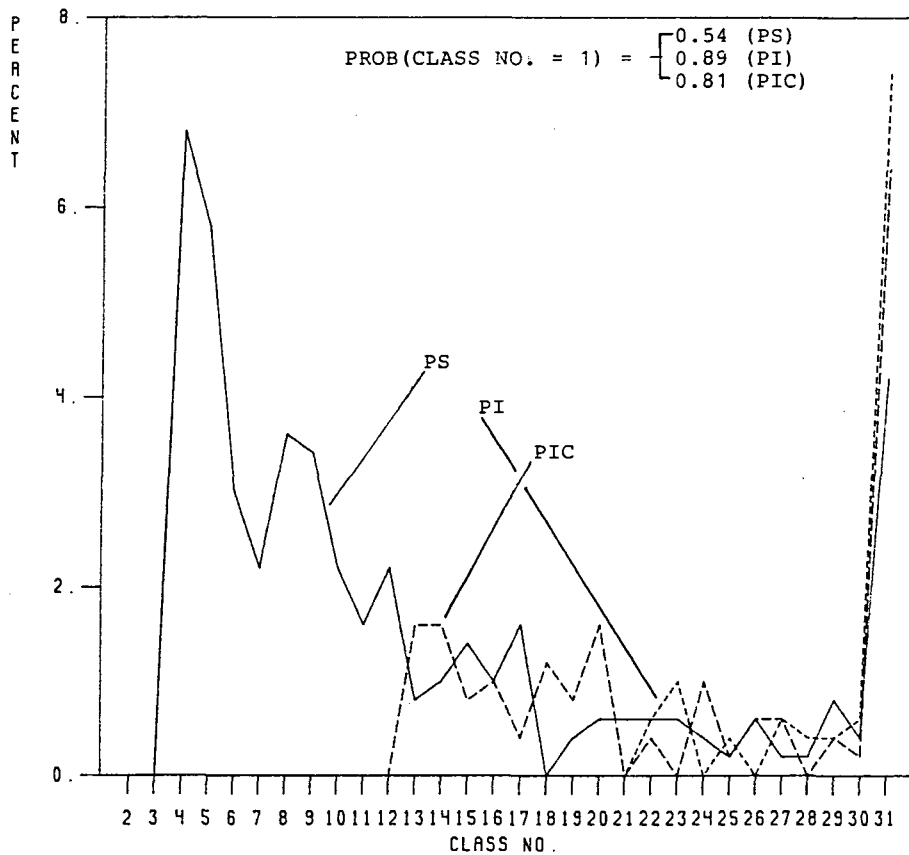


FIG. 4D: TAXES: PS,PI,PIC (B:P=\$30)



**Table 2: Simulation results (oil price \$20):**  
**Effects of hypothetical contract forms**

	(PIRH)	(PIRL)	(IH)	(IL)	(IRH)	(IRL)
no. of fields developed	57	57	89	113	113	113
marginal field (mill b)	25.4	25.4	17.3	13.0	13.0	13.0
avNPV (mill \$)	-22.9 (4.0)	-21.2 (4.8)	-18.7 (4.4)	-12.2 (3.9)	-18.8 (3.5)	-17.2 (3.6)
av.taxes (mill \$)	32.0 (4.1)	30.3 (4.1)	32.0 (3.5)	27.2 (3.3)	33.7 (3.5)	32.0 (3.5)
avNPV, dev. fields (mill \$)	-7.8	7.3	9.7	31.2	2.0	9.6
cor.avNPV (% of (PS))	--	23.3	48.0	196.2	12.5	60.7
cor.av.taxes (% of (PS))	34.5	32.6	53.7	57.9	71.9	68.3

**Table 3: Simulation results (oil price \$30):**  
**Effects of hypothetical contract forms**

	(PIRH)	(PIRL)	(IH)	(IL)	(IRH)	(IRL)
no. of fields developed	121	121	153	168	168	168
marginal field (mill b)	12.1	12.1	9.2	7.1	7.1	7.1
avNPV (mill \$)	-20.4 (3.1)	-15.4 (3.7)	-10.6 (3.5)	1.9 (3.3)	-12.8 (3.0)	-9.0 (3.1)
av.taxes (mill \$)	69.1 (3.3)	64.8 (3.2)	62.8 (3.0)	51.1 (3.0)	65.8 (3.1)	62.0 (3.1)
avNPV, dev. fields (mill \$)	-6.3	14.4	21.9	54.7	11.1	22.5
cor.avNPV (% of (PS))	--	19.3	37.2	102.1	20.6	42.0
cor.av.taxes (% of (PS))	62.6	58.7	71.9	64.3	82.8	77.9

of the production sharing / income tax system. These results can also be deducted from Figures 4a through 4d.

In Tables 2 and 3 the performance of various hypothetical tax systems is summarized. There cannot be identified any tax that dominates pure production sharing (PS) (cf. Table 1) in the sense that it provides higher average net present values as well as higher tax revenues. A pure income tax system with a tax rate rate of 61% (IL), equivalent to the 50% company production share under certain cost assumptions (cf. 2.2.3), improves average net present value in the \$20-scenario (cf. also Figure 5) and average net present value of developed fields in both price scenarios, but lowers tax revenues, since less fields will be developed. A higher income tax rate reinforces this bias, at least in the \$20-scenario, and it also depresses average net present values (cf. (IH) in Tables 2 and 3). A lower income tax rate will increase the number of developed fields, but decrease tax revenues at the expense of increasing average net present values.<sup>30</sup>

Finally some experiments have been performed with the resource rent tax. Compared to the investment tax credit (PIC) the increase of the company production share from 50% to 75% (PIRH and PIRL) leads to an increase in the number of fields developed. The higher tax rate for the upper range of profits guarantees higher tax revenues. The average net present value of all fields is similar for the three taxes in the \$20-price scenario, irrespective of the resource rent tax rate (75% or 25%; cf. Table 2). The resource rent taxes provide tax revenues in the lower range of classes, while classes indicating higher tax revenues have a greater probability in the case of the investment tax credit (cf. Figure 6). Therefore the average net

30 These results differ from statements of theoretical models concerning the biases caused by the introduction of taxes (cf. e.g. Dasgupta/Heal (1979, 361ff)). But in those models, firms adapt to equilibrium price paths by choosing optimal extraction profiles. In comparison, in this simulation model the length of the time horizon and the extraction profile are predetermined and firms can adapt to taxation only by eventually turning down the development option.



present value of developed fields is reduced by the resource rent taxes. In the case of a 75% resource rent tax rate (PIRH), the profits of big developed fields cannot even make up for losses due to development costs of small fields. Comparing investment tax credit and resource rent tax in the two price scenarios, the progressivity of the resource rent tax is demonstrated. Average net present value increases considerably for the investment tax credit, but less for the resource rent taxes. The same is true for a mutual comparison of the two resource rent taxes.

A second group of experiments served to analyse the capability of the resource rent tax to provide higher tax revenues without introducing major disincentives to development. Two resource rent tax systems (tax rates of 61% (IRH) and 45% (IRL) together with an income tax rate of 61%, but without production sharing) were compared with a pure income tax of 61% (IL) and 76% (IH), respectively. The two resource rent tax systems lead to the same number of developed fields, but higher tax revenues as the 61% income tax. Compared to the 76% income tax, the resource rent taxes provide both a higher number of developed fields and the company is not worse off. In this respect, a resource rent tax system could serve as a compromise. But, compared with the results of other simulation models (cf. Johnson 1981 and Kemp/Rose 1984), the resource rent tax does not perform as well as expected in this model because of Peruvian geological and cost features. The probability of discovering oil bonanzas, i.e., low cost / high volume deposits, is too low to compensate for the many high cost / low volume deposits.

The relative spread of the projects' net present values and of the tax revenues, i.e. the coefficient of variation, is also reported in Tables 1 through 3. Note that the combination of production sharing and income taxation leads to the highest,

FIG. 5: NPV: PS, IL (A:P=\$20)

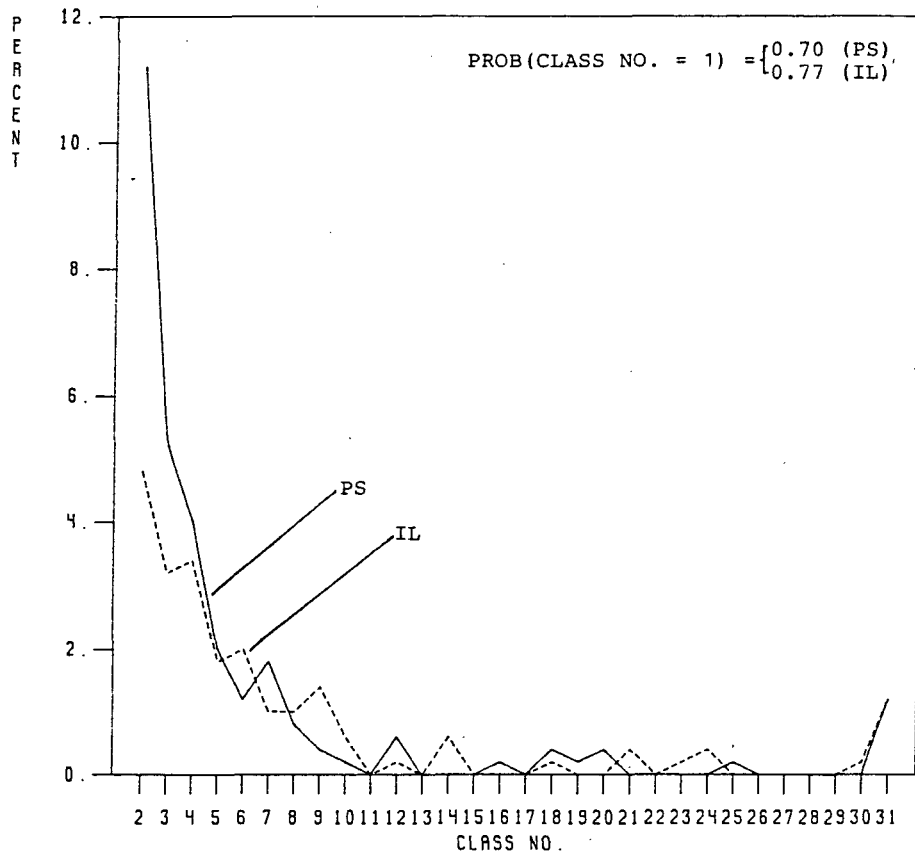
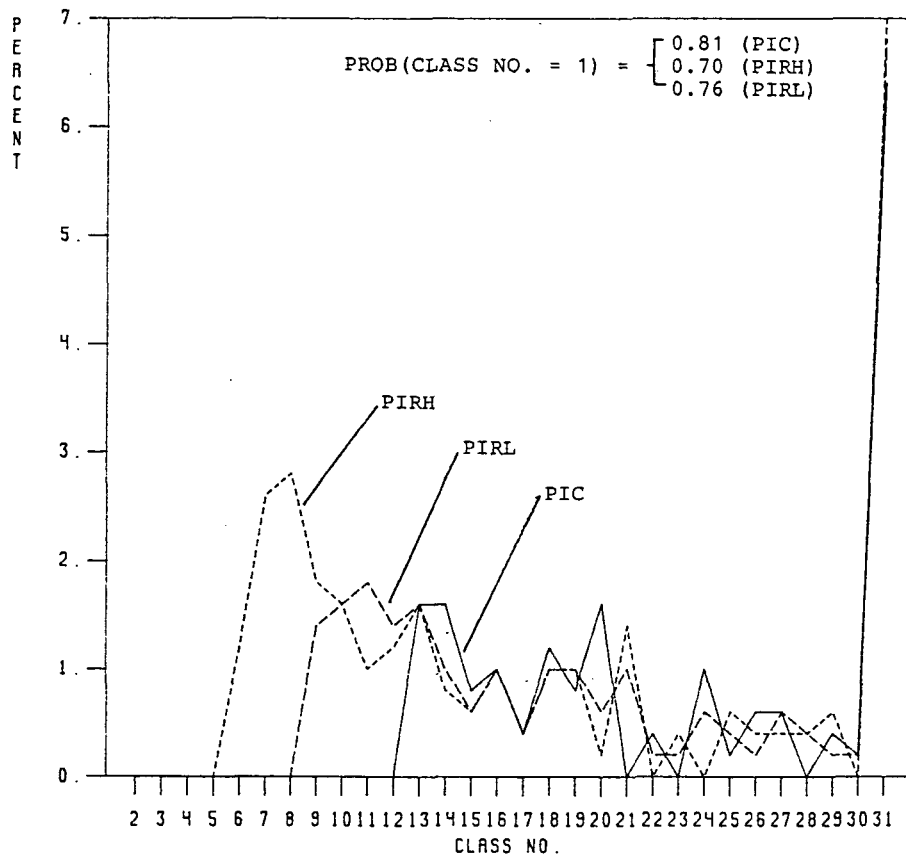


FIG. 6: TAXES: PIC,PIRH,PIRL (B:P=\$30)



pure production sharing to the lowest spread among the tax systems. Generally, spreads are lower in the \$30-scenario, but they do not differ very much.

## 5. Conclusion

If we join the various tessere provided by the analysis of the preceding sections, the picture of performance in the past as well as of future prospects of the Peruvian petroleum sector does not seem very bright. Peruvian contract and tax schemes have developed in direction to an increased public share of petroleum revenues and increased regulation by the government. In times of a rising world market price this does not seem to have a negative effect on investment levels, as well as on current production levels. But with a low price, foreign companies seem reluctant to invest in countries where both the probability to find petroleum reserves is low and the government share of resource revenues is rather high. Under these circumstances it is rather difficult to identify a contract system that reconciles the needs of both the foreign investors and the resource-rich country.

In the simulation model, the pure production sharing system performed best among all the tax systems under consideration. But the adoption of this system is no more possible because of restrictions imposed by the investors' home governments. A resource rent tax, complemented by an income tax, could perhaps serve as a substitute. It does not introduce major disincentives by securing a certain rate of return to the investor and on the other hand, it provides relatively high tax revenues, especially in times of a rising resource price or in case of bonanzas.

## Appendix: The econometric model - data and sources

## Sources

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- (14) Mining Annual Review 1978
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- (17) World Oil, Aug. 15, 1984 and 1985
- (18) BCRP, Memoria, various issues

Variable	Description	Source
Q	crude oil production of foreign companies in Peru (million barrels) $Q = QS - QP$	
QS	total crude oil production in Peru	60-74: (1) 75-80: (2) 81 : (1) 82 : (3) 83-84: (4)
QP	crude oil production of national companies in Peru	60-63: (5) 64-75: (6) 76-79: (1) 80-82: (7) 83-84: (17)

I	real capital expenditures by majority-owned foreign affiliates of U.S. companies in the Peruvian petroleum sector (million \$ of 1980, deflator: PWUS), I=IUSR	60-84: (8)
IPPR	real gross fixed capital formation of Petroperú (million \$ of 1980, deflator: PWUS)	68-84: (18)
PWUS	U.S. wholesale price index (1980=100)	60-84: (9)
cv	cost of variable inputs in crude oil production (1980=1) $cv := [0.4 * PIC / (ER / 288.5) + 0.3 * (EUVI + EUVO)] / 100$	
PIC	Peruvian consumer price index (1980=1)	60-84: (9)
ER	exchange rate (Soles/U.S. \$)	60-84: (9)
EUVI	export prices: index of unit values in terms of U.S. \$, industrialized countries (1980=1)	60-84: (9)
EUVO	export prices: index of unit values in terms of U.S. \$, oil-exporting countries (1980=1)	60-84: (9)
p	crude oil spot market price index, Arabian Light, yearly average (1980=1)	60-81: (10) 82-84: (11)
R	proven petroleum reserves in Peru at yearend (million barrels)	60-68: (12) 69-70: estimat 71-79: (13) 77 : (14) 80 : (15) 81-82: (16) 83-84: (17)
DP	internal Peruvian demand for petroleum products (million barrels)	60-67: (12) 68-81: ((13) 82-84: (4)
c	user costs of capital 60-72, 80: $c := [c_k / ER * (r + d) * (1 - \tau((1 - \exp(-r * 1)) / r * 1))] / (1 - \tau)$ 73-79: $c := [c_k / ER * (r + d)] / (1 - \tau_{pt})$ 81-84: $c := c_k * r / ER * [(1 + d * (1 + \tau * s)) - \tau * (1 - \exp(-r * 1)) / (r * 1) * (1 + d / r)] / (1 - \tau * (1 - s))$	
ck	purchase price of an additional unit of capital services, here $c_k = PIC$	

r interest rate 60-84: (9)  
 here:  $r=0.1161$  (60-84 average of the real  
 U.S. federal funds rate, Deflator: PWUS)  
 d rate of economic depreciation,  
 here  $d=0.067$   
 l lifetime of capital stock for tax  
 purposes, here  $l=1/d=15$   
 $\tau$  effective corporate income tax rate cf. sec. 2.2  
 $\tau_{pt}$  output share of contractor,  $\tau_{pt}=0.5$   
 s investment tax credit,  $s=0.45$

## Data

	Q	IUSR	R
60- 1	18.2210	48.1586	197.000
61- 1	18.3600	28.4091	202.000
62- 1	19.7280	25.4958	201.000
63- 1	19.3950	28.4091	200.000
64- 1	20.4360	25.5682	205.000
65- 1	20.4150	22.2841	200.000
66- 1	20.5630	51.2129	190.000
67- 1	23.5040	64.5161	185.000
68- 1	25.0270	94.4882	171.000
69- 1	14.5070	15.1515	160.000
70- 1	15.8140	4.86618	150.000
71- 1	13.3280	30.6604	183.000
72- 1	15.2030	137.698	230.000
73- 1	13.2180	195.609	359.000
74- 1	14.3430	334.454	768.000
75- 1	11.6750	413.846	747.000
76- 1	14.5260	249.633	728.000
77- 1	14.3130	217.452	728.000
78- 1	33.8930	205.392	727.000
79- 1	51.3830	305.936	755.000
80- 1	55.4000	208.000	800.000
81- 1	55.1000	316.224	835.000
82- 1	54.9750	305.481	775.000
83- 1	45.1140	186.335	696.000
84- 1	45.0050	121.317	670.000

	P	C	Cv	
60-	1	.452778E-01	.313288E-01	.222313
61-	1	.436111E-01	.342514E-01	.234605
62-	1	.422222E-01	.364476E-01	.242565
63-	1	.416667E-01	.386565E-01	.252675
64-	1	.402778E-01	.430744E-01	.270495
65-	1	.394444E-01	.497013E-01	.297825
66-	1	.377778E-01	.541191E-01	.317145
67-	1	.369444E-01	.520360E-01	.309625
68-	1	.366667E-01	.541843E-01	.296842
69-	1	.352778E-01	.575708E-01	.311775
70-	1	.336111E-01	.609573E-01	.328809
71-	1	.469444E-01	.643438E-01	.350043
72-	1	.505555E-01	.694236E-01	.379644
73-	1	.780556E-01	.851562E-01	.435912
74-	1	.305000	.993489E-01	.586864
75-	1	.289722	.116672	.665487
76-	1	.323056	.110304	.651707
77-	1	.349167	.104421	.659556
78-	1	.358611	.883047E-01	.635139
79-	1	.810833	.102407	.768408
80-	1	1.00000	.286868	1.00000
81-	1	.949167	.432066E-01	1.10473
82-	1	.882222	.430640E-01	1.08335
83-	1	.800000	.375662E-01	.971111
84-	1	.782500	.384630E-01	.967252

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