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Institutional arrangements for natural resources

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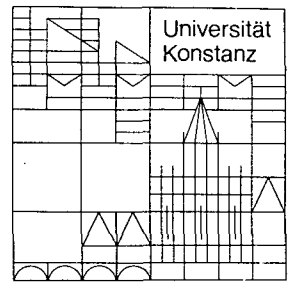
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Sonderforschungsbereich 178
„Internationalisierung der Wirtschaft“

Diskussionsbeiträge



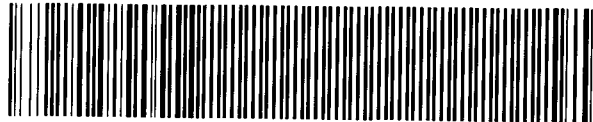
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Horst Siebert

**Institutional Arrangements
for Natural Resources**

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INSTITUTIONAL ARRANGEMENTS FOR NATURAL RESOURCES

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Institutional Arrangements for Natural Resources

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World wide, institutional arrangements for natural resources have undergone a major redesign in the last twenty years. Property rights for reserves of oil and minerals have effectively gone over from international firms to the resource countries. For some renewable resources threatened by extinction such as endangered species new property rights have been established. The "High Sea", the "res nullius" (Hugo Grotius 1601) or a non-property up to now, has different subsets of property titles attached to it such as the 200 mile economic zones, international fishing commissions and schemes for using the minerals of the sea bottom. Environmental scarcity - another aspect of nature's resources - has forced the industrial nations to introduce major laws regulating the national use of the environment as a receptacle of waste. A series of transfrontier pollution problems like the acid rain in Europe or global issues such as the protection of the ozone layer still have to be solved. Eventually, property rights for the atmosphere or outer space will have to be developed.

Institutional arrangements and property rights are related concepts. A property right specifies the allowable use of resources and goods and it may be envisioned as a set of norms and sanctions, legal rules and procedures as well as informal ways defining the feasible set for decision making of the

individual units of an economy. In contrast to such a narrowly interpreted concept of a property right institutional arrangement is a wider terms including a set of property rights, for instance for an economy, as well as relationships among autonomous economic units such as contracts. More specifically, institutional arrangement suggests a broader term of norms and rules including such concepts as the incentive system of an economy, "Ordnung" and the economic constitution.

Institutional arrangements for natural resources may be a matter of contractual relations between private organizations such as resource suppliers and buyers. But in many instances the government is involved as one partner in the contractual relationship, for instance by defining taxation schemes for the resource industry. Governments will come in when merit goods are at stake such as securing part of the resource rents for the country or taking into account the interest of future generations, and when public goods are involved, for instance in the case of environmental quality.

What is so specific about property rights and institutional arrangements for natural resources? Our contention is that natural resources exhibit specific characteristics that have implications for institutional arrangements. Analyzing these implications will provide additional insights into institutional economics and may permit analogies to institutional arrangements for other economic issues. In section 1, we study some specifics of natural resources and of their use. Among the many characteristics, different types of risk evolve as an important category. Risk allocation and risk management is therefore at the core of institutional

arrangements for natural resources. In the case of private risks, contractual arrangements can be used to shift some of the risk from one agent to another. These contractual relationships such as extraction rights and long-term contracts and their risk shifting properties will be addressed in section 2. Contractual arrangements may not be incentive compatible. One of the agents may have an incentive to breach the contract so that the contract becomes obsolete. This contract risk is analyzed in section 3. Finally, social risks may arise in using natural resources, requiring specific institutional settings. Reduction of social risk implies to attribute the user costs of social risks. This aspect of institutional arrangements is studied in section 4.

1. Specifics of natural resource allocation

The production and the use of natural resources is characterized by a set of specifics.

Long time horizon. If we follow the Hotelling paradigm, the extraction of natural resources is determined in an intertemporal optimization framework with a time horizon extended far into the future. This is due to the fact that the stock of a nonrenewable resource is finite implying the explicit consideration of user costs; in the case of a renewable resource a long-run steady-state of the resource stock has to be established. As a more practical argument, the life time of technical facilities in the resource industry such as mining shafts, smelters and refineries is estimated to be 20 to 30 years or more.

Vertical stages of production. Technically, natural resource products are not produced in a single process of production, they follow a vertical chain of production processes with the stages exploration, setting up the extraction facilities, financing, resource extraction, refining and distribution. As a rule, these stages of production are spatially separated. For instance, refining activities tend to be located near the market of the final product.

The vertical stages of production may be organized within a hierarchy, for instance an international oil firm with complete downstream integration, or they may involve a set of agents such as the resource countries, exploration firms, banks, contractors, extraction firms, refining firms and distributors. When different agents are involved, markets and analogous mechanisms of coordination as well as property rights, for instance the right to extract, play an important role.

Besides production, recycling and the return of unusable resource material (SO₂, other emissions) to nature is another aspect of the vertical stage of production and of use.

High set-up costs. The resource industry is characterized by high set-up costs. For instance, developing the North Slope of the Prudhoe Bay in Alaska has cost 24 bill. US- $\$$; 6,7 bill. US- $\$$ were spent for the Ekofisk oil field in the North Sea. Other examples are given in Siebert (1986). High set-up costs do not only arise in resource development but also in transportation (port facilities, pipelines, LNG-facilities), in refining and converting (electricity plants) and on the demand side (energy saving capital).

Private risks. The characteristics of the resource industry mentioned so far, namely long-time horizon, high set-up costs and a set of autonomous players in the different vertical stages of production are already a sufficient reason, that the relationship between the different autonomous agents tends to be of a long-run nature. Another argument in this direction is the existence of risks which are too large to be carried by a single actor and somehow must be reduced for the single agent by shifting part of the risk to other agents.

Risk means that some of the variables relevant for an agent, for instance for the profit-maximizing mine, are random variables. The agent can assign probabilities to the occurrence of a specific value of a variable. Risk then is defined as the deviation of the value of a variable from the mathematical expected value, that is from the mean.

It is usual to distinguish technological, economic (market) and political risks (Siebert 1986). Technological risks relate to innovations in extraction procedures (Alasca), to the success of exploration (exploration risk) and to the quality and the size of a deposit (resource risk). Economic risks refer to the resource price, to quantities sold and to costs (operating costs, closing costs, completion costs). Finally, political risks address expropriation, variations in extraction rights and in taxation schemes or in permits. All these risks make up financial risk. The sums invested in a project may be lost; the present value of profit is a random variable.

The risks of the resource industry are to a large extent explained by high set-up costs and the other characteristics of the resource industry. For instance, a randomness in price

becomes especially relevant when high set-up costs are involved and when the decision problem is characterized by a long time horizon.

Idiosyncratic investment. High set-up costs and high private risks create an additional problem when the investment is transaction-specific or "idiosyncratic" (Williamson 1979, 234). This case arises when the capital value of a project is at the mercy of the other agent. Consider for instance the case when the product of a mine can only be sold to one buyer or when the supply can only be provided by one seller. Expropriation of an extraction facility by the resource country, a drastic change in the taxation schemes, variations in the transport conditions by a pipeline company are other examples. In all these cases, indivisibilities are involved giving rise to the strategic position of one agent. It is not possible to undermine the strategic position of an agent by markets. For instance, as a rule there is no market for extraction rights with many partners on the supply side. Note that only part of the set-up costs are idiosyncratic because markets, if they exist, are a vehicle to destroy idiosyncrasy.

The agent with the idiosyncratic investment is "locked in" in his position, as soon as the investment is undertaken. Then he is exposed to the risk of strategic behavior by the other agent. The idiosyncratic character of part of the high set-up costs in the resource sector leads to the necessity of long-run contractual arrangement by which the risk of strategic behavior is reduced.

Social risk. The production and the use of natural resources may also give rise to social risk. Then, private contractual

arrangements cannot allocate risk because public goods aspects are involved. Institutional arrangements have to be developed which introduce incentives to reduce the social risk.

It may be argued that all the above arguments relate to large-scale investments in general and that they are not specific to the resource industry. If this view is correct, the resource sector exhibits only a gradual variation of a more general problem. It seems to me that the resource industry shows a concentration of specific characteristics. Moreover, experience suggests the resource industry applies institutional arrangements such as project financing and long-term contracts that are not formal in other industries.

2. Risk allocation in contractual arrangements

Risk shifting is based on the phenomenon that a given variance in a variable does not have the same impact for different agents. The agents may have different attitudes towards risk, they may have different target functions and they may have a different set of constraints for their maximization behavior. A given variance in the price of a natural resource has a smaller risk for a country, if the country not only exchanges the resource against consumption goods but if it has accumulated financial assets. Or assume that a resource country uses part of the resource in production at home. Then the probability of a fall in the resource price will hit the country's export earnings, but industrial activity at home may be stimulated due to lower resource prices. A distribution with weight in the tail for low prices of a natural resource represents a risk for a resource-exporting country, but a

similarly skewed probability distribution is an insurance to a resource-importing country.

In order to understand risk allocation we first develop a frame of reference in which we assume only one agent being the sponsor, the operator and the supplier of capital. Consider a price risk as shown in figure 1a with mean \bar{p} and let α measure the price risk. Let the price risk α be identically and independently distributed over time so that the distribution shown in Figure 1a holds for each period¹⁾. The firm as a single agent cannot influence the given probability distribution of the resource price in a period.

The decision problem of the resource firm is to determine the optimal time profile of extraction for a finite resource stock and if, capacity is not fixed by technical conditions, to determine its optimal level of initial investment. Let A denote initial financial outlays, let $\pi(t)$ be period profits and let δ be the discount rate. Then the resource firm maximizes the expected utility of the present value of profits

$$EU \Omega = -A + EU \int_0^T e^{-\delta t} \pi(t) dt$$

subject to the usual constraints. Due to the price risk α in each period, the present value of profit Ω of the resource firm is a random variable (Figure 1b). Although the price risk α for any period is given, the firm can influence the probability distribution of the present value of profit, i.e. its variance ρ , by adjusting the time profile of extraction (and the initial level of investment). Thus, the probability distribution for Ω in Figure 1b reflects an "optimal" time profile of extraction for the firm. Note that the risk-averse agent will not choose

the mean $\bar{\Omega}$, but the certainty equivalent present value of profit $\hat{\Omega}$.

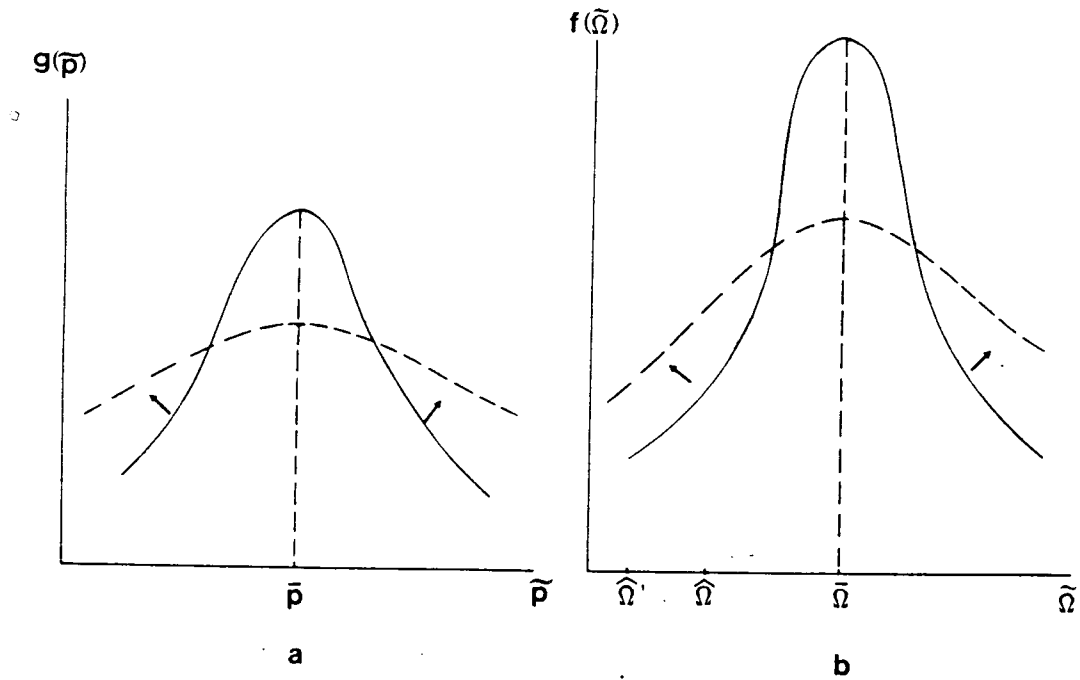


Figure 1

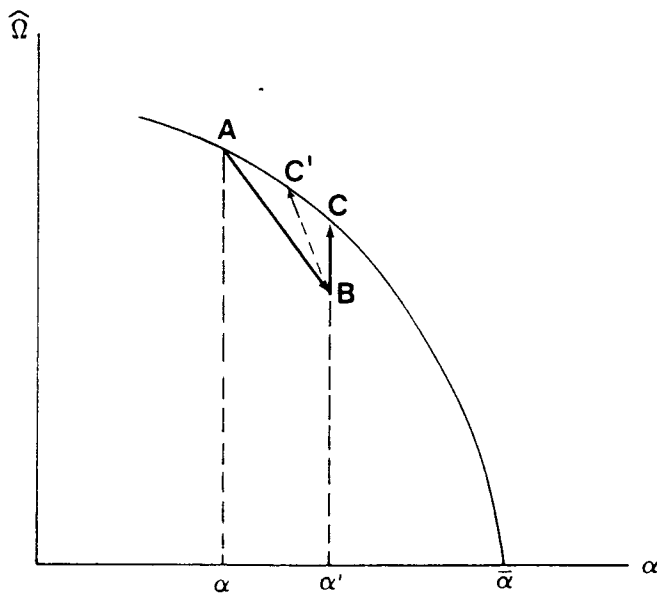


Figure 2

Assume now that there is more risk α' in the probability distribution of price in each period (Figure 1a). Assume that the increased price risk in each period implies a larger spread in the present value of profit for a constant mean $\bar{\Omega}$, that is the present value of profit $\bar{\Omega}$ has become more risky; the variance has increased.

The firm's adjustment to the increased risk can be broken down into two effects: If the (risk-averse) firm does not adjust its control parameters to the increased risk, for instance, if it sticks to its previous extraction profile, the variance of the present value of profits, ρ , is increased as shown in Figure 1b. The firm will choose $\hat{\Omega}'$ instead of $\hat{\Omega}$ with $\hat{\Omega}'$ lying to the left of $\hat{\Omega}$. In figure 2, the movement from $\hat{\Omega}$ to $\hat{\Omega}'$ due to a higher price risk α' is shown by the movement A to B with A corresponding to $\hat{\Omega}$ and B to $\hat{\Omega}'$.

The firm will, however, adjust its expected-utility-maximizing control parameters in such a way that the variance in the resource price becomes less relevant for the present value of profit. By adjusting its control parameters, e.g. the time profile of extraction, to the increased price risk α' the firm can influence the probability distribution of the present value of profit, ρ , so that a more favorable probability distribution (not shown in Figure 1b) will yield a certainty equivalent for the present value of profit somewhere between $\hat{\Omega}'$ and $\hat{\Omega}$ (figure 1b). The arrow BC in figure 2 illustrates the increase in the certainty equivalent present value of profit due to adjustment of the internal control parameters of the firm²⁾. We then define a functional relationship between the expected present value of profit and the level of risk after the firm has used all internal adjustments to risk: adjusting the time profile of

extraction, adjusting the level of initial investments, etc.³⁾ Then we have a function $\hat{\Omega}(\alpha)$ for which we postulate the property

$$\hat{\Omega}(\alpha) \text{ with } \hat{\Omega}_\alpha < 0, \hat{\Omega}_{\alpha\alpha} < 0. \quad (1)$$

Equation 1 is illustrated in figure 2. With price risk in each period increasing, the certainty equivalent present value of profits is reduced.

2.1 Risk allocation

If we now introduce a second agent, the firm may be able to vary the density function of the present value of profit Ω , ., or, reduce the price risk α . For instance, the firm may be able to sell the resource stock to a second agent for a lump sum payment Ω_{LL} thus eliminating the price risk completely. The difference $\Omega - \Omega_{LL}$ is the risk premium that the firm is willing to give up in order to obtain its "certainty equivalent profit". Another example is a long-run sales contract. For instance Ω_L may be the result of a long-run sales contract with a lower (and upper bound) on the resource price. Institutional arrangements for risk allocation will affect the probability distribution of the present value of profit for one agent by truncating it or by directly altering the density function. In the case of truncating, the unfavorable tail is partly cut off, thus increasing the mean and reducing the variance.

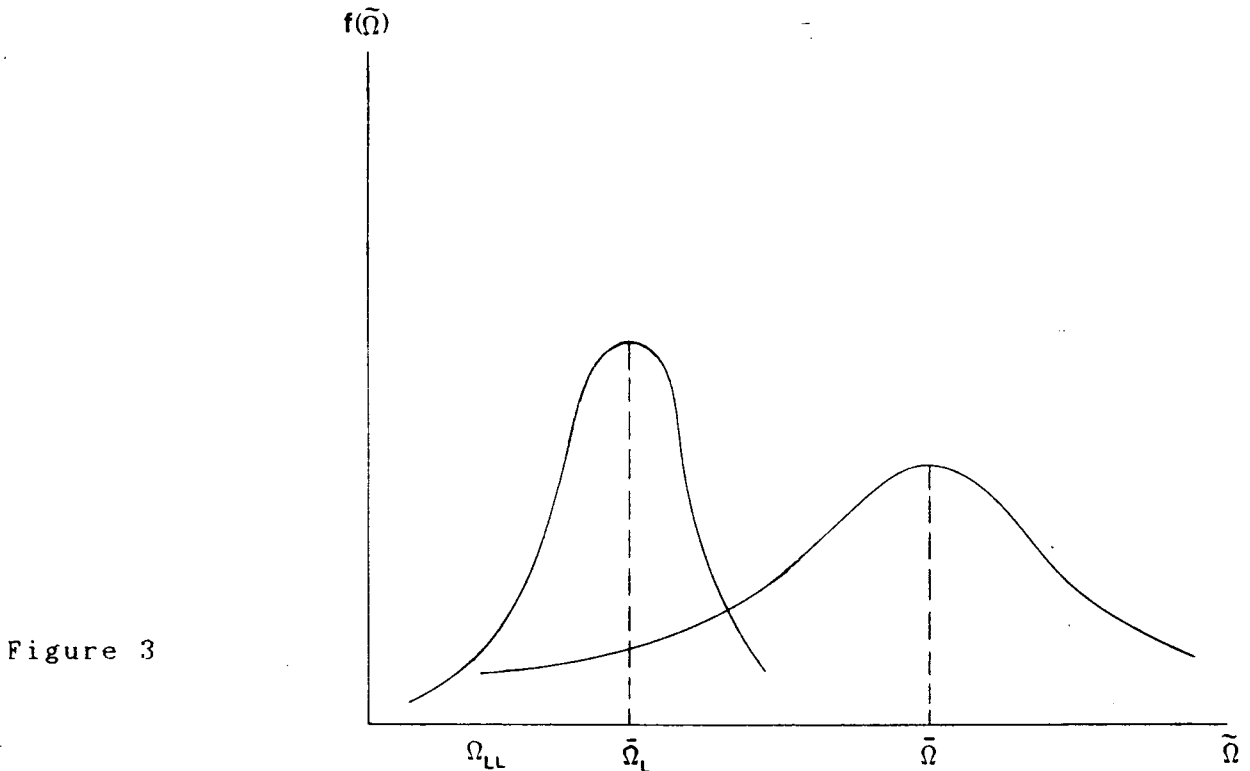


Figure 3

Assume that a continuum of risk reducing institutional arrangements Γ exists, so that we have a relationship describing the remaining risk α as a function of Γ

$$\alpha(\Gamma) \quad , \quad \alpha_{\Gamma} < 0, \alpha_{\Gamma\Gamma} > 0. \quad (2)$$

With a price v for using the institutional arrangement Γ , we have for the present value of profit of the resource firm

$$G = \Omega [\alpha(\Gamma)] - v\Gamma \quad (3)$$

with

$$\frac{dG}{d\Gamma} = \Omega_{\alpha}\alpha_{\Gamma} - v = 0 \quad (3a)$$

The term $\Omega_{\alpha}\alpha_{\Gamma}$ in equation 3a denotes the willingness to pay for a marginal variation of the institutional arrangement Γ ; it can be interpreted as the demand function for shifting risk as shown in Figure 4 .

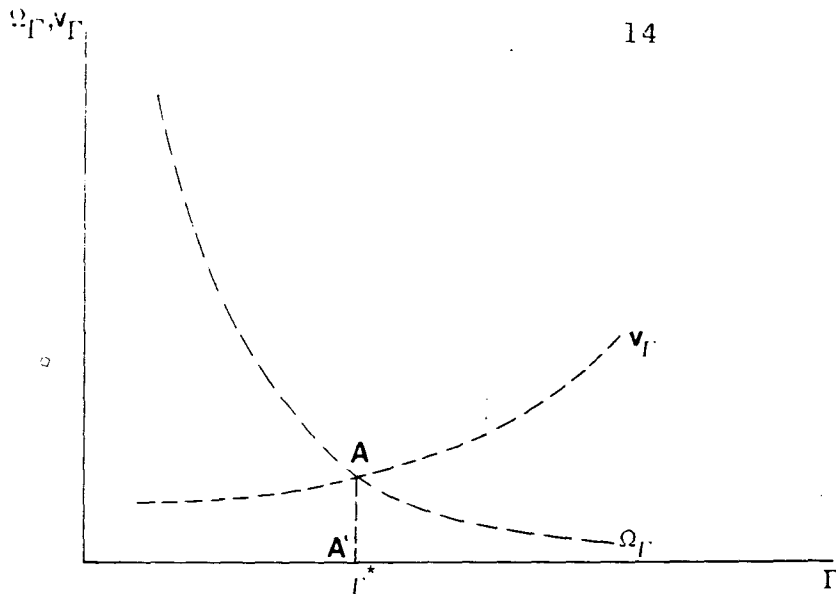


Figure 4

Assuming that v increases with the level of risk shifted, Figure 4 illustrates the shifting of risk. The institutional arrangement Γ allows benefits for the demand side to shift risk (demand side rent) and for the supply side taking over the risk (supply side rent).

In reality, the institutional arrangement can take a variety of forms and risk allocation will vary with the institutional arrangement. In the following, we study the risk allocation properties of extraction rights.

2.2 Extraction rights

An important institutional arrangement for natural resources is the right to extract. In defining this right, the government may have quite a few different objectives in mind. It may want to develop its resource base, it may want to recuperate some of the resource rents and it may want to prevent a too early depletion of the resource stock. But at the same time, the

institutional arrangement must be attractive enough for firms to explore, to provide capital, technology and access to markets. These aspects may weigh especially heavy in the case of developing countries. The allocation of risks associated with the development of the resource base varies with the institutional arrangement.

Traditional concessions. Prior to the oil crisis, the traditional concessions gave the firm the right to explore and to extract. As a rule, this extraction right referred to all the resources of the country⁴), including reserves not yet discovered (Kobrin 1984). The firm had to pay a royalty, and it carried all the economic risks (except for the proportion of revenue risk carried by the country in form of royalty income). The concessions had a duration of up to seventy years, so that the extraction rights used to be rather stable. With the property rights of resources going over to the resource countries, the contracts became less stable.

Production sharing. In this form of contract, a state resource firm and a foreign firm cooperate (Blitzer et al. 1982). The foreign firm undertakes the exploration, puts up the capital for the development of the resource deposit and also carries the operating costs. A certain percentage of output is used to cover the firm's cost ("cost oil"), the remaining part of output is split between the state firm or country and the private firm ("profit oil"). The private firm carries the political risk, the exploration risk and the cost risk. Revenue risk is split between the country and the firm.

Toll-per-barrel. The toll per barrel contract is a specific type of a production sharing arrangement. The country pays a

fixed toll per barrel to the foreign firm. Both the price risk and the quantity risk are taken over by the country.

Service contracts. In the case of service contracts, the country pays the firm for a specific service such as exploration, the delivery of extraction facilities (turn key contract), the operation of facilities, refining or distribution. By a set of such service contracts and by bringing in foreign capital through borrowing (instead of equity capital), the country attempts to unpackage the services provided by the multinationals. The country takes over all the risks, the firm being exposed to the political risk only.

A specific form of the service contract is the "net-back" contract used by Iran and Saudi Arabia in 1985 and 1986. The country sells the crude receiving the net of the refined product after transportation and refining costs have been subtracted. The crude is sold today, and the net will only be determined after a lapse of two months when the refined product has reached the market. The country thus takes over all the economic risk, and specifically the price risk for the period between the sale of the crude and the sale of the final product.

Nationalization. As an extreme case, the country may extract the resource via a state company thus taking over all the economic risks.

Bidding schemes. Contractual arrangements grant a right to extract. Under a set of conditions, the value of these extraction rights can be determined in auctions. If the auction requires an initial lump sum fee and no period payments, the up

front financial exposure of the resource firm is increased. Such an arrangement is only conceivable where the political risk is negligible. It is therefore no surprise to find auctions applied in industrial countries, for instance for offshore licences in the U.S. Even then, an initial lump sum payment may tilt the time profile of extraction too much in favor of present generations, and a tax per unit extracted, a royalty or a profit related payment may be necessary to generate an extraction profile with longer run orientation. Instead of initial lump sum payments, bidding arrangements can relate to payments in each period, to quantities, revenues or profits. Apparently, a developing country could reduce the political risk for the firm by making an initial lump sum payment to the firm and then requiring a higher tax per unit of output or a higher royalty later. However, this is unrealistic because the developing country is short of financial capital.

A specific problem arises if bidding schemes establish a monopoly for the successful bidder in future periods, for instance if the country has only one resource base. Then care must be taken that the monopoly is checked by other institutional devices.

The existing contractual arrangements produce different allocations of risk to the resource country and to the firm. In table 1 risks are shown vertically and contractual arrangements are horizontally. In the case of the concession, the firm takes over all the risks, whereas in the case of nationalization all the risks go over to the country. Production sharing and toll per barrel contracts partition the risk among country and firm.

Table 1: Risk allocation and extraction rights

Contractual relations →		Concession	Production sharing	Toll-per-Barrel	Service contract	Nationali-sation
Risks ↓						
Political Risk		Firm	Firm	Firm	Firm	-
Exploration Risk		Firm	Firm	Firm	Country	Country
Economic Risk	Cost Risk	Firm	Firm	Firm	Country	Country
	Quantity Risk	Firm	Firm	Country	Country	Country
	Price Risk	Firm	Firm	Country	Country	Country

2.3 Taxation

The taxation of natural resources can be considered to be a specific institutional arrangement for the development of natural resources. The purpose of resource taxation may consist in participating in the resource rents or in influencing the time profile of extraction, but taxation schemes also have an impact on the allocation of risks associated with a resource project. Write-offs for capital allow to recuperate financial outlays quickly; depletion allowances may have a similar role. Hotelling-type severance taxes represent an incentive to shift extraction into the future and to take over some future price risk.

An interesting taxation scheme is the resource rent tax (Garnaut and Clunies Ross 1975; 1983; Meyer 1984). The resource rent tax is a profit tax; investment can be written-off immediately (100 per cent). A negative profit can be carried forward to the next periods. An interest rate agreed upon in the contractual arrangement between resource country and the mining firm is applied to the loss being carried forward. The firm starts paying taxes with a percentage rate in the cash flow in each period as soon as the current value of the accumulated cash flow in a period becomes positive.

The resource rent tax is intended to prevent a too early depletion of the resource stock and to reduce the incentive for contract risk (obsolescence bargaining). Carrying forward the loss with a discount rate reduces the period cash flow relevant for taxation; thus the political appetite for changing the taxation scheme is weakened.

2.4 Long-term sales contracts

Long-term sales contracts are another example of a contractual relationship prevailing in the resource industry. Such contracts are universal in the natural gas industry, they dominate in the world coal trade (80 per cent of the total trade) and they are also used in petroleum (around 40 per cent, 1983) and in the uranium and in the steel industry. The basic reason for these long-run sales contracts is that buyer or seller may be locked in by their initial investment which is transaction specific. A randomness in some variables like the resource price or in quantities supplied or bought will reduce the rentability of the investment and may make it (partly) obsolete. A long term sales contract will reduce part of the risk (Siebert 1987), for instance by cutting off part of the unfavorable tail in the probability distribution of the present value of profit.

To what extent risk, for instance financial risk of a mine, can be shifted depends on the specifics of the contract. We here order the contractual arrangements along a continuum with backward and forward integration as extreme cases.

Backward integration. The buyer integrates extraction, transportation, refining and similar activities into his organization, and he takes over all the risks. Assuming that the buyer has paid a lump sum initially, the seller of the resource stock has shifted all his risks.

Plus cost. The contract specifies an initial price and allows for a cost increase, possibly a mark-up. Adjustment clause can relate to different cost categories such as transportation,

mining equipment etc. (Pollard 1985, Vogelsang 1986). The seller of the resource is protected against revenue risk and also against cost risk. As a rule, the take is fixed. The disadvantage of cost plus arrangements is a hazard problem because the buyer cannot control the costs of the seller.

Fixed price. Fixed price contracts can come in various forms. A floor price protects the seller in truncating the unfavorable part of the density function of the resource price and consequently of the present value of profit; the price risk is shifted to the buyer. A fixed price protects the buyer and shifts all the risks to the seller. If instead of an upper and a lower bound on the price the contract specifies a single price, both parties are protected against unfavorable cases. If low prices materialize, the seller is protected; with high prices, the buyer receives the advantage.

Take or pay. In this arrangements the buyer can reduce quantities to a certain limit without financial consequences. When this limit is reached, payments have to made or if delivery of the take had occurred. The sums paid can be used for the payment of deliveries in the future. Thus, the supplier is exposed to minor fluctuations in demand, but he is protected against major variations. The take or pay provision guarantees a minimal level of revenue; it cuts off part of the unfavorable tail in the probability distribution of the present value of profits.

Price adjustment clauses. Price adjustment provisions allow for changes in the contract. The "most-favored-nation" clause ties contract prices to prices paid in other contracts, for instance in the same geological basin, or links them to the price of a

dominating energy (oil in the case of coal). A specific form of price adjustment is brick pricing. Prices are adjusted for part of the quantity every other year.

Take or pay with price clauses. In reality we observe a mixture between take or pay contracts and price adjustment clauses. A pure take contract without specifying the price shifts the quantity risk away from the seller, but the financial risk arising from the randomness in price still remains. Similarly, fixing a price without specifying quantities does not protect against the financial risk sufficiently. A combination of quantity and price rules can exclude unfavorable cases for the profit of buyer and seller. Specific risk aspects for one agent, for instance, when the buyer being too severely committed, can be accommodated through special provisions such as "market out". As a rule, a more precise agreement on one variable, e.g. quantity, allows more leeway with the other variable, e.g. price, and vice versa.

Vertical forward integration. In this case, the seller takes control of the downstream activities, and the long-run contract is substituted by a vertical hierarchy. The seller takes over all risk.

Bidding. Long-run sales contracts can be auctioned off among the suppliers (Vogelsang 1986) with the successful bidder paying a lump sum for the right of delivery. This lump sum payment is supposed to capture the resource rent of the supplier. The problem is that a monopoly may be established and that moral hazard problems may be involved (see above).

Table 2 shows how the allocation of risk shifts with different types of long-term sales contracts.

Table 2: Risk allocation and long-run sales contracts

Contract Forms		Backward Integration	Plus-Cost*	Floor price*	Take or pay	Fixed price ceiling	Forward Integration	
		Risks						
Financial Risk		Buyer	Buyer	Buyer	Buyer	Seller	Seller	Seller
Revenue	Price Risk	Buyer	Buyer	Buyer	Buyer	Seller	Seller	Seller
Risk	Quantity Risk	Buyer	Buyer*	Buyer	Buyer	Seller	Seller	Seller
Cost-Risk		Buyer	Buyer	Seller	Seller	Seller	Seller	Seller
Contract Risk		Seller	Seller	Seller	Seller/Buyer	-	Buyer	

* with guaranteed take

2.5. Large-scale ventures

Large-scale resource ventures represent an interesting example of an institutional arrangement of risk allocation. In contrast to extraction rights and long-run contracts, large-scale ventures do not represent a bilateral relationship of risk allocation. Many agents are involved in large-scale ventures: the project operator making the investment and operational decisions, sponsors providing some of the capital, know-how and access to market, contractors responsible for construction, suppliers of input, banks and other financial institutions, the government defining the right to extract, granting permits of operation and specifying taxes, as well as international organizations and the customer (Siebert 1987d).

The different types of risk are allocated to the different agents in a complex net of contractual arrangements. The financial risk is split up into a set of risks which are taken over by different agents. Here are some of the most important instruments of risk shifting:

Limits on financial exposure. Financial risk can be reduced by putting a limit on financial exposure. This can be achieved by establishing a vehicle company separating the risk of the large-scale venture from the sponsor's balance sheet (Walter 1986). The financial risk can be further reduced by bringing in additional sponsors thus spreading the risk on many shoulders.

Shifting financial risk to banks. The project operator can reduce his financial risk through project finance. Banks provide part of the capital taking over some of the financial risk. If in some future periods the price will fall and if

principal and interest cannot be paid, the banks may lose part of their investment. Cofinancing from international organizations is another way to reduce financial risk.

Supplier and customer credit. The supplier of an input may provide a credit in order to stimulate his sales, either in the case of machinery or when a large-scale venture uses a permanent stream of the input (coal in electricity generation). The customer may be willing to provide a credit to be paid off by future deliveries. In this case, customer credit is likely to be linked to a long-run sales contract.

Shifting set-up cost to the resource country. Price risk and the financial risk can be shifted by reducing initial outlays for the right to extract and then receiving only a portion of the price which is random. In theory, the price risk could be shifted by moving away from a concession with a large initial lump sum payment to production sharing, a toll per barrel contract or even a service contract. In the real world, this option of risk shifting, however, increases the political risk of a change in taxation schemes or in the contract (obsolescence bargaining, contract risk). It is therefore rather unlikely as a risk management policy. Moreover, the historical change from concession of the 1960's to the more recent forms of contracts such as the toll-per-barrel arrangement reflects a change in the property rights and in the bargaining position vis-à-vis risk assignment.

Completion guarantees. Completion risk can be reduced by completion guarantees from the leading contractor and by stand-by-letters of credit from banks (Walter 1986).

Long-run sales contract. Price risk can be reduced by using long-run sales contracts (see above).

Downstream integration. Under specific conditions, a firm may be able to reduce price risk by vertical integration. Such an approach can be followed if downstream products are less volatile in price, or more specifically, if downstream activities would open up a secure line of production (chemical products in the case of an oil producing firm) whose price has a negative correlation with the oil price. Note, however, that this policy requires additional financial outlays, and although the price risk may be reduced, the risk of financial loss may rise. Of course, vertical integration may be spread over time thus allowing the reduction in the risk of financial loss.

Integrated risk management. Although the different types of separate risks mentioned above partly overlap, they may arise simultaneously thus increasing the variance in the present value of profit. The increase in the price risk, in environmental and technological risk eventually augment the variance of expected profits. Therefore, different policies of risk management may be called for simultaneously. Institutional arrangements are required that reduce several risks such as the risk financial loss, the risk of technological failure and price risk at the same time. A case in point is the Russian German gas deal where German banks provided the financing, a German and other international steel producers delivered the pipes and other technological equipment and where a long-run sales contract reduced Russia's price risk.

Risk allocation can be interpreted as a system of contractual arrangements or a set of risk markets for the different types of risk and among different participants. The different contracts are interlinked in the sense of a general equilibrium

model. Successfully shifting completion risk to the leading contractor implies a reduction in financial risk and may have an impact on financing. Allocating the price risk to the customer or to a government also reduces financial risk and requires lower risk premiums to be paid to banks.

2.6. Contractual arrangements and other forms of coordination

Contracts and arrangements must be compared to other arrangements for coordination such as spot markets, future markets and coordination through hierarchies. The problem is under what conditions which "governance structure" (Williamson 1979, 235) does a better job than other mechanisms of coordination.

The relative advantage of a contractual arrangement varies with the existence and efficiency of markets. Contracts for extraction rights are not needed, if a market for extraction rights can be established. Project finance is not necessary if the capital market were perfectly efficient with respect to large-scale ventures. And long-run sales contracts are not needed when the time depth of future markets in the resource area is sufficiently large. Apparently, contractual arrangements lose their advantage with the efficiency of markets. The relative advantage of contractual arrangements also varies with the amount of risk that agents on different sides of a market perceive. Consider the world oil market with its "anxiety gap" in the seventies. When the excess supply on the spot market dropped to 2 mbd, the price was expected to rise. In such a situation, long-term contracts play an important role. When market conditions, and the perceived risk

of disruption change such as the eighties, spot-markets become more interesting (see "net-back contracts").

3. Stability of contractual arrangements

Contracts represent an institutional arrangement by which risks of the resource industry are allocated ex ante to the different agents involved. These contractual arrangements attempt to alleviate the risky position of one of the agents or of both.

3.1. Classical and relational contracts

Due to the very nature of the risk allocation contractual arrangements have a specific quality distinguishing them from the classical contract. The classical contract is characterized by discreteness and presentation. The transaction is discrete and "entirely separate not only from all other present relations but from all past and future relations as well" (Macneil 1978, 856). The "presentation of transaction involves restricting its expected future effects to those defined in the present" (Macneil 1978, 862). According to Williamson (1979, 236), the identity of the parties can be treated as irrelevant, the nature of the agreement is delimited and remedies for nonperformance are clearly defined.

A classical contract cannot fulfill the risk allocation needed in the resource industry. Presentation in the strict sense is not possible because risk must be accommodated and contractual claims are contingent on the states of nature materializing in the future. Moreover, a specific transaction is not separated from other transactions; a long-run relationship exists between the parties involved. Different "governance structures"

(Williamson 1979) such as a neoclassical contract and a relational contract are needed.

The neoclassical contract is characterized by making discreteness and presentation more "blurred", allowing adjustment of the contract and devising mechanisms such as arbitration to ensure the stability of the contract. Whereas the neoclassical contract still is a contract, the relational contract is a broader concept of relationships including relations within a firm. The relational contract can be interpreted as a social relationship, it is "a minisociety with a vast array of norms beyond those centered on the exchange and its immediate processes" (Macneil 1978, 901).

X 3.2. Causes of contract risk

There are two underlying reasons for the instability of contractual arrangements: a change in market conditions and the ideosyncrasy of investment.

Ex post versus ex ante. The contract is supposed to protect the single agent against a too unfavorable state of the world. Risk is allocated ex ante, and each partner expects a benefit from the contract. When the states of the world emerge, the expected benefits may not show up, and an agent may evaluate the contract as a serious disadvantage. Market processes may have undermined the advantages of a contract to a specific agent. An example is a pay-or-take contract in a situation with extremely low resource prices (for instance the iron ore contracts between Japan and Venezuela altered in 1986).

Ideosyncrasy. Another cause for the instability of a contract consists in the ideosyncrasy of investment and the locked-in position⁵⁾ of one partner which gives a strategic position to the other partner, once investment is undertaken. This phenomenon is a systematic cause of contract risk even if market processes do not undermine the expected contract benefits for a specific agent. The attitude towards the contract changes systematically with the change in the bargaining position, that is with the investment being undertaken. Then, the contractual arrangement can become obsolete (obsolence bargaining, Vernon 1971).

3.3. Reducing contract risk

Both causes of contract risk represent a hazard problem. A partner may show opportunistic behavior and walk away from the contract. This attempt is partly checked by the more permanent nature of the relationship since an agent having a disadvantage today can expect a benefit tomorrow. The hazard problem is also affected by attitudes towards contracts and by the dichotomy between private advantages and moral sentiments. For a merchant of the Hanse in the "good old days" a word given was binding even if conditions become unfavorable. This behavior was possibly motivated with an eye to his followers in the firm. Today, the world may have a shorter memory, at the same time being more complex. Moreover, there may be something specifically American in the hazard aspect.

Since the contractual arrangement cannot be enforced as in a classical contract due to the contingent-claims aspect, other mechanisms must be developed to prevent a partner from walking away from a contract. An important approach is to keep the

contractual arrangement flexible and to allow adjustment to new conditions. Price adjustment clauses, cost escalators and other mechanisms such as the "most-favored nation clause" provide some type of formular flexibility. Standards, direct third-party determination of performance (arbitration) and to some extent one-party control of terms are more complicated institutional mechanisms to accommodate changing economic conditions. A much broader approach is to specify modalities of a renegotiation (Harries 1980) or an "agreement to agree" (Macneil 1978, 870). Finally, a contract may be more stable if conditions are clearly specified under which an agent may discontinue the contract. For instance, the "market out" provision allows the buyer to discontinue his take if prices are too unfavorable. "Force majeure" or hardship clauses relate to situations in which it has become impossible for a partner to continue a contract.

The more systematic contract risk due to the idiosyncrasy of investment requires a different remedy. Adjustment clauses cannot solve idiosyncrasy problems. Strategic behavior of one partner made possible by the locked-in position of the other agent must be prevented by the contractual arrangements. More specifically, the incentive for strategic behavior must be eliminated in the contractual arrangements or must be checked by appropriate opportunity costs. A case in point is the resource rent tax which attempts to prevent "obsolescence bargaining". Explicitly carrying forward the capital cost or past losses to the future by an agreed discount rate reduces the political demand in the resource country to change the contract because period profits are expressed correctly. Moreover, excessive period profits are subject to a profit tax. Another example is project financing which can be interpreted

as a complex net of contractual arrangements where the relational contract refers to a set of many agents partly checking each other. Finally, the idiosyncratic nature of investment may be offset by the control of technology so that there may be a countervailing asset specificity with respect to technology in favor of the foreign firm⁶). Asset specificity on both sides of a contract is a precondition for equilibrating hazards (Masten 1987, Williamson 1985).

4. Attributing the user costs of social risks

In the analysis so far, we have studied the problem how risks in the resource sector can be allocated to different agents through contractual arrangements. This problem only refers to so-called private risks being defined as the variance in variables relating to resources as private goods, for instance to the price of oil, to quantities sold or to the present value of period profits. In these cases, the risk is carried by the autonomous subsystems of the economy. Private risk may be reduced by shifting it to another agent. Private risk is not correlated across persons and can be interpreted as independent risk (Dasgupta 1982, 81).

4.1. Social risk

In contrast to private risk, the use of natural resources may also be connected with social risks relating to the randomness in some public goods aspect of natural resources. The public goods aspect implies that the resource in question "must be used in equal amounts by all" (Samuelson 1954). Examples are the risk of extinction, the risk of too early depletion if markets are short-sighted and the risk of environmental

degradation, for instance through the accumulation of pollutants. In the case of social risk, all agents are exposed to the same randomness. Risk is correlated across persons, and, by definition, risk cannot be shifted.

Pure social risks cannot be handled by private contractual arrangements. However, under a set of conditions the public good aspect may be changed into a private good if private parties can develop property rights and thus transform the social risk into private risk. We then would have a Coase scenario for risks (Siebert 1987a).

Another approach is to interpret the management of social risk as a special aspect of the more general problem of expressing opportunity costs, or in an intertemporal interpretation, user costs through appropriate institutional arrangements.

Property rights, or more specifically their transferability, can be interpreted as a vehicle which makes sure that the opportunity costs of private decisions are taken into account. Consider the normal static allocation problem of using a resource in a specific activity. Then the transferability of the property right, together with a set of other conditions such as working markets, guarantees that the opportunity cost of using the resource in a specific activity, that is the utility foregone from using it in another opportunity, is taken into account in the decisions of the autonomous subsystem of an economy.

As a rule this also holds for intertemporal decisions. User costs, that is the opportunity costs of not using the resource in the future, are expressed by a set of institutional

arrangements such as future markets, selling the capital value of a resource stock to the next generation, selling land, a resource firm, evaluating a resource firm in the stock market etc. If it is judged that these mechanisms are not sufficiently oriented towards the future and that user costs are underestimated by markets, i.e. that too high a discount rate is applied, the government can introduce additional institutional aspects such as steering the permits for the quantity to be extracted or using appropriate taxation (severance taxes) that shift the time profile of extraction into the future. In this case, a public goods aspect of caring for the future has been brought in by a new institutional reasoning.

4.2. Signalling the user costs of social risks

How can user costs of social risks in using natural resources be signalled to the subsystems of the economy? As an example consider the risk of extinction or the risk of environmental degradation (Siebert 1987) where environmental quality is a random variable. Two issues arise: First, how much risk is society willing to tolerate? Second, by which institutional arrangement can we ensure that the tolerable level of risk is not surpassed?

The target problem of determining the tolerable or optimal level of social risk exhibits all the problems of public goods: the aggregation of individual preferences for public goods may not be consistent (Arrow Paradoxon) ; the individual may behave as a free rider and the institutional mechanisms for aggregating individual preferences may not satisfy the usual optimality criteria of economics (for instance voting).

Nevertheless, the political process has to determine the tolerable level of social risk.⁷⁾ Practical decision rules such as benefit-cost analysis as well as practical institutional mechanisms (voting systems, constitutional restraints, log rolling, etc.) come into play.

Once the tolerable level of social risk is specified as the target, the problem is to devise institutional arrangements in such a way that the user costs are signalled to the autonomous subsystems and that the user costs are taken into consideration by the decentralized units. Since we are dealing with social risks, the institutional arrangement cannot aim to shift the risk. The appropriate policy therefore is risk reduction. This can be obtained by new property rights for resources and for environmental use.

In the real world we see a broad spectrum of new property titles in the area of natural and environmental resources ranging from direct controls to price incentives. Extending government control in space (200 miles zone) and other dimensions (emissions; extinction of species), using permits for extraction or for emissions, introducing the transferability of permits including markets for permits, relying on price mechanisms via taxation (severance taxes, emission taxes) and defining product norms can be interpreted as institutional arrangements to reduce social risk. In this problem of developing new incentives for the use of natural resources, the public good problem overlaps with the common property issue. In the past, quite a few natural resources have been used as a common property with free access (fish of the ocean, the environment as a receptacle of wastes).

The costs of risk reduction play a role in determining the tolerable level of risk. An important aspect of the management of social risk therefore is how the costs of risk reduction are allocated to the agents causing the risks. For instance, in contrast to natural hazards such as earthquakes a significant ingredient of environmental risks is man-made, namely pollutants. Thus, one strategy of risk reduction is to attribute the costs of reducing social risks to the decentralized units of the economy. By efficiently allocating the costs of risk reduction to those decentralized units that cause the social risk in the first place, an incentive is installed to reduce the social risk. If the environment can be used free of charge as a receptacle of waste, no incentive is installed to reduce emissions. If emission taxes, other pricing instruments for emissions and other policy instruments are applied, in a rather general way some of the social risk of environmental degradation is reduced.

5. Conclusions

The production and the use of natural resources is characterized by a long time horizon, a multitude of agents in different stages on the vertical scale of production, high-set up costs, private and social risks as well as idiosyncratic investment. The existence of private risks has led to institutional arrangements by which part of the risks can be reduced for the individual agent and shifted to another agent. Such arrangements are extraction rights, taxation schemes, long-run sales contracts and project finance. Contractual relations may involve only two parties, but they can also be a complex net of contractual arrangements between many agents as in large-scale ventures.

Contractual arrangements in the resource industry for the reduction of private risk are exposed to contract risk. In contrast to the classical contract, the contractual arrangements lack discreteness and presentation, and the relational contract may not be stable. Market processes may induce a partner to behave opportunistically, and the idiosyncrasy of investment may imply "obsolescence bargaining". Therefore, long-run contracts representing contingent claims must be flexible to accomodate new developments.

Resource production and resource use also involve social risk which cannot be shifted because they have a public good aspect. Here risk management requires institutional arrangements by which the user costs of social risk and the opportunity costs of reducing the risk are transmitted to the decentralized units of an economy.

Footnotes

* I appreciate comments from D. Folkerts-Landau, B. Frey, J. Keck, C. Kirchner, E. Mohr and G. Ronning.

1) Price risk is not affected by the business cycle so that there is no covariance structure between price and the business cycle (quantities sold). Moreover, it is assumed that the stochastic unformation is complete, i.e. an agent does not get additional (risk reducing) information over time and does not learn. In that case, risk would have to be modeled as a stochastic process, for instance as a Wiener process.

2) In the case of price risk it is reasonable to assume that the probability distribution of the resource price cannot be influenced by the firm. With respect to other risks, for instance cost risk, the firm may be in a position to influence the risk. In that case, the arrow BC' indicates that the risk per period can be reduced.

3) We can define a function describing the relationship between the variance of the present value of profit and the price risk

$$\rho = \rho [\alpha, m] , \quad \partial \rho / \partial \alpha > 0, \quad \partial^2 \rho / \partial \alpha^2 < 0$$

where m denotes the control instruments such as the time profile of extraction. Then

$$\hat{\Omega}(\rho) , \quad \hat{\Omega}_\rho < 0, \quad \hat{\Omega}_{\rho\rho} > 0$$

and equation 1 can be written as

$$\hat{\Omega} = \hat{\Omega}(\alpha), \quad \hat{\Omega}_\alpha = \hat{\Omega}_\beta \quad \partial\rho/\partial\alpha < 0, \quad \hat{\Omega}_{\alpha\alpha} = \hat{\Omega}_{\rho\rho} \quad \partial^2\rho/\partial\alpha^2 < 0$$

4) Talking of a country is an abbreviation. Country here means the set of agents in a nation including the government, sectors of the economy etc. Risk taken over by the country will be allocated to the different agents within a country. Risk allocation among the agents within a country may have an impact on the risk allocation between the country and the firm. This was pointed out by B. Frey.

5) The ideosyncrasy problem is also at the core of the borrowing problem. As soon as the credit is granted, the creditor is locked in and the sovereign borrower can behave strategically.

6) I owe this comment to C. Kirchner.

7) All the problems known from determining the optimal environmental quality also arise in the case of social risk. Compare Siebert (1987).

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