# Investing without credible inter-period regulations:

# A bargaining approach with application to investments in natural resources


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December 1999


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Abstract

A government's lack of credibility when promising future taxation and regulation of foreign direct investment is often regarded as an obstacle to foreign investment. As shown in this paper, the total lack of inter-period credibility may not necessarily prevent investments from taking place. Both the government and the investor can benefit from negotiating a series of short-lived agreements where the investor gets a share of the revenue generated from previous investments against the undertaking of making new investments. This assumes that intra-period agreements are respected by the parties.

JEL classification: G31, G38, C78

Key words: Investment, regulation, bargaining, credibility

Abbreviation: Investment, regulation, and bargaining.

Acknowledgements: I thank the participants at the faculty seminar at Boston University, School of Management, for helpful comments and suggestions. Financial support from The Center for Monetary and Financial Research ("Senter for pengepolitisk og finansiell forskning"), Oslo, is gratefully acknowledged.

Other: The idea of this article is based on chapter five in Nordal [9].

INTRODUCTION

When making foreign direct investments, one of the primary concerns of the investor is how the government in the host country will regulate the investment. If the government is credible, it can announce the regulatory regime for the investment. The investor will then trust the government and decide whether the investment is profitable within the announced regime. If the government is not credible, the investor will not believe in the government's announced policy. He will now evaluate the possibility of changes in the announced regime when he makes his investment decision. The question of credibility is important to the investor because it partially determines the value of the investment and therefore also influences the investor's decision of whether to invest. Whether the lack of credibility is important to the country depends on whether the government wants the foreign investor to make the investment. If, e.g., the government is able to make the investment by itself through a state owned company, the credibility issue related to regulation of a specific investment may be of less interest. In most cases, however, it is reasonable to believe that even countries with a large state-owned sector to some degree are dependent on foreign private investments and therefore are concerned with the question of credibility.

A generic game with investment and regulation is in a form where the investor makes an effort (investment) at a point in time, and the government decides how much reward (return on the investment) the investor will receive at a later point in time. In these models it is a necessary condition for the investments to take place that the investor receives, or believes that he will receive, a sufficiently large reward later. The seminal article by Kydland and Prescott [7] addressed the inherent problem in selecting optimal policies in a multi-period setting[1]. If the investor has rational expectations, he will see that it may be optimal for the government to change the pre-announced regulation at a later point in time. This will influence the investor's decision making. The result may be that the investment is not made, even though both the investor and the government in principle could have benefited from the investment. As noted by Fischer [4], if some form of cooperation between the regulator and the regulated could be achieved, both parties could be made better off as compared to the situation with no cooperative behavior.

The aim of our work is to present a model where the cooperation between the investor and the government is modeled explicitly as the outcome of a bargaining process between the investor and the government. We assume from the outset that the investor knows for certain that the government is not credible. We also assume that the investment series finite, and that the information is complete and perfect. This means that the investor's and the government's reward functions, the structure of the game, and all previous moves are known by the players. The presented model is an alternative to existing models that may be used for analyzing the interaction between an investor and a regulator when credibility is an issue. We now look at competing alternative models that may be used when analyzing the investment-taxation game.

The profit from the investment leading to extraction and subsequent sale of natural resources may be viewed as a "pie" which the government and the investor may share. If the investment series is infinite and if the government and the investor have perfect information regarding previous play and each other's utility functions, we may apply the Folk Theorem to model how the profit from the investments will be shared. In short, see, e.g., Fudenberg and Tirole [5] pages 150-160, the Folk Theorem suggests that any sharing of the "pie" may be obtained if the players have discount factors close to one. The result is based on an equilibrium strategy involving punishment. If one of the players deviates from the optimal strategy, this will trigger a punishment of the deviating player by the others players for the remaining part of the game. When the investment series is finite, when the final date of the game is sufficiently large, and maintaining the assumption of perfect information, it may still be possible to model the parties' equilibrium strategies such that investment may occur. As in Benoit and Krishna [1] and [2], this must involve a "reward cycle" at the end of the game where both the players receive a sufficiently high payoff. This future reward will discipline the players such that the players' equilibrium strategy resembles "cooperative behavior". This equilibrium relies on the punishment of the deviating player as in the Folk Theorem.

Of course, if the government could commit itself to the pre-announced regime, it could select a regime such that the investor would decide to invest. This assumes that the government would have to behave sub-optimal at future dates. One reason why the government would behave sub-optimal is because it is concerned with its reputation. In order to discuss reputation, it is necessary to introduce different generic types of a player and also imperfect information regarding the true type of the player. This was the idea of Kreps and Wilson [6]. In these models investment may occur even if there is only a small probability that the government will stick to its pre-announced regime. Examples of articles analyzing credibility in finite games with imperfect information are, e.g., Cherian and Perotti [3], Rodrik [10] and [11]. In the simplest form the government may be one which will tax all the profit at a suitable date, or one which will not. The investor assigns at the initial date a probability that the government is of a "tax everything"-type, and decides whether to invest. The investor then updates this probability based on observing the government's actions and uses the updated probability when determining the optimal play.

Our model offers the advantages that it may help to explain the interaction between the investor and the regulator when we consider the players' information to be complete and perfect, and when the investment series is finite. While Benoit and Krishnan model the cooperative behavior as resulting from an equilibrium strategy in a non-cooperative game, we rely on the assumption that the parties are able to cooperate by entering into short-lived agreements if it is to their advantage, i.e., agreements that are valid within a period only. Whether this is a reasonable assumption, will of course depend on the problem being analyzed. First of all, it seems reasonable to assume, due to practical considerations, that the number of investors participating in the bargaining should be restricted. There is only one investor in the model we suggest. This investor may be thought of as a single large investor, or as the representative of several large investors in the economy. The second question to consider when judging whether the model is reasonable, is the type of regulation the investor and the government may bargain over. An investment may, in principle, be influenced by three types of regulatory regimes: General regulations applying to all companies in the economy, industry specific regulation applying to companies in an industry like, e.g., the oil and gas industry, and investment specific regulation applying to the specific investment being made. For the latter case, the investment should be especially large and important to the government. Examples of such investments may be the development and extraction of large natural resources. In order to interpret the model with respect to industry specific regulation, it is necessary to assume that the modeled investor is a representative of all the investors in the industry. For investment in, and taxation of, natural resources, especially oil and natural gas, we claim that the presented model may, in some instances, help in understanding the interaction between the investors and the government. At least from an outside observer's point of view, it seems that the big oil companies frequently approach the government in the country where they invest in order to achieve lower taxes or more lenient terms for their operations. This seems especially to be true when new large investments are considered. We also observe that regulations relating to the oil and gas industry are frequently changed.

We represent regulation by a royalty, i.e., a sales tax. The royalty is meant to represent any transferal of value between the investor and the government. A negative royalty means that the government pays a subsidy to the investor. This subsidy may be paid in units of money, or, e.g., by a change in environmental regulations leading to a less expensive investment expenditure or as a discount to the investor for the purchase of a share in a state owned-company being privatized. At the beginning of each period the investor and the government bargain over the royalty that will apply to the previous period's production and the investment activity the investor will perform during the current period. If an agreement is not reached, a non-cooperative sub game will start. The country will declare the royalty rate and the investor will decide whether to continue to invest or abandon the investment series. By introducing bargaining within a period we assume that the parties will stick to an agreement within the period. This assumes intra-period credibility, which is a less strict assumption than inter-period credibility.

The model does not include any uncertainty regarding the investment opportunity or the revenue the investment will generate. In the model, only the investor may make the investment. If the investor decides to abandon the investment series, the decision is irreversible. These assumptions are simplified and may make the model less realistic for many countries. However, these assumptions may be realistic in situations where the government cannot make the investments through a state-owned company, e.g., due to lack of know-how. Because there is no uncertainty related to the commodity price, we do not include decisions such as to close down production temporarily or to wait. The investor's only choice is whether to make the investment or abandon the investment series. These assumptions are primarily made to simplify the presentation and maintaining the focus on the players' strategies and the effect of bargaining. For a specific solution to the game, we derive a sufficient condition for when an investment series will be undertaken.

We start in the next section by presenting the investment opportunity and the game. We then study a particular solution. We present numerical examples before summarizing the main results in the final section.

## A MODEL WITH INTRA-PERIOD BARGAINING

### The investment opportunity

We consider a model with a fixed time horizon, *T*, where *t* is a specific point in time, $t = 0,1,2,....,T$. The investment opportunity consists of a series of one-period investments, where the payment of an investment cost at time *t*, $k_t$, will lead to proceeds from the investment at time *t*+1, $p_{t+1}$. The proceeds at the first time, $p_0$, is equal to zero. The sequence of investment amounts is $(k_0, k_1,.., k_T)$, and we assume that all but the final investments are strictly positive and that the final investment amount is equal to zero, i.e., $k_t > 0$ for $t = 0,1,2,....,T-1$ and $k_T = 0$.

### The game

The total game consists of *T* sub games, where the sub game played at time *t* is as outlined in Figure 1. The players are the government of the country, *C*, and the investor, *I*. A pure strategy for player *i* in the sub game at time *t*, $s_{i,t} = (a_{i,t}^N, a_{i,t}^A, a_{i,t}^D)$, is a complete plan for how to play the sub game, i.e., the announcement of the acceptable royalty in the negotiations, $a_{i,t}^N$, the action to choose in case an agreement is reached, $a_{i,t}^{A}$, and the action to choose if an agreement is not reached, $a_{i,t}^{D}$. The country and the investor start by negotiating. They negotiate over the royalty, $r_t$, which the country will announce and which will apply to the proceeds from the investment made at time $t-1$, and over the investor's investment expenditure, $e_t$. An *agreement* is a specification of how the parties will act, i.e., the pair $(a_{C,t}^{A}, a_{I,t}^{A})$.

(insert Figure 1 approximately here)

The negotiated royalty rate at time *t*, $\tilde{r}_t$, is resulting from the negotiations between the parties. We let the country's action in the negotiations, $a_{C,t}^{N}$, be to declare the lowest royalty the country is willing to accept in order to enter into an agreement, and the investor's decision is to declare the highest royalty he is willing to accept, $a_{I,t}^{N}$. We will also use the term *demanded royalty* when we mean the players' acceptable royalty. An agreement solution at time *t* is *feasible* if $a_{C,t}^{N} \leq \tilde{r}_t \leq a_{I,t}^{N}$. If there is no room for negotiations, the resulting solution will be the empty set $\emptyset$. If an agreement is feasible, we assume that the negotiated royalty rate will be equal to a weighted average, with weight $0 \leq \alpha \leq 1$, of the parties announced acceptable royalty[2], i.e.,

$$\tilde{r}_t = \begin{cases} a_{C,t}^{N} + (a_{I,t}^{N} - a_{C,t}^{N})\,\alpha & \text{if} \quad a_{C,t}^{N} \leq a_{I,t}^{N} \\ \emptyset & \text{otherwise} \end{cases} \qquad (1)$$

In order for (1) to be well defined, we make the assumption that the demanded royalty is bounded, i.e., $a_{i,t}^{N} \in N$, $i = C, I$. The highest allowed royalty is $\bar{r}$, the lowest allowed royalty is $\underline{r}$, and $\underline{r} \leq N \leq \bar{r}$. This is an assumption made for technical reasons to avoid infinite royalty.

If an agreement is not made, the country will announce a royalty, $a_{C,t}^{D}$, and the investor will determine the investment expenditure, $a_{I,t}^{D}$. Even though the government may set an extraordinary high royalty equaling more than hundred per cent of proceeds, the investor does not have to pay this if he decides to abandon the investment. We therefore get the following restrictions on the actual royalty at time *t*. If the investor continues to invest, he must pay the royalty declared by the country. In this case we may have that $r_t > p_t$, which means that the investor does not keep anything from proceeds from previous investments, and in addition he must pay the country an amount equal to $(r_t - p_t)$. If $r_t < 0$, the country subsidizes the investor. Note that if the country pays subsidies in case of a disagreement, the investor may take the subsidies and leave the country.

Based on the parties' pure strategies for the sub game at time *t*, the resulting royalty and investment expenditures will be determined such that either an agreement solution or a disagreement solution is resulting from the played strategies, i.e.,

$$(r_t, e_t) = \begin{cases} (a_{C,t}^{A}, a_{I,t}^{A}) & \text{if an agreement is feasible} \\ (a_{C,t}^{D}, a_{I,t}^{D}) & \text{if an agreement is not feasible and } a_{I,t}^{D} = k_t \\ (\min(a_{C,t}^{D}, p_t), a_{I,t}^{D}) & \text{if an agreement is not feasible and } a_{I,t}^{D} \neq k_t \end{cases} \quad (2)$$

The history of the game at time *t*, $h^t$, is a collection of the players' sub game strategies up to that time,

$$h^t = (s_0, \ldots, s_{t-2}, s_{t-1}), \tag{3}$$

where $s_t = (s_{C,t}, s_{I,t})$ and the history at time zero is the empty set, ∅. We assume that the investor's decision to abandon the investment is irreversible. The players' permissible actions at time *t*, $A(h^t)$, are conditioned on whether the investment series have been abandoned previously, i.e.,

$$s_t \in A(h^t) = \begin{cases} \{(N, \tilde{r}_t, \text{☼}), (N, k_t, (0, k_t))\} & \text{if} \quad 0 \notin (e_1, .., e_{t-1}) \\ \{(0, \tilde{r}_t, 0), (0,0,0)\} & \text{otherwise} \end{cases} . \tag{4}$$

We see from (4) that, provided the investment has not been abandoned in the previous play, an agreement will always involve the payment of the investment amount $k_t$. We further notice that intra-period credibility is assumed because $a^A_{C,t} = \tilde{r}_t$ and $a^A_{I,t} = k_t$. Credibility here means that the players will follow the agreement.

The parties set of cash flow at time *t*, $x(h^{t+1})$, is a function of the history of the game at time *t*+1 and the characteristics of the investment opportunity:

$$x(h^{t+1}) = \{x_C(h^{t+1}), x_I(h^{t+1})\} = \begin{cases} \{(r_t + we_t), (p_t - r_t - e_t)\} & \text{if } 0 \notin (e_1,..,e_{t-1}) \\ \{(r_t + we_t), (-r_t - e_t)\} & \text{otherwise} \end{cases} . \quad (5)$$

Equation (4) ensures that the parties' cash flow according to equation (5) will be equal to zero if the investment has been abandoned at a previous point in time. If the investment has not been abandoned, the investor's cash flow equals the proceeds from previous investment less royalty and the investment expenditure. The country's cash flow equals the royalty plus extra revenue generated from the investor's investment activity. This is modeled as a nonnegative constant $w$ multiplied by the actual investment expenditure. The constant $w$ may be thought of as a "multiplier effect" on the economy caused by the investment expenditure.

The parties' utility over cash flow is measured by a set of utility functions $u(x(h^{t+1}))$. We assume that the utility of no cash flow is equal to zero and that players' utility functions are increasing, i.e., $u_i(0) = 0$ and $u_i^{'} > 0$ for $i = C, I$.

The utility for the sub games $t$,..,$T$ discounted to time $t$ is a function from the remaining time of the game and the history at time $T$+1 to the real numbers, i.e., $U(.,.) : (0,1,..,T)xH^{T+1} \rightarrow PxP$, where $H^{T+1}$ is the set of all possible histories for the game. More precisely,

$$U_i(t, h^{T+1}) = \sum_{v=t}^{T} (\delta_i)^{v-t} u_i(x(h^{v+1})) \text{, s.t. } \forall h^{v+1} \in h^{T+1} \text{ and } h^{T+1} \in H^{T+1}, \quad (6)$$

where $\delta_i$ is a discount factor, $0 \leq \delta_i \leq 1$, and where $i = C, I$.

Equilibrium strategies

Care must be taken when characterizing an equilibrium strategy of the game we have suggested. The game contains nodes where the players bargain, i.e., they move together, and nodes where they move independently. If we want to use bargaining theory to determine the outcome of the bargaining process, we need to make certain that the negotiation problem is properly defined. Generally, a negotiation problem consists of the set of possible outcomes, here the range *N*, and the disagreement allocation that the players will receive if the bargaining fails, here $a_{C,t}^{N}$ and $a_{I,t}^{N}$. In this game the disagreement allocation will be determined by the players subsequent play if bargaining fails. From Figure 1 we see that in case of no agreement, the rest of the game starting with the country declaring the "disagreement royalty" may be considered as a game in its own right. By the term *the disagreement game at time t* we mean the sub game where the country declares the royalty, $a_{C,t}^{D}$, and the investor decides whether to invest, $a_{I,t}^{D}$, as well as the rest of the game for time $t = t+1,..,T$. We say that player *i*'s demand in the bargaining at time *t*, $a_{i,t}^{N}$, is a *credible demand* if player *i* is not made worse off by entering into an agreement with a royalty $a_{i,t}^{N}$, as compared to the alternative of not entering into an agreement. In order to make this precise, we first introduce the concept of a pure strategy for player *i* of the game starting at time *t* and ending at time *T*, i.e., for the rest of the game. This strategy, $s_i \mid h^t$, is conditioned on the history of the game at time *t*. The players' utility discounted to time *t* for the remaining part of the game starting at time *t*, is a function of the players' pure strategies for the remaining part of the game. We define

$$U_i(s_C \mid h^t, s_I \mid h^t) \equiv U_i(t, h^{T+1}) \quad \text{s.t.} \quad (s_C \mid h^t, s_I \mid h^t) \in h^{T+1}, i = I, C. \tag{7}$$

We first consider a specific strategy combination, $(\hat{s}_C \mid h^t, \hat{s}_I \mid h^t)$, where an agreement is entered into at time *t* and where the negotiated royalty is equal to one of the players' demanded royalty, i.e.,

$$(\hat{s}_C \mid h^t, \hat{s}_I \mid h^t) \quad \text{s.t.} \quad (r_t, e_t) = (a^A_{C,t}, a^A_{I,t}) \quad \text{and} \quad a^A_{C,t} = \hat{a}^A_{i,t}\,. \tag{8}$$

We then consider another strategy combination, $(\overline{s}_C \mid h^t, \overline{s}_I \mid h^t)$, which is identical to $(\hat{s}_C \mid h^t, \hat{s}_I \mid h^t)$ except for player *i*'s demanded royalty in the negotiations, $\overline{a}^N_{i,t}$. This demanded royalty is such that an agreement will not be entered into at time *t*. We say that $\hat{a}^N_{i,t}$ in (8) is a credible demand for player *i* in the negotiations at time *t* if the following equation holds:

$$U_i(\hat{s}_C \mid h^t, \hat{s}_I \mid h^t) = U_i(\overline{s}_C \mid h^t, \overline{s}_I \mid h^t)\,. \tag{9}$$

The set of strategies for player *i* such that the demands in the negotiations are credible for all *t* is $S^{Cred}_i \mid h^0$. We may now define a Nash equilibrium of the whole game with credible demands in the negotiations in the traditional way as the strategy pair $(s^*_C \mid h^0, s^*_I \mid h^0)$ characterized by

$$U_C(s_C^* \mid h^0, s_I^* \mid h^0) \geq U_C(s_C \mid h^0, s_I^* \mid h^0) \text{ for all } s_C \mid h^0 \in S_C^{Cred} \mid h^0, \tag{10}$$

and

$$U_I(s_C^* \mid h^0, s_I^* \mid h^0) \geq U_I(s_C^* \mid h^0, s_I \mid h^0) \text{ for all } s_I \mid h^0 \in S_I^{Cred} \mid h^0.$$

## THE GAME SOLVED WITH BACKWARD INDUCTION AND WITH CREDIBLE DEMANDS IN THE NEGOTIATIONS

We assume that the restriction of the players' demanded royalty in the negotiations to the set $N$ is not binding, i.e., $a_{i,t}^{*N} \in N$ for all $t$, $i = I,C$.

**Proposition 1** *The country's and the investor's discounted utility will be nonnegative for all t, i.e.,* $U_i(s_C^* \mid h^t, s_I^* \mid h^t) \geq 0$, $t = 0,....,T$, $i = I,C$.

Proof: The proof is shown in the appendix. ⌉

It is appropriate to make the following observation based on Proposition 1. If the model with intra-period bargaining is compared to another model where the country is credible and able to dictate the royalty, then the investor will not be worse off at time zero in the model with intra-period bargaining. This because in the latter model it will be optimal for the county to announce a royalty that leaves the investor with zero utility at the initial date, but where he will undertake the investment series.

**Lemma 1** *If the investment series has not been abandoned previously and further investment is achieved in the disagreement game at time t, i.e., $a_{I,t}^{*D} = k_t$, then the parties will enter into an agreement and $\tilde{r}_t = a_{C,t}^{*N} = a_{I,t}^{*N}$.*

Proof: The proof is shown in the appendix. ⌉

The implication of Lemma 1 is that if the players in the case of a disagreement at time *t* achieve further investment, then they will not be worse off making an agreement where the agreed royalty is equal to the royalty the country otherwise would have declared.

**Lemma 2** *Assume that the investment series has not been abandoned previously. The investment series will then be abandoned at time t, i.e., $e_t \neq k_t$, if, and only if, an agreement is not feasible at time t.*

Proof: The proof is shown in the appendix. ⌉

According to Lemma 1 and 2, the investor will abandon the investment series the first time the country and the investor are not able to cooperate. The country will then prefer the alternative of full taxation of proceeds from the previous investment and the subsequent departure by the investor to the alternative of an agreement involving further production.

We now turn to the question of deriving a sufficient condition for when the whole investment series will be undertaken in the game. We say that *the country would prefer to undertake the one-period investment at time t by itself* if

$$u_C(p_t - k_t + wk_t) + \delta_C u_C(p_{t+1}) \geq u_C(p_t)\,. \tag{11}$$

The right hand side of (11) is the country's utility from full taxation of the revenue at time *t*. The left hand side is the country's time *t* utility from further production and full taxation of the revenue at the next point in time. We may interpret inequality (11) in the following way: The country is willing to finance the investment expenditure $k_t$ with the proceeds $p_t$. With this interpretation, the investment expenditure is fully financed by the proceeds if $p_t \geq k_t$. If $p_t < k_t$, the country would have to obtain additional financing.

**Proposition 2** *If the country would undertake the one-period investment at time t by itself for all* $t = 0,....,T-1$*, then the whole investment series will be undertaken by the private investor in the game with intra-period bargaining.*

Proof: The proof is found in the appendix. ⌉

Example

We consider an example with two investment amounts, i.e., the game covers two periods and three points in time. The gross return on the investment, *g*, is assumed constant, i.e., $p_t = k_{t-1}(1+g)$ for $t = 1,2$, where $g = 0.3$. The parties' utility functions are linear. The country's utility function is $u_C(r_t + we_t) = r_t + 0.05e_t$. The investor's utility function is $u_I(p_t - r_t - e_t) = p_t - r_t - e_t$. The country's and the investor's discount factors are 0.95 and 0.9, respectively. We further assume that $\alpha = 0.5$, see equation (1). The initial investment, $k_0$, is 10. For three different investment amounts at time one we study how the game will be played when solved with backward induction and with credible demands in the negotiations. See Table 1 for a summary of the variables and the players' equilibrium strategies. In all three cases, the country receives the whole revenue at the final time.

For the case when $k_1$ is equal to 78, the investor's optimal decision at time one if an agreement is not entered into is not to make the final investment, i.e., $a_{I,1}^{*D} = 0$. In order to enter into an agreement, the agreed royalty should at least leave the investor with an after royalty income equal to the investment amount, i.e., $a_{I,1}^{*N} = 13 - 78 = -65$. In case of a disagreement, the country will tax everything from the first investment, i.e., $a_{C,1}^{*D} = 13$. In order for the country to enter into an agreement, it should not be worse off compared to the full taxation of the first revenue, i.e.,

$$a_{C,t}^{*N} + 0.05 \cdot 78 + 0.95 \cdot 101.4 = 13.$$

Solving this equation, we get that $a_{C,1}^{*N} = -87.2$. Because $a_{C,1}^{*N} \leq a_{I,1}^{*N}$, an agreement is feasible. The negotiated royalty rate is equal to –76.1. The parties' utilities discounted to time one are 24.1 and 11.1 for the country and the investor, respectively. At time zero, the investor's utility from investing will be equal to zero, i.e., $-13 + 0.9 \cdot 11.1 = 0$. The investor will therefore be willing to make the investment.

(insert Table 1 approximately here)

Concentrating on time zero, we see that if $k_1$ is equal to 70, the investor would not be willing to undertake the first investment unless an agreement is entered into. The country is willing to pay a subsidy of 22.3 in order to make the investor invest while the investor only would require a subsidy of 1. The negotiated royalty is –11.7. The result is that the investor invests, and his utility at time zero is 10.7. When $k_1$ is equal to 90, the investor would be willing to pay a royalty at time zero of 1.5 in order to undertake the investment. In case of a disagreement at time zero, the country would then declare a royalty equal to 1.5 and the investor would invest. In this case an agreement will be entered into, and the agreed royalty is equal to 1.5.

## SUMMARY

We have presented a investment and taxation game between an investor and a government, where:

1. The information is complete and perfect.
2. The time horizon is finite.
3. The government cannot commit itself to a tax regime for future periods, but both the investor and the government are able to make short-lived agreements covering the current periods.
4. The bargaining over the tax that will apply to the current period's revenue and the continued investment activity of the investor, is explicitly included in the game.

For a specific solution to this game we have shown sufficient conditions for when an investment series will be undertaken. We have also shown that the parties' utility from playing the game, when this specific solution is applied, is nonnegative. When modeling investment and taxation games, the presented model is an alternative to existing models, many of whom rely on an infinite time horizon or on incomplete or imperfect information.

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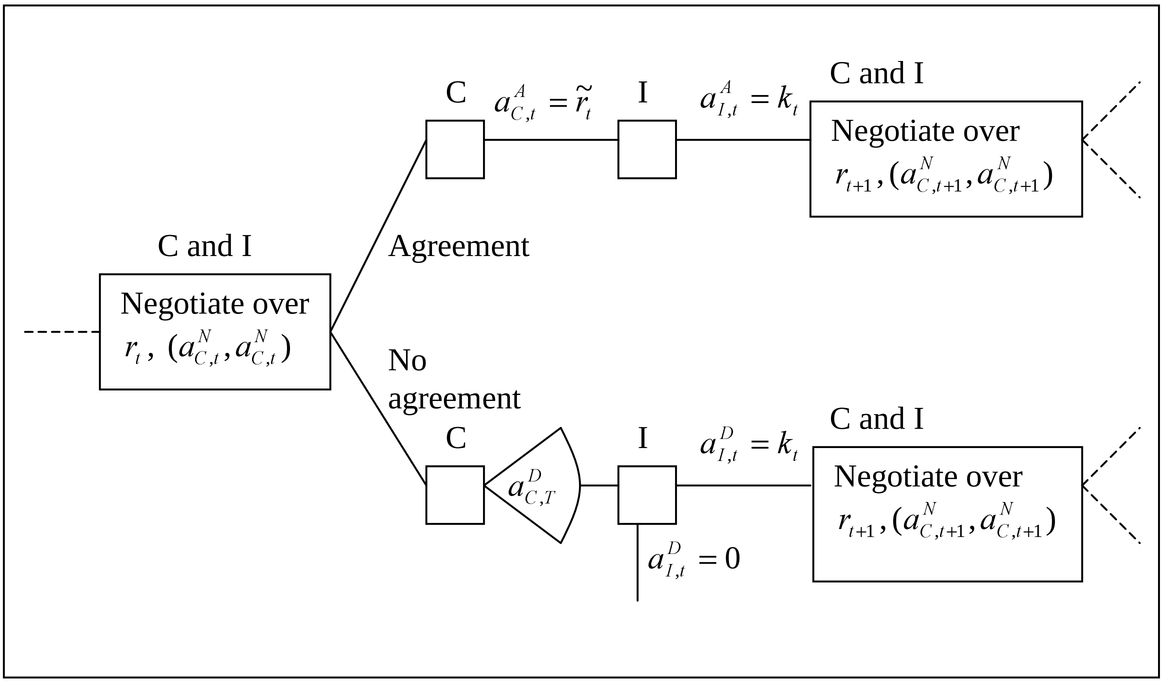


Figure 1 Sub game played at time *t*

| Time | $k_1$ | $(a_{C,t}^{*N}, a_{C,t}^{*D}), (a_{I,t}^{*N}, a_{I,t}^{*D})$ | $p_t$ | $r_t$ | $e_t$ | $U_C(t, h^{*3})$ | $U_I(t, h^{*3})$ |
|---|---|---|---|---|---|---|---|
| $t = 2$ | 78 | (101.4,101.4),(101.4,0.0) | 101.4 | 101.4 | 0.0 | 101.4 | 0.0 |
| | 70 | (91.0,91.0),(91.0,0.0) | 91.0 | 91.0 | 0.0 | 91.0 | 0.0 |
| | 90 | (117.0,117.0),(117.0,0.0) | 117.0 | 117.0 | 0.0 | 117.0 | 0.0 |
| $t = 1$ | 78 | (-87.2,13.0),(-65.0,0.0) | 13.0 | -76.1 | 78.0 | 24.1 | 11.1 |
| | 70 | (-77.0,13.0),(-57.0,0.0) | 13.0 | -67.0 | 70.0 | 23.0 | 10.0 |
| | 90 | (-102.7,13,0),(-77,0,0.0) | 13.0 | -89.8 | 90.0 | 25.8 | 12.8 |
| $t = 0$ | 78 | (0.0,0.0),(0.0,10.0) | 0.0 | 0.0 | 10.0 | 23.4 | 0.0 |
| | 70 | (-22.3,0.0),(-1.0,0.0) | 0.0 | -11.7 | 10.0 | 10.7 | 10.7 |
| | 90 | (1.5,1.5),(1.5,10.0) | 0.0 | 1.5 | 10.0 | 26.5 | 0.0 |

Table 1 Summary of the game with intra-period bargaining for different levels of investments at time $t = 1$, $k_1$, when $k_0 = 10$

## APPENDIX

### Proof of Proposition 1

When the game is solved with backward induction, the players' optimal strategy for the sub game at time *t* will be a part of the optimal strategy for the rest of the game. The investor has always the option to abandon the investment series. Because, by assumption, $u_I(0) = 0$, any optimal strategy for the investor cannot leave him with a lower discounted utility than zero. Similarly, the country can always select a strategy where the proceeds from previous year's investment is taxed in full. Because the proceeds are nonnegative, and by assumption, $u_C(0) = 0$, any optimal strategy for the country cannot leave the country with a lower utility than zero. ⌉

### Proof of Lemma 1

Consider the situation for the country at time *t* in the situation when an agreement is not reached. The country's action, $a_{C,t}^D$, may then influence the investor's action of whether to invest. The investor will choose to invest if

$$u_I(p_t - a_{C,t}^D - k_t) + \delta_I U_I(t+1, \hat{h}^{T+1}) \geq u_I(p_t - \min(a_{C,t}^D, p_t)) + \delta_I U_I(t+1, \overline{h}^{T+1}), \qquad \text{(A1)}$$

where $\hat{a}_{I,t}^D = k_t$, $(a_{C,t}^D, \hat{a}_{I,t}^D) \in \hat{h}^{T+1}$, $\overline{a}_{I,t}^D = 0$, and $(a_{C,t}^D, \overline{a}_{I,t}^D) \in \overline{h}^{T+1}$. The left hand side (LHS) of (A1) is the investor's utility if he chooses to invest, and the right hand side (RHS) is his utility if he chooses to abandon the investment. Because $\delta_I U_I(t+1, \overline{h}^{T+1}) = 0$ when the investor abandons the investment, we may rewrite (A1) as

$$u_I(p_t - a_{C,t}^D - k_t) + \delta_I U_I(t+1, \hat{h}^{T+1}) \geq u_I(p_t - \min(a_{C,t}^D, p_t)) \ . \qquad \text{(A2)}$$

Consider first the case when the country cannot select a royalty such that this inequality will hold. It will then be optimal for the country to announce $a_{C,t}^{*D} = p_t$ because this maximizes the country's utility. The investor will then abandon the investment.

Consider then the case where the country can declare a royalty such that (A2) holds, and consider the largest royalty rate for which (A2) will hold, $a_{C,t}'^D$. Because of the assumption of increasing utility functions, the investor will choose to invest if the announced royalty is not higher than this level, and to abandon the investment if the royalty is higher. Whether the country prefers that investment takes place, depends on its utility from the rest of the game. Consider another royalty rate announced by the country, $a_{C,t}''^D$, such that $a_{C,t}''^D > a_{C,t}'^D$. The country would then prefer to announce $a_{C,t}'^D$ if

$$u_C(a'^D_{C,t} + wk_t) + \delta_C U_C(t+1, \hat{h}'^{T+1}) \geq u_C(\min(a''^D_{C,t}, p_t)) + \delta_C U_C(t+1, \bar{h}''^{T+1}), \tag{A3}$$

where $\hat{a}^D_{I,t} = k_t$, $(a'^D_{C,t}, \hat{a}^D_{I,t}) \in \hat{h}'^{T+1}$, $\bar{a}^D_{I,t} = 0$, and $(a''^D_{C,t}, \bar{a}^D_{I,t}) \in \bar{h}''^{T+1}$. The LHS of (A3) is the country's utility if the investment is made and the RHS is its utility if the investor abandons the investment. The term $\delta_C U_C(t+1, \bar{h}''^{T+1})$ will be zero because the investor abandons the investment series.

We first look at the situation when $a'^D_{C,t} \geq p_t$. We then see that inequality (A3) will always hold and $a^{*D}_{C,t} = a'^D_{C,t}$. If $a'^D_{C,t} < p_t$, the country must compare its utility when investment continues with its utility if it declares maximum royalty and the investment is abandoned, i.e.,

$$u_C(a'^D_{C,t} + wk_t) + \delta_C U_C(t+1, \hat{h}'^{T+1}) \geq u_C(p_t), \tag{A4}$$

where we have used the fact that it would not be optimal for the country to set $a''^D_{C,t} < p_t$ if the investor will abandon the investment.

If (A4) does not hold, $a^{*D}_{C,t} = p_t$ and the investor will abandon the investment. If (A4) does hold, $a^{*D}_{C,t} = a'^D_{C,t}$ and the investor will not abandon the investment.

We have now completely described the players' optimal actions in the sub game conditioned on no agreement being reached at time *t*. The parties' utility resulting from this sub game will determine their credible demands, or credible threats, in the negotiations, $(a_{C,t}^{*N}, a_{I,t}^{*N})$ (we simplify the notation by only using the symbol $h^{*T+1}$ for the equilibrium strategies):

$a_{C,t}^{*N}$ s.t.

$$\left.\begin{cases} u_C(a_{C,t}^{*N} + wk_t) + \delta_C U_C(t+1, h^{*T+1}) = u_C(a_{C,t}^{*D} + wk_t) + \delta_C U_C(t+1, h^{*T+1}) & \text{if } a_{I,t}^{*D} = k_t \\ u_C(a_{C,t}^{*N} + wk_t) + \delta_C U_C(t+1, h^{*T+1}) = u_C(p_t) & \text{if } a_{I,t}^{*D} = 0 \end{cases}\right\}, \qquad \text{(A5)}$$

and $a_{I,t}^{*N}$ s.t.

$$\left.\begin{cases} u_I(p_t - a_{I,t}^{*N} - k_t) + \delta_I U_I(t+1, h^{*T+1}) = u_I(p_t - a_{C,t}^{*D} - k_t) + \delta_I U_I(t+1, h^{*T+1}) & \text{if } a_{I,t}^{*D} = k_t \\ u_I(p_t - a_{I,t}^{*N} - k_t) + \delta_I U_I(t+1, h^{*T+1}) = u_I(0) & \text{if } a_{I,t}^{*D} = 0 \end{cases}\right\} \text{(A6)}$$

We see from conditions (A6) and (A5), that if $a_{I,t}^{*D} = k_t$, then $a_{I,t}^{*N} = a_{C,t}^{*D} = a_{C,t}^{*N}$ which also will be equal to $\tilde{r}_t$ by equation (1). ⌉

<u>Proof of Lemma 2</u>

If the investment series has not been abandoned previously, we know that $e_t = k_t$ if $a_{I,t}^{*D} = k_t$ by Lemma 1. The only case where $e_t \neq k_t$ is therefore if $a_{I,t}^{*D} \neq k_t$. Consider the situation for the country where $a_{C,t}^{*N}$ is defined by the second line in (A5). We insert the investor's maximum acceptable royalty, $a_{I,t}^{*N}$, and get that the country would accept this royalty if

$$u_C(a_{I,t}^{*N} + wk_t) + \delta_C U_C(t+1, h^{*T+1}) \geq u_C(p_t)\,. \tag{A7}$$

If inequality (A7) does not hold, the investor's acceptable royalty is not higher than the country's acceptable royalty. It will therefore be optimal for the country that an agreement is not entered into, the country taxes in full the proceeds from the previous year's investment, and the investor abandons the investment. In this case we have that $a_{C,t}^{*N} > a_{I,t}^{*N}$ and an agreement is not feasible. If however (A7) does hold, the country would prefer that an investment is made. In this case, $a_{C,t}^{*N} \leq a_{I,t}^{*N}$, and an agreement is feasible. ⌉

Proof of Proposition 2

By Lemma 1 we know that we only need to consider the case when the investor will abandon the investment in case of an agreement, i.e., when $a_{I,t}^{*D} \neq k_t$. The condition for when the country would be willing to undertake the one-period investment at time *t* by itself is given by inequality (11). We now compare inequality (11) with the second line in (A5). Because $\delta_C u_C(p_{t+1}) \leq \delta_C U_C(t+1, h^{*T+1})$, we know that $a_{C,t}^{*N}$ in equation (A5) is not larger than $(p_t - k_t)$ in inequality (11), i.e., $a_{C,t}^{*N} \leq (p_t - k_t)$. By inserting $a_{C,t}^{*N}$ in the investor's second line of (A6), we find that the investor will enter into an agreement if

$$u_I(p_t - a_{C,t}^{*N} - k_t) + \delta_I U_I(t+1, h'^{*T+1}) \geq u_I(0). \qquad \text{(A8)}$$

The RHS of (A8) is zero by assumption. The LHS of (A8) will be nonnegative. The discounted future utility, $\delta_I U_I(t+1, h^{*T+1})$, is nonnegative and $u_I(p_t - a_{C,t}^{*N} - k_t)$ is nonnegative because $a_{C,t}^{*N} \leq (p_t - k_t)$. This means that the investor will always be willing to enter into an agreement, i.e., $a_{I,t}^{*N} \geq a_{C,t}^{*N}$. ⌉

END NOTES

[1] Credibility is important in economic theory related to many policy issues other than taxation. For fiscal and monetary policy issues, see, e.g., the book edited by Persson and Tabellini [13].

[2] In the modeling of the outcome of the negotiations we have chosen the axiomatic approach of Nash [8]. The parameter $\alpha$ represents the negotiating power of the country. An alternative approach would be to use the Rubinstein-Ståhl bargaining model, see Rubinstein [12] and Ståhl [14]. In order to include the Rubinstein-Ståhl model, which is a multi-period model, into our model, we would need to assume that each round of negotiations over a specific royalty would take place at the same point in time.