Acquisition of Mines by Resource-importing Firms and Distribution of Profits from Resource Extraction

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Abstract

This paper examines the welfare effect of the acquisition of mines by firms in resource-importing countries. In particular, we focus on the distribution of profits from resource extraction between exporting and importing countries. We consider one resource-extracting firm, which is located in a resource-exporting country, and two resource-importing firms, which are located in resource-importing countries. We demonstrate that, when a resource-importing country buys the interests of mines from the resource-extracting firm, the welfare of the resource-exporting country as well as that of resource-importing countries increases. This is because the insufficient supply of resource is mitigated. Subsidy by the government of a resource-importing country encourages the acquisition of mines by the resource-importing firm of the country. However, a part of the subsidy shifts from the resource-importing firm to the resource-exporting country through a price increase of interests. Thus, the welfare of the resource-importing country may decrease. We also consider the case in which resource-importing firms explore new mines in their own countries.

Keywords: Acquisition of mines, Interests, Resource-importing firm, Subsidy
JEL classification: Q31, Q34.

1. Introduction

Expecting that many types of resources will become scarcer in the near future, intermediate and final goods producers have been competing seriously for stable procurement of resources. The variety of resources that serve as inputs into the production of products has also increased, and products developed over the past few decades increasingly use very scarce resources, such as rare earth metals. For example, nickel, chrome, titanium, and palladium are used to produce cell phones. And, gallium is used to produce light emitting diodes. In some industries, these minor metals are critical for production. Accordingly, the producers of such products, particularly those in resource-importing countries, have increased efforts to acquire these resources.

These mining resources are often unevenly distributed across a small number of countries. Furthermore, resource mines may be owned by a small number of resource-extraction firms called *resource majors*. Thus, the concentration ratios of several types of resource markets are very high.[2] In contrast, the number of intermediate/final goods producers is relatively large. Thus, resource extracting firms have bargaining power when resource prices are being determined.

Given this situation, some final goods producers have begun to acquire and develop their own mines. The governments of resource-importing countries have been supporting these firms by providing capital contributions and/or loans with low interest rates.[3] These policies aim to encourage investment in the search for and acquisition of new mines by domestic final goods producers with a view to achieving stable resource procurement at low prices.

This paper theoretically examines the effect of acquisition of interests in mines by firms of resource importing countries on the resource prices and output of final goods. We also consider the effect of acquisition on welfare of each country: resource importing countries

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[2] See, for example, the Minerals Yearbook by the United States Geological Survey (USGS) (http://minerals.usgs.gov/minerals/pubs/myb.html) and Strategic Metal Investments Ltd. (SMI Ltd.) (http://www.strategic-metal.com/index.php/news/content/chinas minor metals part1).

[3] See, for example, Challenges and Actions in Economic/Industrial Policies by the Ministry of Economy, Trade and Industry

(http://www.meti.go.jp/english/aboutmeti/policy/fy2012/fy2012policies.pdf)

and the United States Department of Energy

(http://energy.gov/sites/prod/_les/piprod/documents/USJapan REE Meeting.pdf).

and a resource exporting country. Moreover, we examine the effect of support by the governments of resource importing countries for encouraging acquisition of mines on welfare of each country.

In this paper, we assume that there are one resource extraction firm, which is located in the resource exporting country, and two final goods producers, each of which is located in each resource importing country. By this setting of the model, we are able to clarify the distribution of profits from extraction of resources among countries.

Several researches examined the extraction behavior of firms under imperfect competition: see Sadorsky (1992), Polasky (1996), and Sadorsky (1992) among others. Sadorsky (1992) examined the effect of a change in the number of firms on exploration and extraction quantities. Polasky (1996) focused on asymmetric information on the stock of resources owned by each firm. Howeer, they did not deal with the process of the price setting by resource extraction firms. Moreover, they did not conduct welfare analysis by separating resource exporting and importing countries. Karp and Newbery (1991, 1992), Chou and Long (2009) examined the optimal policies for resource importing countries. However, they focused not on the effect of acquisition of interests in mines but on trade policies.

The main results are as follows. First, when final goods producers buy interests from the resource extraction firm, the profits of final goods producers do not change. On the other hand, the profit of the resource extraction firm and consumer surplus are necessarily greater when there is acquisition of interests by final goods producers than when there is no such acquisition. An increase in consumer surplus arises because the problem of insufficient supply caused by imperfect competition is mitigated by acquisition of interests. Therefore, welfare of each country is necessarily greater when there are acquisition of interests by final goods producers than when there is no such acquisition. However, the problem of insufficient supply does not vanish completely. Therefore, the amount of acquisition is insufficient in terms of world welfare.

Support by the government of a resource importing country encourages acquisition of mines by a final goods producer which is located in the country. However, at least, a part of subsidy is shifted to the resource exporting country through a price increase of interests. Therefore, the support does not necessarily increase welfare of the country. On the other hand, the resource exporting country benefits from this rent shift. Moreover, the support

decreases the resource price in the resource market, welfare of the other resource importing country increases.

Second, when final goods producers explore mines in their own or the other resource importing countries, in equilibrium, the profit of the resource extraction firm when final goods producers acquire positive amounts of mines is necessarily smaller than when final goods producers do not own any mines at all. On the other hand, the profit of each final goods producer, consumer surplus, and welfare of each resource importing country are necessarily greater when final goods producers acquire positive amounts of mines than when final goods producers do not own any mines at all. This is because the resource price in the resource market decreases because of exploration. Moreover, the amount of exploration may be excessive in terms of world welfare. This is because extraction shifts from efficient resource extraction firm to relatively inefficient final goods producers.

The rest of the paper is organized as follows. Section 2 describes the basic model. Section 3 examines the acquisition behavior of final goods producers. Section 4 examines the support policy by the governments of resource importing countries for encouraging acquisition of interests by final goods producers. Section 5 provides concluding remarks.

2. The Model

There is one resource exporting country, which is called Country R, and two resource importing countries, which are Country H and Country F. There is one resource extracting firm (Firm R) in Country R. On the other hand, there is one final goods producer in each resource importing country: Firm H and Firm F, respectively. Firm R extracts resources and sells them to final goods producers. Because Firm R is a monopolist, it can set the resource price in the resource market. We assume that Firm R determines the price of the resource for selling to each final goods producer separately. Although each final goods producer owns its own mines and extracts resources from those mines, the amount of its own extraction is smaller than the total amount it needs to input into the production process. Thus, they also purchase resources from Firm R. The final goods producers sell their products in the integrated world final goods market. Consumers exits in all countries (R、H、F).

The order of decision makings is as follows. In the first stage, each final goods producer

determines its amount of acquisition of mines. We consider two cases: in the first case, each final goods producer buys interests of mines from Firm R; in the second case, it explore mines in its own country, and acquire them. In the second stage, Firm R determines the resource price for each final goods produce. In the third stage, each final goods producer determines the amount of production. The notion of equilibrium is subgame perfect Nash equilibrium.[4]

The world inverse demand for final goods is given by:

$$p_x = A - aX ,$$

where p_x and X denote the price and the total supply of final goods, respectively. Let β_H, β_F, and β_R denote the ratio of each country's market scale to the total market scale: $\beta_H + \beta_F + \beta_R = 1$. That is, when the price is $\breve{p}_x$, the demand in country i is given by $X_i = \beta_i(A - \breve{p}_x)/a \ (i = H, F, R)$.

Both final goods producers are price takers in the resource market, while they compete on quantity in a Cournot fashion. One unit of final goods is produced from one unit of resource. The objective function of each final goods producer in the third stage is

$$\pi_i = (A - aX) \cdot x_i - p_{r,i} \cdot (x_i - e_i) - c_i \cdot e_i, \qquad i, j = H, F, \ i \neq j , \tag{1}$$

where x_i, $p_{r,i}$, e_i, c_i denote the output of Firm i, the price of resource which Firm R sells to Firm i, the amount of extracted resource by Firm i, and the marginal extraction cost of Firm i. The marginal extraction cost is constant and, accordingly, the extraction amount depends on the mines which Firm i acquires in the first stage. It does not depend on the resource price set by Firm R. Moreover, the marginal cost for producing final goods is zero except for the extraction and the purchase of resource from Frim R.

The first-order condition (FOC) for the profit maximization of Firm i $(i = h, f)$ is given by

$$\frac{\partial \pi_i}{\partial x_i} = A - 2ax_i - ax_j - p_{r,i} = 0, \qquad i, j = H, F, \quad i \neq j \tag{2}$$

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[4] In this paper, we do not consider the collusion of two final goods producers theoretically to avoid complicated negotiation processes. We briefly refer to this point descriptively in the conclusion.

The second-order conditions (SOCs) are satisfied in this case.[5] Thus, the equilibrium output given the resource price set by Firm R $(\tilde{x}_i)$ is obtained:、

$$\tilde{x}_i = \frac{A - 2p_{r,i} + p_{r,j}}{3a} .$$ (3)

Therefore, the demand of Firm i for the resource supplied by Firm R is $\tilde{x}_i - e_i$.

The objective function of Firm R in the second stage is given by

$$\pi_R = \sum_{i=H,F} (p_{r,i} - c_r) \cdot (x_i - e_i)$$ (4)

where c_r denotes the marginal extraction cost of Firm R, which is constant. In the second stage, given the amount of mines owned by final goods producers (e_i ($i = H, F$)), Firm R determines the resource price for each final goods producer. The FOC for the profit maximization is

$$\frac{\partial \pi_R}{\partial p_{r,i}} = \frac{A - 4p_{r,i} + 2p_{r,j} + c_r}{3a} - e_i = 0, \qquad i = H, F, \quad i \neq j .$$ (5)

The SOCs are satisfied in this case.[6] Then, we obtain the equilibrium resource price given e_i ($i = H, F$):

$$\hat{p}_{r,i} = \frac{A - 2ae_i - ae_j + c_r}{2}$$ (6)

From (3) and (6), the equilibrium output given e_i ($i = H, F$) can be written as:

$$\hat{x}_i = \frac{A + 3ae_i - c_r}{6a}$$ (7)

It is clear from (6) that an increase in the mines acquired either final goods producer in the first period lowers the resource price for both final goods producers in the second period. This is because the total demand of resource supplied by Firm R decreases. However, the effect of an increase in the acquisition by Firm i (e_i) on the resource price offered to Firm i ($p_{r,i}$) is greater than that on the resource price offered to Firm j ($p_{r,j}$). Each final

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[5] Precisely, the SOCs are:

$\partial^2 \pi_i / \partial x_i^2 = -2a < 0$、および $\partial^2 \pi_i / \partial x_i^2 \cdot \partial^2 \pi_j / \partial x_j^2 - \partial^2 \pi_i / \partial x_i \partial x_j \cdot \partial^2 \pi_j / \partial x_i \partial x_j = 3a > 0$.

[6] Precisely, the SOCs are: $\partial^2 \pi_R / \partial p_{r,i}^2 = -4/3a < 0$ and

$\partial^2 \pi_R / \partial p_{r,i}^2 \cdot \partial^2 \pi_R / \partial p_{r,j}^2 - \partial^2 \pi_R / \partial p_{r,i} \partial p_{r,j} \cdot \partial^2 \pi_R / \partial p_{r,i} \partial p_{r,j} = 4/3a^2 > 0$.

goods producer does not extract resources from its own mines when the marginal cost (c_i) is greater than the resource price offered by Firm R. Thus, we set up the following assumption throughout the paper:

$$\hat{p}_{r,i} > c_i, \quad i = H, F.$$

As we will refer to this point later, this inequality necessarily holds under both Assumptions 1 and 2. This inequality ensures that final goods producers acquire their own mines in the first stage.

3. Acquisition of Interests of Mines and Distribution of Profits

This section focuses on the effect of acquisition of mines on the behavior of firms, consumer surplus, and welfare of each country.

3.1 The case of acquisition from Firm R

First, we consider the case in which final goods producers buy interests of mines from the resource extracting firm (Firm R). In other words, Firm R sells a part of its mines to final goods producers. The profit of each final goods producer including transactions of mines is given by

$$\Pi_i = \left(A - a\hat{X}\right)\cdot \hat{x}_i - \hat{p}_{r,i} \cdot \left(\hat{x}_i - e_i\right) - c_i \cdot e_i - p_{m,i}\left(e_i, e_j\right), \qquad i, j = H, F, \ i \neq j \qquad (8)$$

where $p_{m,i}$ is the price of interests. This is not a unit price of mines but the total price for acquisition. From (1), (2), and the envelope theorem, a change in the profit of Firm i except for the payment to Firm R due to a marginal increase in the amount of acquisition is represented as

$$\frac{d\hat{\pi}_i}{de_i} = -a\hat{x}_i \frac{d\hat{x}_j}{de_i} - \frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot \left(\hat{x}_i - e_i\right) + \hat{p}_{r,i} - c_i \qquad (9)$$

where $\hat{\pi}_i$ denotes the equilibrium profit given $e_i\left(i = H, F\right)$ in the second stage, which does not include the payment for acquisition in the first stage. From (3) and (6), it holds that

$$\frac{d\hat{x}_j}{de_i} = \frac{\partial \tilde{x}_j}{\partial p_{r,j}} \frac{\partial \hat{p}_{r,j}}{\partial e_i} + \frac{\partial \tilde{x}_j}{\partial p_{r,i}} \frac{\partial \hat{p}_{r,i}}{\partial e_i} = \frac{2}{3a} \cdot \frac{a}{2} - \frac{1}{3a} \cdot a = 0 \qquad (10)$$

From (6) and the assumption on the relationship between the resource price and the marginal

extraction cost ($\hat{p}_{r,i} > c_i$), (9) can be rewritten as

$$\frac{d\hat{\pi}_i}{de_i} = -\frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot (\hat{x}_i - e_i) + \hat{p}_{r,i} - c_i > 0 \tag{9}$$

On the other hand, when Firm R sells interests, it can expect that the resource price in the second stage decreases, and that the total demand decreases. Thus, the revenue and, accordingly, the profit from selling resources in the second stage also decrease. From (4) and the envelope theorem this effect is represented as

$$\frac{d\hat{\pi}_R}{de_i} = -\left(\hat{p}_{r,i} - c_r\right) < 0 \tag{11}$$

From (6), (9)', and (11), it may hold that

$$\frac{d\hat{\pi}_i}{de_i} > -\frac{d\hat{\pi}_R}{de_i} \tag{12}$$

When this inequality holds at $e_i = 0$, transactions of interests between Firm R and Firm i ($i = h, f$) are made. From (9)' and (11), if $c_i < c_r$, Firm R gives up selling resources in the second period, and sells interests as many as possible in the first stage. To exclude such a situation, we set up the following assumption.

Assumption 1. $c_i > c_r$, $i = H, F$

Let us now consider the price of interests and profits of firms. We assume that Firm R has bargaining power, which is consistent with the situation in the second stage. In this case, from (9)', an increase in the total acquisition price due to a marginal increase in the interests is represented as

$$\frac{\partial p_{m,i}(e_i, e_j)}{\partial e_i} = -\frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot (\hat{x}_i - e_i) + \hat{p}_{r,i} - c_i. \tag{13}$$

Because

$$\frac{d^2\hat{\pi}_i}{de_i^2} = 2 \cdot \frac{\partial \hat{p}_{r,i}}{\partial e_i} - \frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot \left(\frac{\partial \tilde{x}_i}{\partial p_{r,i}} \frac{\partial \hat{p}_{r,i}}{\partial e_i} + \frac{\partial \tilde{x}_i}{\partial p_{r,j}} \frac{\partial \hat{p}_{r,j}}{\partial e_i} \right)$$

$$= \frac{3}{2} \cdot \frac{\partial \hat{p}_{r,i}}{\partial e_i} < 0, \quad i = H, F, \quad i \neq j \tag{14}$$

it is clear that the price of an additional interest is decreasing. It also holds that

$$-\frac{d^2\hat{\pi}_R}{de_i^2} = \frac{\partial \hat{p}_{r,i}}{\partial e_i} < 0 .\tag{15}$$

The comparison of (14) and (15) reveals that as the acquisition amount increases, the possibility that (12) holds becomes smaller.

Because Firm R has bargaining power, the total acquisition price is equal to the difference between the Firm i's profit when it acquires its own mines and that when it does not own any mines at all. Therefore, even when the transactions are made, the profit of each final goods producer is equal to that when it does not have any mines On the other hand, it is obvious from (11) and (12) that these transactions increase the profit of Firm R.

Figure 1 depicts this situation. In this figure, the amount of interests transacted between Firm i and Firm R is represented by e_1. The price is given by $\square ACe_1O$. A decrease in

the profit of Firm R from selling resources in the second stage is given by $\square BCe_1O$.

Thus, an increase in the sum of the profits of Firm i and Firm R is given by $\triangle ABC$.
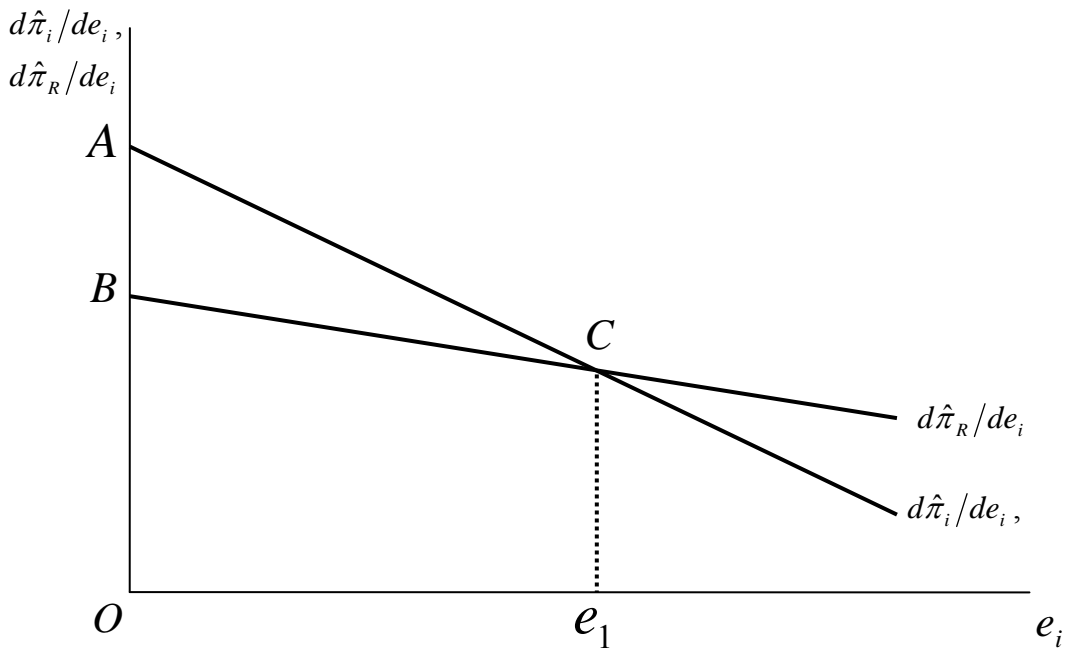

Fig 1. Acquisition of Interests and its Price

Why do transactions of mines in the first stage increase the sum of the profits of both firms? The intuition is as follows. Firm R is a monopolist in the resource market in the

second stage. Thus, the resource is supplied insufficiently.[7] Transaction of mines in the first stage increases the total output of final goods. This increase implies that the loss from insufficient supply of resources in the second stage decreases. Firm R cannot shift the rent, which is generated by an increase in total extraction, from Firm i to Firm R only with selling resources in the resource market. Transactions of mines make Firm R realize the rent shift.

We also obtain that

$$\frac{d^2\hat{\pi}_i}{de_i\,de_j} = \frac{\partial\hat{p}_{r,i}}{\partial e_j} - \frac{\partial\hat{p}_{r,i}}{\partial e_j}\cdot\left(\frac{\partial\widetilde{x}_i}{\partial p_{r,i}}\frac{\partial\hat{p}_{r,i}}{\partial e_j} + \frac{\partial\widetilde{x}_i}{\partial p_{r,j}}\frac{\partial\hat{p}_{r,j}}{\partial e_j}\right) = \frac{\partial\hat{p}_{r,i}}{\partial e_j} < 0 \tag{16}$$

and

$$-\frac{d^2\hat{\pi}_R}{de_i\,de_j} = \frac{\partial\hat{p}_{r,i}}{\partial e_j} < 0\,. \tag{17}$$

These inequalities reveal that the amount of acquired mines of Firm i does not affect that of Firm $j(i\neq j)$. Moreover, using the envelope theorem, we obtain that

$$\frac{d\hat{\pi}_i}{de_j} = -a\hat{x}_i\cdot\left(\frac{\partial\widetilde{x}_j}{\partial p_{r,i}}\frac{\partial\hat{p}_{r,i}}{\partial e_j} + \frac{\partial\widetilde{x}_j}{\partial p_{r,j}}\frac{\partial\hat{p}_{r,j}}{\partial e_j}\right) - \frac{\partial\hat{p}_{r,i}}{\partial e_j}\cdot\left(\hat{x}_i - e_i\right) \tag{18}$$

From (3) and (6), (18) is rewritten as

$$\frac{d\hat{\pi}_i}{de_j} = -\frac{a}{2}\cdot e_i \tag{18'}$$

(18)' implies that the profit of Firm i when it does not acquire any interests is not influenced by the acquisition amount of Firm $j(i\neq j)$. Moreover, when Firm i acquires a positive amount of interests, an increase in the acquisition amount of Firm j decreases the profit of Firm i. The intuition is as follows. Firm i ($i=H,F$) can decrease the amount of resource purchase in the second stage by acquiring interests of mines in the first stage. On the other hand, an increase in the acquisition of mines by the rival producer (Firm $j(i\neq j)$) decreases the resource price in the second stage. This effect decreases the marginal increase in the profit of Firm i by acquiring mines in the first stage and decreasing the purchase

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[7] We do not consider the problem of inter-temporal scarcity.

amount in the second stage.

Let us also examine the consumer surplus. From (3), we obtain that

$$\widetilde{X} = \widetilde{x}_H + \widetilde{x}_F = \frac{2A - \hat{p}_{r,H} - \hat{p}_{r,F}}{3a} \tag{19}$$

From (6) and (19), it is clear that an increase in the acquisition amount leads to an increase in the total output of final goods. Thus, the consumer surplus increases.

Proposition 1. *Suppose that final goods producers buy interests of mines from Firm R. Then, in equilibrium, the profit of each final goods producer when it acquires mines is equal to that when it does not acquire any mines. On the other hand, the profit of resource extraction firm (Firm R) and consumer surplus necessarily increase by transactions of mines in the first stage. Therefore, welfare of each country in the presence of transactions of mines is necessarily greater than that in the absence of such transactions.*

One point should be noted. Proposition 1 does not mean that the amounts of transactions of mines in the first stage is optimal in terms of world welfare. The amount of transacted mines between Firm R and Firm i is determined so that

$$\frac{d\hat{\pi}_i}{de_i} = -\frac{d\hat{\pi}_R}{de_i} \tag{20}$$

holds. Then, from (6), (7), (9)', and (11), the equilibrium amount of transacted mines is obtained:

$$e_i^* = \frac{A + 3c_r - 6c_i}{3a} \tag{21}$$

We assume in this chapter that this amount is positive. Thus, we set up the following assumption.

Assumption 2. $A > 6c_i, \quad i = H, F.$

Moreover, substitution of (21) into (6) yields

$$\hat{p}_{r,i} = 2c_i + c_j - c_r.$$

Thus, the resource price in the second stage is necessarily higher than the marginal

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extraction cost of final goods producers when Assumptions 1 and 2 hold.

Equation (20) reveals that a marginal change in the profit of Firm i is equal to that of Firm R in equilibrium. Therefore, the effect of a marginal increase in the acquisition of interests by Firm i on world welfare at equilibrium is given by the effect on the sum of consumer surplus and the profit of Firm $j (i \neq j)$. From (19) and the fact that $CS = aX^2/2$, we obtain that

$$\frac{dCS}{de_i} = a\hat{X}\frac{d\hat{X}}{de_i} = a\hat{X} \cdot \left(-\frac{1}{3a}\right) \cdot \left(\frac{\partial \hat{p}_{r,i}}{de_i} + \frac{d\hat{p}_{r,j}}{de_i}\right) = a\hat{X} \cdot \left(-\frac{1}{3a}\right) \cdot \left(-a - \frac{a}{2}\right) = \frac{a\hat{X}}{2}$$

$$= \frac{2A + 3ae_i + 3ae_j - 2c_r}{12}$$

(22)

(18)', (22), and Assumptions 1 and 2,

$$\frac{dCS}{de_i} + \frac{d\pi_j}{de_i} > 0$$

necessarily holds at equilibrium (e_i^*). As noted above, the amount of acquisition of interests of Firm i is not influenced by that of Firm j. Consequently, we obtain the following proposition.

Proposition 2. *Suppose that final goods producers buy interests of mines from Firm R. Then, the amount of acquisition of mines is smaller than the world optimum.*

Consumers benefit from the acquisition of mines by Firm i through a decrease in the resource price. This positive effect dominates the negative effect on the profit of Firm j caused by the relationship between final goods producers: strategic substitutes. However, Firm i does not take into consideration the effects on consumers and the rival firm when determining the amount of acquisition. Therefore, distortion caused by insufficient supply of resources remains even when final goods producers acquire interests.

3.2 The case of exploring mines in resource importing countries

Next, we examine the case in which final goods producers explore mines in their own

countries.[8] The cost of exploring one unit of resource is $c_{W,i}$ $(i = H, F)$, which is constant.[9]

The structure of the second and the third stages are the same as that in the previous section. Moreover, because there is no transactions of mines between final goods producers and the resource extracting firm, $p_{m,i}$ does not exist in this subsection.

A change in the profit of Firm i except for the exploring cost caused by an increase in the amount of acquisition is also represented as (9)'. The FOC for the profit maximization is

$$\frac{\partial \hat{\Pi}_i(e_i, e_j)}{\partial e_i} = -\frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot (\hat{x}_i - e_i) + \hat{p}_{r,i} - c_i - c_{W,i} = 0. \tag{23}$$

(6) and (7) reveal that the SOCs are satisfied.[10] From (16), the amount of acquisition by Firm i affects that of Firm $j (i \neq j)$. From (6), (7), and (23), we obtain the following reaction function:

$$e_i = \frac{4A - 3ae_j - 6\tilde{c}_i + 2c_r}{9a},$$

where $\tilde{c}_i = c_i + c_{W,i}$. Thus, the equilibrium amount of acquisition of mines (e_i^{**}) is obtained:

$$e_i^{**} = \frac{4A - 9\tilde{c}_i + 3\tilde{c}_j + 2c_r}{12a} \tag{24}$$

Substituting (24) into (6) yields

$$\hat{p}_{r,i} = \frac{5\tilde{c}_i + \tilde{c}_j + 2c_r}{8}, \quad i, j = H, F, \ i \neq j.$$

Unless $c_{W,i}$ $(i = H, F)$ is very small, $\hat{p}_{r,i} > c_i$ holds. Each final goods producer acquire a positive amount of mines ($d\hat{\pi}_i / de_i |_{e_i=0} > 0$), from (11), (18)', and (22), the following proposition is obtained.

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[8] Even if we assume that the rest of the world exists and that final goods producers explore mines in the rest of the world, the results do not change essentially.

[9] When considering exploration in the rest of the world, even if we assume a transaction in which the profits from extraction are divided between the rest of the world and the final goods producer, the results do not change essentially.

[10] Precisely, the SOCs are: $\partial^2 \hat{\Pi}_i / \partial e_i^2 = \partial p_{r,i} / \partial e_i \cdot (2 - \partial x_i / \partial e_i) < 0$, and
$\partial^2 \Pi_i / \partial e_i^2 \cdot \partial^2 \Pi_j / \partial e_j^2 - \partial^2 \Pi_i / \partial e_i \partial e_j \cdot \partial^2 \Pi_j / \partial e_i \partial e_j > 0$.

Proposition 3. *Suppose that final goods producers explore mines in their own countries. Then, in equilibrium, the profit of Firm R when final goods producers acquire positive amounts of mines is necessarily smaller than when final goods producers do not own any mines at all. On the other hand, the profit of each final goods producer, consumer surplus, and welfare of each resource importing country are necessarily greater when final goods producers acquire positive amounts of mines than when final goods producers do not own any mines at all.*

Then, is the amount of exploration insufficient or excessive in terms of world welfare? Because $d\hat{\pi}_i/de_i = 0 \ (i = H, F)$ holds in equilibrium, a change in world welfare caused by a marginal increase in the acquisition of mines by Firm i is given by

$$\left.\frac{dCS}{se_i}\right|_{e_i=e_i^*} + \left.\frac{d\hat{\pi}_j}{de_i}\right|_{e_i=e_i^*} + \left.\frac{d\hat{\pi}_R}{de_i}\right|_{e_i=e_i^*}.$$

Substitution of (11), (18)', and (22) into (23) yields

$$\left.\frac{dCS}{se_i}\right|_{e_i=e_i^*} + \left.\frac{d\hat{\pi}_j}{de_i}\right|_{e_i=e_i^*} + \left.\frac{d\hat{\pi}_R}{de_i}\right|_{e_i=e_i^*} = \frac{4A - 21\widetilde{c}_i + 6\widetilde{c}_j + 20c_r}{24}.$$

Consequently, the following proposition is established.

Proposition 4. *Suppose that final goods producers explore mines in their own countries Then, it becomes more likely that the amount of exploration/acquisition of mines is excessive in terms of world welfare, as $c_{W,i} \ (i = H, F)$ becomes greater.*

The intuition is as follows. Similar to the case of buying mines from Firm R, an increase in the acquisition of mines mitigates the problem of insufficient supply of resources. In this respect, this behavior of final goods producers improves world welfare. However, there is an additional effect in this case. When the exploration cost is high, part of supply of resources shifts from Firm R, which has relatively efficient extraction technology, to final goods producers whose extraction technology is relatively inefficient. This effect works against

world welfare. When the latter effect dominates the former, an increase in the amount of acquisition of mines by a final goods producer deteriorates world welfare.

4. The Effect of Support by the Government

In the previous section, we focus on firms' behavior. However, the governments often support the firms' acquisition of mines by subsidy and/or low-interest loan. It is important to clarify who benefits from this type of support policy. In this section, we examine the effect of subsidy by the government of a resource importing country to encourage the acquisition of mines. The acquisition of mines is realized in the first stage, the situations of the second and the third stage is the same as those in the previous section. Let s_i denote the subsidy of the government of Country i $(i = H, F)$ provided to Firm i. Then, from (8), the profit of Firm i is rewritten as

$$\Pi_i = (A - a\hat{X}) \cdot \hat{x}_i - \hat{p}_{r,i} \cdot (\hat{x}_i - e_i) - (c_i - s_i) \cdot e_i - p_{m,i}(e_i, e_j), \qquad i, j = H, F, \ i \neq j. \ (8)'$$

Then, from (9), the effect of a small increase in the acquisition of mines on the profit is given by

$$\frac{d\hat{\pi}_i}{de_i} + s_i = -\frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot (\hat{x}_i - e_i) + \hat{p}_{r,i} - c_i + s_i > 0 \qquad\qquad (9)''$$

Note that (9)'' does not include the cost for acquisition. The comparison of (9)' and (9)'' reveals that the government's subsidy increases the price that the final goods producer willingly pays to Firm R to acquire interests. In other words, subsidy by the government of Country i increases the incentive of Firm i to acquiring interests.

First, we consider the case in which final goods producers buy interests of mines from the resource importing country (Firm R). The effect of an increase in the acquisition of mines by a final goods producer on the profit of Firm R is given by (11). Therefore, it can be said that the government's support increases the transactions of mines. The change in the amount of transaction of interests is shown in Figure 2. The curve which represents the willingness to pay of Firm i for an additional interest shifts upwards. Thus, the transaction of interests between Firm i and Firm R is given by e_2, which is greater than when there is no subsidy. The total price of transaction is $\square DFe_2O$, and an increase in the profit of Firm

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i is shifted to Firm R through an increase in the transaction price in the first stage. Moreover, a decrease in the profit of Firm R in the second stage is represented by $\square BFe_2O$. Thus, an increase in the sum of the profits of both firms caused by the transaction of interests in the first stage is represented by $\triangle DBF$.
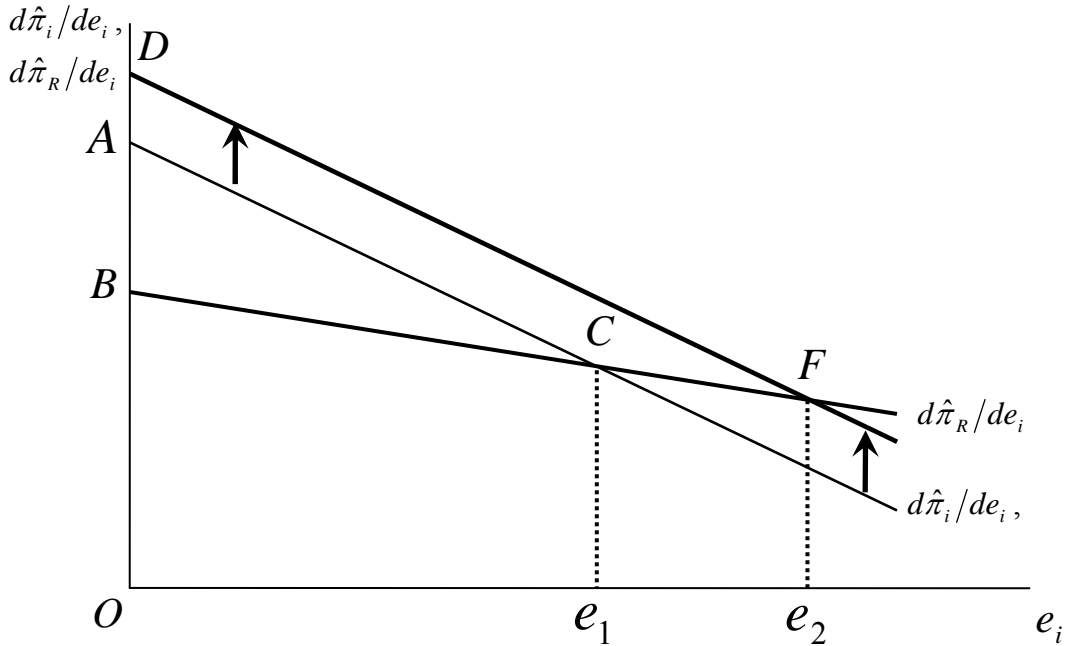

Fig 2. The Government's Support and Acquisition

Let us now examine the effect of support by the government of a resource importing country on welfare of each country. Because this type of support increases the transaction amount of interests between the final goods producers and the resource extraction firm, the resource price in the second stage decreases ((6)). Therefore, consumer surplus increases. Because Firm R has bargaining power, an increase in the sum of the profits of both Firm i and Firm R, which is indicated by $\triangle DBF$, is obtained by Firm R. This amount of rent shift is greater in the presence of the support by the government of Country i than in the absence of the government's support. Thus, it can be said that the support of the government of Country i necessarily increases the profit of Firm R. Interestingly, when considering the policy set by the government of a resource importing country to encourage final goods producers in the country to acquire mines, the policy increases welfare of the resource exporting country.

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On the other hand, the profit of Firm i is equal to that in the absence of the government's support. This fact implies that subsidy is shifted to Firm R. Therefore, if an increase in consumer surplus dominates subsidy expenditure, welfare of Country i improves. From (9)'' and (21), the equilibrium amount of acquisition of mines in the presence of the government's support (e_i^{s*}) is given by

$$e_i^{s*} = \frac{A + 3c_r - 6(c_i - s_i)}{3a}.$$ (25)

The sum of changes in consumer surplus and subsidy expenditure is

$$\beta_i \cdot \frac{dCS}{de_i} \cdot \frac{de_i}{ds_i} - e_i - s_i \cdot \frac{de_i}{ds_i}.$$

From (22), the evaluation of this amount at $s_i = 0$ yields

$$\frac{2A + 3ae_i + 3ae_j - 2c_r}{12} \cdot \frac{2}{a} - \frac{A + 3c_r - 6c_i}{3a} = \frac{A - 9c_i - 3c_j}{3a}.$$

This can be either positive or negative. The extraction cost plays a key role. An increase in the acquisition of mines by a final goods producer increases the amount of extraction by the final goods producer, while decreases the extraction amount of Firm R. From Assumption 1, these changes in the extraction amounts implies that supply of resources shifts from the relatively efficient resource extraction firm to the relatively inefficient final goods producer. If this inefficiency dominates the mitigation effect of insufficient supply, the support of the government of a resource importing country decreases welfare of its own country.

Finally, we examine the effect of the support by Country i on welfare of the other resource importing country, Country j. From (25), this support does not affect the behavior of Firm j, while increases consumer surplus. Thus, welfare of Country j improves.

Proposition 5. *Suppose that final goods producers buy interests of mines from Firm R. Then, the support by the government of a resource importing country necessarily increases welfares of both the resource exporting country and the other resource importing country. On the other hand, welfare of its own country can either increase or decrease.*

Next, we examine the case in which final goods producers explore mines in their own countries. Similar to the previous section, from (23), we obtain the marginal profit of

acquiring an additional interest:

$$\frac{d\hat{\pi}_i}{de_i} = -\frac{\partial \hat{p}_{r,i}}{\partial e_i} \cdot (\hat{x}_i - e_i) + \hat{p}_{r,i} - \tilde{c}_i + s_i \qquad (26)$$

Thus, we obtain the equilibrium amount of acquisition (e_i^{s**}):

$$e_i^{s**} = \frac{4A - 9(\tilde{c}_i - s_i) + 3(\tilde{c}_j - s_j) + 2c_r}{12a} \qquad (27)$$

Equation (27) suggests that an increase in the support by the government i increases the acquisition of mines by Firm i, while decrease the acquisition by the other final goods producer, Firm j. Moreover, Equation (7) reveals that an increase in the support by the government i increases the output of Firm i, while decreases the output of Firm j. It is also clear that the total outputs of final goods increases, while the resource extraction by Firm R decreases.

First, we examine the effect of the support by the government i on welfare of Country i. From (22) and (27), evaluation of the sum of changes in consumer surplus and subsidy expenditure at $s_i = 0$ yields

$$\frac{dCS}{de_i} \cdot \frac{de_i^{s**}}{ds_i} - e_i^{s**} = \frac{2A + 3ae_i^{s**} + 3ae_j^{s**} - 2c_r}{12} \cdot \frac{3}{4a} - e_i^{s**}. \qquad (28)$$

Substituting the equilibrium amount of acquisition into (28), we obtain

$$\frac{dCS}{de_i} \cdot \frac{de_i^{s**}}{ds_i} - e_i^{s**} = -\frac{8A - 63\tilde{c}_i + 33(\tilde{c}_j - s_j) + 22c_r}{96a}. \qquad (29)$$

Equation (29) suggests that the smaller is the exploration cost of Firm i ($\tilde{c}_i$), the more likely it is that the government support decreases welfare of its own country. Certainly, subsidy provided by the government of Country i encourages the exploration of mines by Firm i and, accordingly, total output of final goods increases. This leads to an increase in consumer surplus. However, Firm i would not do this additional exploration if there were no subsidy because the cost is high. When $\tilde{c}_i$ is low, subsidy encourages exploration too much. Thus, the negative aspect of subsidy, which is inefficiency of costly exploration dominates the positive aspect, which is mitigation of insufficient supply.

Let us now turn to other countries. Equations (11) and (18)' reveal that the support by the government of Country i decreases the amount of acquisition of mines and the profit of Firm j. It also decreases the profit of Firm R. On the other hand, it increases consumer

surplus. Depending on the sizes of these conflicting effects, welfares of other countries may increase or decrease. Extraction costs also play a key role in this case.

In summary, the support of Firm i by the government i to encourage the acquisition of mines does not necessarily increase welfare of Country i. There are two important reasons: first, subsidy shifts to the resource exporting country through an increase in the price of interests; second, subsidy encourages inefficient exploration. In particular, when the costs of exploration and extraction of final goods producers are high, the effect of government's support should be estimated carefully.

5. Conclusion

This paper theoretically examined the effect of acquisition of interests in mines by firms of resource importing countries on the resource prices and output of final goods. We also considered the effect of acquisition on welfare of each country: resource importing countries and a resource exporting country. Moreover, we examined the effect of support by the governments of resource importing countries for encouraging acquisition of mines on welfare of each country.

The main results are as follows. First, when final goods producers buy interests from Firm R, the profits of final goods producers do not change. On the other hand, the profit of Firm R and consumer surplus are necessarily greater when there are acquisition of interests by final goods producers than when there is no such acquisition. An increase in consumer surplus arises because the problem of insufficient supply caused by imperfect competition is mitigated by acquisition of interests. Therefore, welfare of each country is necessarily greater when there is acquisition of interests by final goods producers than when there is no such acquisition. However, the problem of insufficient supply does not vanish completely. Therefore, the amount of acquisition is insufficient in terms of world welfare.

Support, such as subsidy and/or low-interest loan, by the government of a resource importing country encourages acquisition of mines by a final goods producer which is located in the country. However, at least, a part of subsidy is shifted to the resource exporting country through a price increase of interests. Therefore, the support does not necessarily increase welfare of the country. On the other hand, the resource exporting country benefits from this rent shift. Moreover, the support decreases the resource price in the resource

market, welfare of the other resource importing country increases. In this respect, if the purpose of the support of the government of a resource importing country is to improve welfare of its own country, it may not be able to achieve the goal.

Second, when final goods producers explore mines in their own or the other resource importing countries, in equilibrium, the profit of the resource extraction firm when final goods producers acquire positive amounts of mines is necessarily smaller than when final goods producers do not own any mines at all. On the other hand, the profit of each final goods producer, consumer surplus, and welfare of each resource importing country are necessarily greater when final goods producers acquire positive amounts of mines than when final goods producers do not own any mines at all. This is because the resource price in the resource market decreases because of exploration. Moreover, the amount of exploration may be excessive in terms of world welfare. This is because extraction shifts from efficient resource extraction firm to relatively inefficient final goods producers. The important difference between the first and second cases is that, in the second case, acquisition of mines by final goods producers does not necessarily increase welfare of all countries.

Moreover, in the second case, welfare effect of the government's support on each country is ambiguous. This type of support may encourage inefficient extraction by final goods producers. In such a case, an additional support may be needed such as that for investment in technology of exploration and extraction.

In the real world, in some cases, firms in the resource-importing countries obtain the interests of mines from resource majors. In such a case, the amount of acquisition is insufficient in terms of world welfare. This implies that the subsidy of the resource-importing country encourages the acquisition: it is likely that world welfare improves. However, the rent-shift from the resource-importing firm to the resource extraction firm is great, welfare of the resource-importing country may decrease. Thus, it may be needed that the government also participates in the negotiation for the acquisition of interests. If the government has some bargaining chips, such as official development aid, the government can help the resource-importing firm acquire the interests with advantageous terms. For firms, it may be needed to make collusion with firms of other resource-importing countries. For example, it may be good strategy for Japanese steel companies to cooperate with Korean and Chinese steel companies to acquire mines.

On the other hand, in other cases, firms in the resource-importing countries explore mines by themselves. In such a case, whether the government should support the domestic firm depends on the costs of exploration and extraction. If the costs are high, the subsidy encourages the inefficient extraction, which does not benefit the resource-importing country. Therefore, when the domestic firm begins to explore mines, the government should support the technological progress on extraction.

Because we focused on the most important aspects of resource extraction and transactions, we did not deal with some interesting aspects. The first one is bargaining of buyers of resources. Firms in resource importing countries often have advanced extraction technologies, or produce intermediate goods for plants and equipment. In such cases, acquisition of mines will become greater. Moreover, final goods producers collude with each other to obtain stronger bargaining power against the resource extraction firm. In such a case, it can be considered that the price of interests will be lower than that in the case analyzed in this paper. Then, resource importing countries are able to get more profits. The second one is negotiation between governments. Transactions of interests are not always made between firms. The government of a resource exporting country sometimes transfers interests of mines to a resource importing country conditioned on the investment in construction of infrastructure and public goods. In such a case, consumers and other industries of the resource exporting countries gain additional benefits from the transaction of interests. Thus, the amount of acquisition may be greater than that obtained in this paper.

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