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Does the Acquisition of Mines by Firms in Resource-importing Countries Decrease Resource Prices?[1]

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Abstract

This paper examines both theoretically and empirically the effects of the acquisition of mines by firms in resource-importing countries on resource prices. In the theoretical part, we consider a simple two-period model. We demonstrate that the acquisition of mines may increase either present or future resource prices. This implies that the consumption of resources in either period may decrease. Strategic behavior of a resource-mining firm, demand for final goods, and extraction costs play key roles. In the empirical part, using a dynamic panel model and oil price data, we estimate the effect of the acquisition of mines on resource prices. We find that prices in the present period increase, while those in the future period decrease.

***Keywords*:** Acquisition of mines, Resource prices, Extraction cost

***JEL classification*:** Q31, Q34.

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1. Introduction

Energy resource such as petroleum and natural gas, common metals such as iron, copper, and aluminum, and minor metals such as nickel, chrome, titanium, and palladium are indispensable for modern economic activities. According to the economic growth of many developing countries, demand for resources have been increasing constantly and, accordingly, the importance of stable procurement of resources have become important for resource importing countries. In particular, the present reserves of minor metals are small, and deposits are unevenly distributed, and they are sometimes costly to extract. Therefore, minor metals are more scarce than other kinds of metals.

Even other kinds of resource are also distributed unevenly. For example, world oil reserves is 1.6527 trillion barrels as of the end of 2011.[2] 18.9 percent of this reserve is existed in Venezuela, 16.1percent in Saudi Arabia, and 10.6 percent in Canada. 48.1 percent of total oil reserves is existed in the Middle East (see Figure 1). For some oil producing countries such as the United States and Brazil, consumption is greater than production (Figure 2).

Uneven production and distribution is more remarkable in the case of minor metals.[3] For example, 77 percent of world production of Beryllium, which is used in aerospace and nuclear industries, is extracted in the United States. More than 90 percent of Niobium, which is used to strengthen steel, is produced in Brazil. Moreover, 71 percent of Platinum, which is used as anti-cancer drug and catalyst of fuel cells, is produced in South Africa. The situation is the same for reserves. For example, more than 90 percent of Platinum is existed in South Africa.

These resources are mainly supplied by small number of firms, which are called resource

[2] See BP, Statistical Review of World Energy 2012 for the details. http://www.bp.com/bodycopyarticle.do?categoryId=1&contentId=7052055

[3] Our description is based on the data of Mineral Commodity Summaries 2012, U.S. Geology Survey. http://minerals.usgs.gov/

majors. In the case of petroleum, we can enumerate Exxon Mobil Corporation, British Petroleum, Royal Dutch shell, and so on. In the case of metals, BHP Billiton, Rio Tinto, and VALE are majors among others. For example, the reserve of copper concentrates in Chile. Moreover, as of 2011, the share of top 7 majors of supply is about 50 percent. The situation is the same for iron, petroleum, and nickel.

On the other hand, the number of intermediate and final goods producers, which use resources as inputs, is much greater than that of suppliers (resource majors). Thus, in general, suppliers have bargaining power. Thus, it is very important for those intermediate and final goods producers to procure resources stably at lower price. In fact, some of those producers acquire interests of mines by themselves. For example, Nippon Steel Corporation and JFE Steel Corporation acquired interest of mines of coals and minor metals. Resource extraction firms in resource importing countries also acquire interests actively. For example, Sumitomo Metal Mining Corporation announced its plan to acquire interests in copper mines: it will increase its interests from 120 thousand tons (2012) to 300 thousand tons (2021).

The government and government financial institution have been supporting these acquisition activities of firms in its own country. It takes a long time for firms to explore and develop new mines. However, it is uncertain how many reserves firms will be able to explore. The resource price may also vary drastically in a short period. Thus, there is a risk that the long-term profit from exploration varies drastically. On the other hand, stable procurement of resources is important not only for firms which use resources as inputs but also the resource importing country. Thus, it may be beneficial to the society to share the risk of exploration through support policies. In the case of Japan, the Ministry of Economy, Trade and Industry support Japanese firms to acquire interests of mines in foreign countries through Japan Bank for International Cooperation, Japan Oil, Gas and Metals National

Corporation, and Nippon Export and Investment Insurance. This supporting policy givens Japanese firms incentives to acquire interest of mines.

Fig.1 Reserves of Petroleum (2011, one billion barrel)

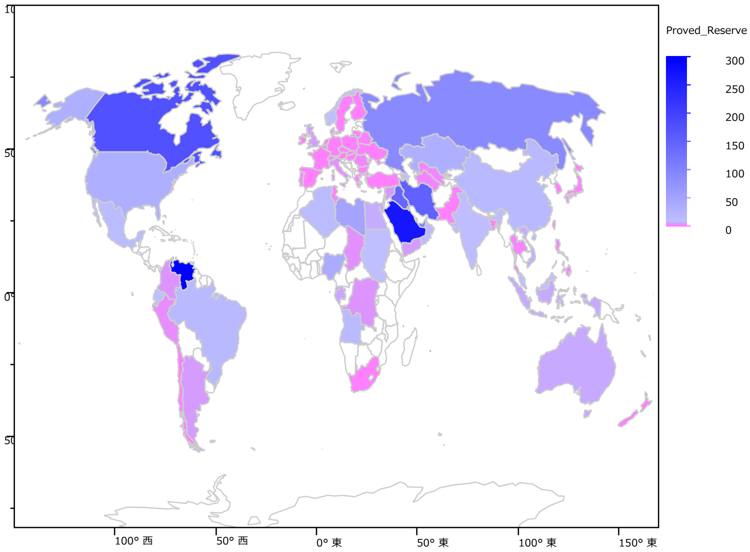
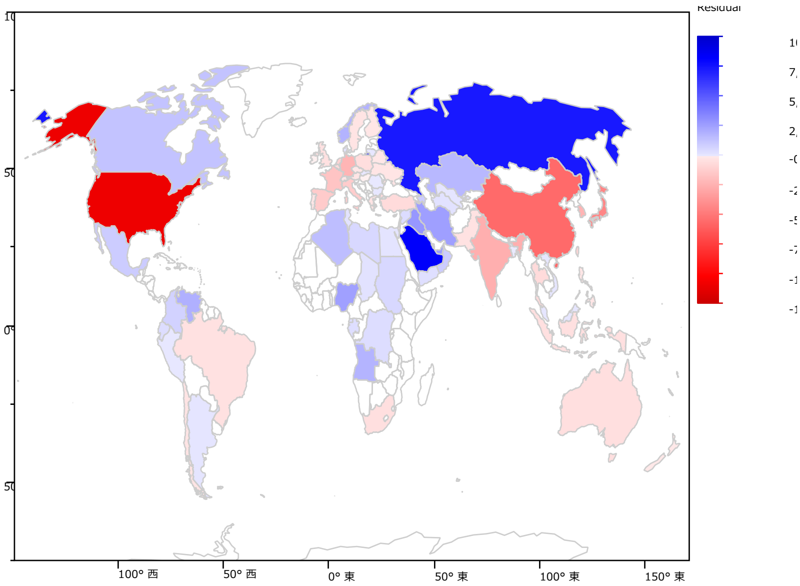


Fig 2 Oil Production minus Oil Consumption (2011, one thousand barrel per day)



Source BP Statistical Review of World Energy June 2012

First, this paper theoretically examines the effect of acquisition of mines by firms of resource importing countries on the resource prices using a simple two-period model. Because it is considered that the support by the government encourages the acquisition activities, the results implicitly suggest the effect of support by the governments of resource importing countries. We examine the effect on the resource price in each period: the present period and the future period. Second, to verify the implication obtained by the theoretical analysis, we estimate the effect of resource acquiring policies of resource importing countries on the resource prices using a dynamic-panel model.

The theoretical model has three features. First, there is one resource extracting firm (Firm f) in the resource exporting country. On the other hand, there are n final goods producers. The resource extraction firm is able to determine the resource price. Second, one of final goods producers is located in the home country (Firm h), and it determines the investment amount for acquisition of interests of mines in the beginning of the first period. However, it can extract resources from its own mines only in the second period. Third, the extraction cost of Firm f depends on the resource stock. Thus, the marginal extraction cost in the second period is higher than that in the first period. These settings of the model take into consideration the following two facts: first, the number of firms becomes very small in the upward sectors of resource industries; second, it usually takes a long time to explore new mines; second; and third, the extraction cost increases as the resource stock becomes smaller.[4]

The main results of the theoretical analysis are as follows. An increase in the acquisition of mines by Firm h may increase the resource price in either the first or second period. This result implies that consumption of resources may decrease in either period. Strategic

[4] The theoretical analyses of resource prices have been conducted for the past several decades. A few articles demonstrated the dynamic process of resource prices (Gilbert and Goldman, 1978, Ulph and Folie, 1980), and other articles tackled the problem of oligopolistic resource markets using two-period models (Sadorsky, 1992, Polasky, 1996). In this paper, small-scale price takers extract resources from their own mines only in the second period. Thus, in terms of decision making of a large-scale resource extraction firm which is located in the resource exporting country, our model is based on Gilbert and Goldman (1978), which examined the monopolist's behavior facing the possibility of new entry in the future.

behavior of Firm f, demand structure for final goods, and the extraction cost of Firm h play key roles in determining the price change.

In the empirical part, we adopt a econometric model which is consistent with the theoretical analysis. Then, we test the three patterns of price changes obtained in the theoretical part. We use the petroleum data in terms of data availability. [5]

The structure of the paper is as follows. Section 2 describes the theoretical model. Section 3 examines the equilibrium price and extraction amounts. Section 4 investigates the effect of an increase in acquisition of mines by a final goods producer on the resource prices. Section 5 estimates an empirical estimation to test the theoretical results. Section 6 provides concluding remarks.

2. Theoretical Model

There is only one resource supplier (Firm f), which is located in the resource-exporting country (Country f). There are n firms that produce final goods X from the resource, which are located in resource-importing countries. One of those final goods producers (Firm h) is located in the home country. The final goods producers including Firm h supply their own products to the integrated world market (see Figure 3 for the structure of the model). We consider a simple two-period model. In each period, Firm f determines the resource price first. Then, each final goods producer chooses its output. Final good producers compete with each other in a Cournot fashion in the final goods market, while they are price takers in the resource market.

Firm h invests in the exploration of mines, and those mines are ready for extraction when it begins the production of final goods in the second period.9 However, it is assumed that the amount of extraction from its own mines is smaller than the amount it needs and, therefore, it also purchases resources from Firm f. Furthermore, we do not consider the effects of

[5] Our analysis can be applied to various kinds of resources as far as the degree of concentration of the upstream industry is higher than that of the downstream industry.

uncertainty on exploration. Thus, an increase in investment in exploration implies an increase in the acquisition of new mines.

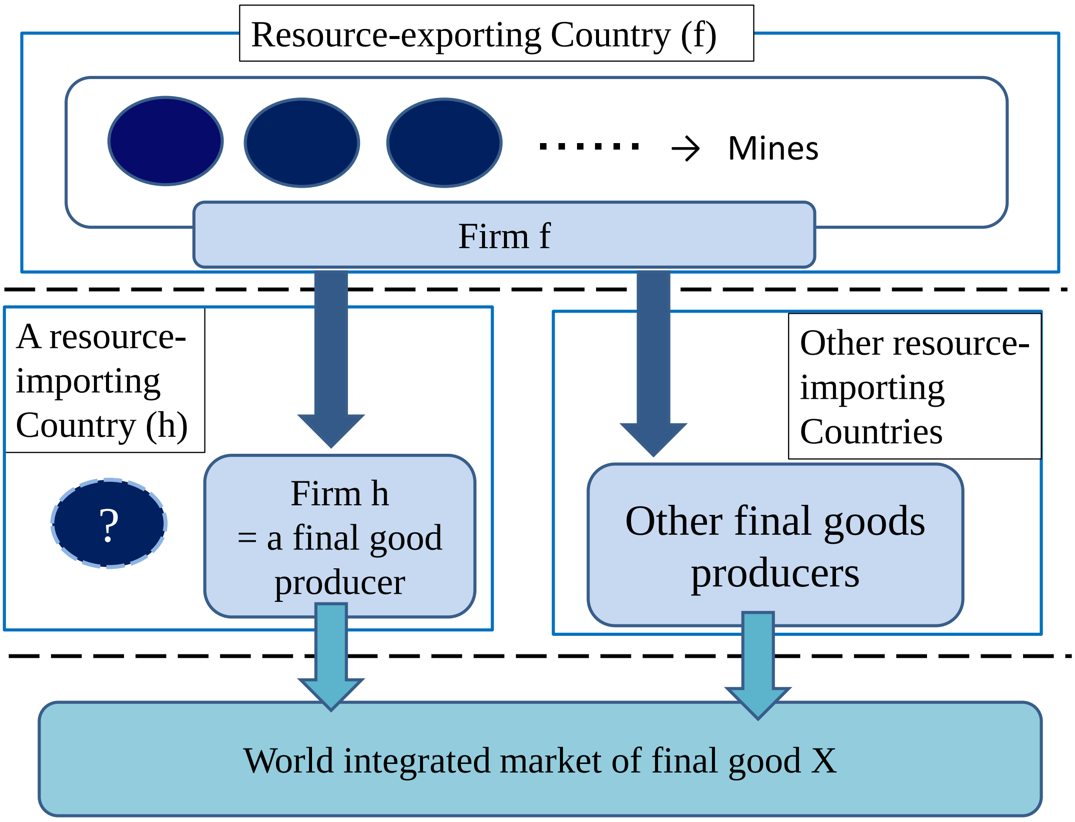


Figure 3. The structure of the model.

Firm h determines the amount of investment in exploration before the first period begins. This setting reflects an important aspect of mining investments: it is time consuming to complete the exploration of new mines. We consider that the investment amount is exogenous when the resource price and outputs are determined in both periods. The world inverse demand curve for the final goods in each period is given by

$$p_{x,j} = P_x(X_j), \qquad P_x' < 0, \qquad j = 1,2$$

The structure of which is fixed through both periods. X_j denotes the total output of final goods in period j. One unit of final goods X is made from one unit of the resource, and the marginal cost for producing the final goods, except for the resource procurement cost, is assumed to be zero. The profit of each final goods producer i, except for Firm h, in each period is given by:

$$\pi_{i,j} = \left(p_{x,j} - p_{r,j}\right)\cdot x_{i,j}$$

where $p_{x,j}$ and $p_{r,j}$ denote the prices of output and the resource in period j (=1, 2), respectively. Moreover, $x_{i,j}$ denotes the output of each final goods producer (Firm i) in period j. For Firm h, the profits of both periods are given by

$$\pi_{h,1} = \left(p_{x,1} - p_{r,1}\right)\cdot x_{h,1}$$
$$\pi_{h,2} = \left(p_{x,2} - p_{r,2}\right)\cdot x_{h,2} + p_{r,2}M_h - C_h\left(M_h, I\right)$$

where M_h, C_h, and I denote the amount of extraction by Firm h, the cost of the extraction, and the investment amount for the exploration/acquisition of mines, respectively. The larger the investment is, the more mines Firm h owns in the second period. We assume that

$$\frac{\partial C_h}{\partial M_h} > 0,\quad \frac{\partial^2 C_h}{\partial M_h^2} > 0,\quad \frac{\partial C_h}{\partial I} < 0,\quad \frac{\partial C_h}{\partial I^2} > 0,\quad \frac{\partial^2 C_h}{\partial I \partial M_h} < 0. \tag{1}$$

The objective of the final goods producers is to maximize their own profits in each period. Because they are price takers in the resource market, and because none of them have any mines in the first period, they do not consider the effect of their own production in the first period on the resource price in the second period.

We assume that the cost for the resource extracting activity of Firm f is stock dependent. Therefore, the marginal cost curve shifts upward in the second period as compared with the first period. The larger the amount of the extraction in the first period, the greater the shift is. In particular, for the total extraction through the two periods (R_S), the total cost is defined as:

$$TC_r = C_f\left(R_1 + R_2\right),\qquad C_f' > 0,\qquad C_f'' > 0.$$

Thus, the cost function for each period is given by:

$$C_{f,1} = C_f(R_1), \quad C_{f,2} = C_f(R_1 + R_2) - C_f(R_1)$$

where R_j ($j = 1,2$) denotes the amount of extraction in period j. Note that R_1 is given at the beginning of the second period. The profit of Firm f in each period is given by:

$$\pi_{f,1} = p_{r,1} R_1 - C_{f,1}(R_1)$$
$$\pi_{f,2} = p_{r,2} R_2 - C_{f,2}(R_1 + R_2) + C_{f,1}(R_1)$$

In the second period, Firm f chooses the resource price ($p_{r,2}$) to maximize $\pi_{f,2}$. In contrast to final goods producers, it considers the effect of its choice of resource price in the first period on the situation in the second period. Therefore, Firm f chooses the resource price in the first period to maximize the total profit:

$$\Pi_f = \pi_{f,1} + \delta \pi_{f,2}$$

where δ is the discount factor.

The government of country h supports the acquisition of interests of mines by subsidy and/or low-interest loan. In this chapter, this type of support is exogenous. We assume that an increase in this type of support encourages firm h to acquire mines.

3. Equilibrium Prices and Extraction

We solve the game by backward induction, and the notion of equilibrium is the subgame perfect Nash equilibrium (see Figure 4 for the structure of the game).[6]

3.1 The Second Period

Final goods producers including Firm h choose outputs to maximize their own profits given the resource price, pr;2. The first-order condition (FOC) for each producer is

[6] In the transactions in the real world, the seller and buyer often negotiate for the price. However, for simplicity, we assume that only one resource extraction firm exists, and accordingly, we exclude the negotiation processes.

$$\frac{\partial \pi_{i,2}}{\partial x_{i,2}} = p_{x,2} + P'_{x,2}\, x_{i,2} - p_{r,2} = 0 \qquad (2)$$

where $P'_{x,2} = P'_x(X_2)$.The second-order condition (SOC) is assumed to hold globally.

1st period

The home government subsidizes the investment in exploration of mines by Firm h. (Exogenous)
→ Firm h determines the investment amount. (Exogenous)

Firm f chooses the resource price in the first period.
↓
Final goods producers choose their own outputs (and the amounts of resource inputs)

2nd period

Firm f chooses the resource price in the first period.
↓
Firm h chooses the extraction amount.
↓
Final goods producers choose their own outputs (and the amounts of resource inputs)

Figure 2. The structure of the game.

Because final goods producers are symmetric except for the acquisition of mines, equilibrium outputs are the same. We define the equilibrium outputs: $\hat{x}_2 = \hat{x}_2(p_{r,2})$ $\hat{X}_2 = \hat{X}_2(p_{r,2})$. Then, the FOC ((2)) can be rewritten as

$$P_x(n\hat{x}_2) + P_x'(n\hat{x}_2)\hat{x}_2 - p_{r,2} = 0$$

The following stability condition is assumed to hold globally: $(n+1)P_{x,2}' + nP_{x,2}'' x_2 < 0$ .Therefore, $\partial\hat{x}_2 / \partial p_{r,2} < 0$ and $\partial\hat{X}_2 / \partial p_{r,2} < 0$ hold.

Firm h also extracts the resource from mines it owns. Because Firm h is a price taker in the resource market, the amount of extraction is determined so that the marginal extraction cost is equal to the resource price: $p_{r,2} = \partial C_h / \partial M_h$. Thus, we obtain the equilibrium amount of extraction: $\hat{M}_h(p_{r,2}, I)$.Note that it follows from the assumption on the shape of C_h that $\partial\hat{M}_h / \partial I > 0$ and $\partial\hat{M}_h / \partial p_{r,2} > 0$. The demand for the resource extracted by Firm f is given by $R_{D,2}(p_{r,2}, I) = \hat{X}_2(p_{r,2}) - \hat{M}_h(p_{r,2}, I)$. From the shape of the demand and supply curves ($\hat{X}_2, \hat{M}_h$).it holds that $\partial R_{D,2} / \partial p_{r,2} < 0$. Firm f chooses the resource price in the second period to maximize its profit ($\pi_{f,2}$).The FOC is

$$\frac{\partial \pi_{f,2}}{\partial p_{r,2}} = R_{D,2} + \left(p_{r,2} - C_{f,2}'\right) \cdot \frac{\partial R_{D,2}}{\partial p_{r,2}} = 0 \tag{3}$$

The SOC is assumed to be satisfied:

$$\frac{\partial^2 \pi_{f,2}}{\partial p_{r,2}^2} = 2\frac{\partial R_{D,2}}{\partial p_{r,2}} - C_{f,2}''\left(\frac{\partial R_{D,2}}{\partial p_{r,2}}\right)^2 + \left(p_{r,2} - C_{f,2}'\right) \cdot \frac{\partial^2 R_{D,2}}{\partial p_{r,2}^2} < 0 \tag{4}$$

Thus, we obtain the equilibrium resource price and the supply of the resource by Firm f in the second period: $\hat{p}_{r,2}(R_1, I)$, $\hat{R}_2 = R_{D,2}(\hat{p}_{r,2}, I)$.

3.2 The First Period

The determination of the output quantities of final goods is the same as that in the second period. On the other hand, because Firm h has not yet completed the acquisition of mines, it does not extract resources itself, and accordingly, $R_{D,1} = \hat{X}_1\left(p_{r,1}\right)$. Firm f chooses the resource price in the first period to maximize its total profit:

$$\Pi_f = p_{r,1} R_{D,1} - C_{f,1}\left(R_{D,1}\right) + \delta \hat{\pi}_{f,2}$$

where $\hat{\pi}_{f,2}$ denotes the equilibrium profit in the second period given R_1. Using the envelope theorem, the FOC is given by:

$$\frac{d\Pi_f}{dp_{r,1}} = R_{D,1} + \left\{p_{r,1} - (1-\delta)C'_{f,1} - \delta C'_{f,2}\right\} \cdot \frac{\partial R_{D,1}}{\partial p_{r,1}} = 0 \tag{5}$$

It is assumed that the interior solution is obtained in each period. Because $\partial R_{D,1} / \partial p_{r,1} < 0$, the assumption of the interior solution implies that $p_{r,1} - (1-\delta)C'_{f,1} - \delta C'_{f,2} > 0$ necessarily holds in equilibrium. Intuitively, the assumption of interior solution implies that the resource is abundant in the mines owned by Firm f, and accordingly, the marginal cost of extraction for Firm f does not drastically increase. Moreover, the SOC is assumed to be satisfied. Thus, we obtain the equilibrium resource price and extraction amount in the first period: $\hat{p}_{r,1}(I),\ \hat{R}_1 = R_{D,1}\left(\hat{p}_{r,1}\right)$.

4. Acquisition of New Mines and Resource Prices

In this section, we examine the effect of an increase in mines owned by Firm h on the resource prices in both periods. There are two kinds of effects on resource prices: *the direct price effect* and *the supply-shifting effect*. The direct price effect, which is denoted by $\partial \hat{p}_{r,2} / \partial I$, is the effect of an increase in mines owned by Firm h on the resource price in the second period given the resource supply by Firm f in the first period (R_1). From (2), we obtain:

$$\frac{\partial^2 \hat{\pi}_{f,2}}{\partial I\,\partial p_{r,2}} = -\frac{\partial \hat{M}_h}{\partial I} + C''_{f,2}\frac{\partial \hat{R}_2}{\partial p_{r,2}}\frac{\partial \hat{M}_h}{\partial I} - \left(\hat{p}_{r,2} - C'_{f,2}\right)\frac{\partial^2 \hat{M}_h}{\partial I \partial p_{r,2}} \tag{6}$$

Moreover, from (4) and (6), we obtain

$$\frac{\partial \hat{p}_{r,2}}{\partial I} = \frac{\dfrac{\partial \hat{M}_h}{\partial I} - C''_{f,2}\dfrac{\partial \hat{R}_2}{\partial p_{r,2}}\dfrac{\partial \hat{M}_h}{\partial I} + \left(\hat{p}_{r,2} - C'_{f,2}\right)\dfrac{\partial^2 \hat{M}_h}{\partial I \partial p_{r,2}}}{2\dfrac{\partial \hat{R}_2}{\partial p_{r,2}} - C''_{f,2}\left(\dfrac{\partial \hat{R}_2}{\partial p_{r,2}}\right)^2 + \left(p_{r,2} - C'_{f,2}\right)\cdot\dfrac{\partial^2 \hat{R}_2}{\partial p_{r,2}^2}}. \tag{7}$$

Because $\partial \hat{R}_2 \big/ \partial p_{r,2} < 0$ and $\partial \hat{M}_h \big/ \partial I > 0$ hold, we obtain the following lemma.

Lemma 1

If $\partial^2 \hat{M}_h \big/ \partial I\,\partial p_{r,2} > 0$, $\partial\,\hat{p}_{r,2} \big/ \partial I < 0$ holds. This means that an increase in the investment in new mines by Firm h decreases the resource price in the second period through the direct price effect.

$\partial^2 \hat{M}_h \big/ \partial I\,\partial p_{r,2} > 0$ means that, the greater amount of mines Firm h owns, the greater is its response to an increase in $p_{r,2}$ by increasing extraction. In other words, the higher the resource price offered by Firm f in the second period is, the greater the effect of an additional unit of investment on the increase in the extraction by Firm h. The shift of the supply curve that satisfies this inequality is shown in Figure 5. As the investment amount increases, the demand for the resource supplied by Firm f becomes more elastic, which gives Firm f an incentive to lower the resource price in the second period.

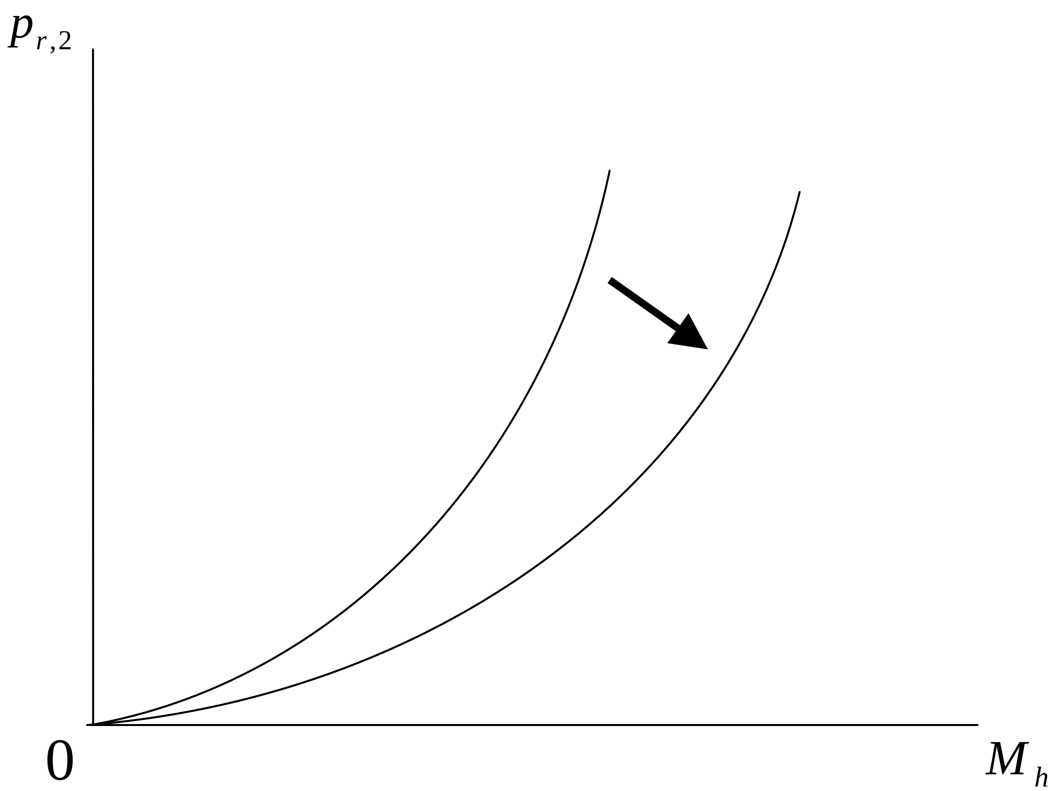


Fig.5. The shift of the supply curve by Firm h when $\partial \hat{M}_h / \partial I \partial p_{r,2} > 0$

Now let us turn to the supply-shifting effect. Observing a change in the investment amount by Firm h and expecting a change in the second-period situation, Firm f increases or decreases the resource supply in each period. In other words, Firm f shifts the resource supply from the first (second) period to the second (first) period to maximize its profit. This effect is given by $\partial \hat{p}_{r,2} / \partial R_1 \cdot \hat{R}_1' \cdot d\hat{p}_{r,1} / dI$ where $\hat{R}_1'$ denotes $\partial \hat{R}_1 / \partial p_{r,1}$. Contrary to the direct price effect, the supply-shifting effect changes the resource prices in both the first and second periods.

We obtain from (5) that

$$\frac{d^2 \hat{\Pi}_f}{dI\, dp_{r,1}} = -\delta C''_{f,2} \frac{d\tilde{R}_2}{dI} R_1' , \tag{8}$$

where

$$\frac{d\tilde{R}_2}{dI} = \frac{\partial \hat{R}_2}{\partial p_{r,2}} \frac{\partial \hat{p}_{r,2}}{\partial I} - \frac{\partial \hat{M}_h}{\partial I} \tag{9}$$

$d\tilde{R}_2 / d\,I$ denotes the effect of a change in the investment by Firm h on the demand for the resource supplied by Firm f given the resource supply in the first period (R_1). Thus, the supply-shifting effect can be rewritten as

$$\frac{\partial \hat{p}_{r,2}}{\partial R_1} \cdot \hat{R}_1' \cdot \frac{d\hat{p}_{r,1}}{dI} = \frac{\partial \hat{p}_{r,2}}{\partial R_1} \cdot \hat{R}_1' \cdot \frac{\delta C''_{f,2} \hat{R}_1' \cdot d\tilde{R}_2 / dI}{d^2 \hat{\Pi}_f / dp_{r,1}^2} \tag{10}$$

From (3) and the fact that $\partial \hat{R}_2 / \partial p_{r,2} < 0$, we obtain

$$\frac{\partial^2 \hat{\pi}_{f,2}}{\partial R_1 \partial p_{r,2}} = -C''_{f,2} \frac{\partial \hat{R}_2}{\partial p_{r,2}} > 0\,. \tag{11}$$

From (4) and (10), it holds that $\partial \hat{p}_{r,2} / \partial R_1 > 0$. Moreover, $R_1' < 0$ and $C''_{f,2} > 0$ hold. Thus, the supply-shifting effect depends on the sign of $d\tilde{R}_2 / dI$.

Lemma 2

If $d\tilde{R}_2 / dI < 0$ holds, an increase in the investment in new mines by Firm h decreases the resource price in the first period, and increases the resource price in the second period through the supply-shifting effect. On the other hand, If $d\tilde{R}_2 / dI > 0$ holds, an increase in the investment in new mines by Firm h increases the resource price in the first period, and decreases the resource price in the second period through the supply-shifting effect.

Suppose that the direct price effect is negative ($\partial \hat{p}_{r,2} / \partial I < 0$). Because $\partial \hat{R}_2 / \partial p_{r,2} < 0$, the price decrease in the second period increases the demand for the resource extracted by Firm f given the amount of extraction of Firm h (the first term in (9)). On the other hand, an increase in investment by Firm h increases the resource supply of Firm h given the resource price, which means that the demand for the resource extracted by Firm f decreases (the second term in (9)). Thus, $d\tilde{R}_2 / dI$ can be either positive or negative. However, when the direct effect is positive ($\partial \hat{p}_{r,2} / \partial I > 0$),both terms work to decrease the demand for the resource extracted by Firm f. In this case, $d\tilde{R}_2 / dI$ is necessarily negative.

From (7) and the fact that $\partial \hat{R}_2 / \partial p_{r,2} < 0$, the more highly the demand for the resource supplied by Firm f is convex ($\partial^2 \hat{R}_2 / \partial p_{r,2}^2 > 0$), the more likely it is that $d\tilde{R}_2 / dI > 0$ holds ((9)). It should be noted that even if the demand curve for final goods is concave, the demand for the resource supplied by Firm f can be convex because $\hat{R}_2 = \hat{X}_2 - \hat{M}_h$. Moreover, even if $\partial^2 \hat{R}_2 / \partial p_{r,2}^2 < 0$, $d\tilde{R}_2 / dI > 0$ may hold.

From Lemmas 1 and 2, we obtain the effects of a change in the investment in the exploration/acquisition of new mines by Firm h on the resource prices in both periods, which depend on the direction and the size of both the direct price and the supply-shifting effects.

First, when $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} > 0$ and $d\tilde{R}_2 / dI > 0$ hold, both the direct price and the supply shifting effects decrease the resource price in the second period, and the latter increases it in the first period.

Proposition 1

Suppose that $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} > 0$ *and* $d\tilde{R}_2 / dI > 0$ *hold. Then, an increase in the mines owned by Firm h increases the resource price in the first period, and decreases it in the second period.*

It is interesting to consider the policy implication of this result. Suppose that the support by the home government for the investment by Firm h increases the amount of investment. In such a case, the government's support may induce an increase in the present resource price.

Next, let us focus on the case in which $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} > 0$ and $d\tilde{R}_2 / dI < 0$. From Lemma 1, the direct price effect decreases the resource price in the second period, while the supply-shifting effect increases (resp. decreases) the resource price in the second (resp. first) period. As far as the resource price in the second period, both effects conflict with each other. Thus, depending on the sizes of both effects, there are two possible cases.

Proposition 2. *Suppose that* $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} > 0$ *and* $d\tilde{R}_2 / dI < 0$ *hold. If the demand curve for final goods is concave, an increase in the mines owned by Firm h necessarily decreases the resource prices both in the first and second periods. On the other hand, if the demand curve for final goods is convex, an increase in the mines owned by Firm h may increase the resource price in the second period.*

See Appendix for the proof. The intuition is as follows. When $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} > 0$, an investment in the exploration of new mines by Firm h makes the demand for the resource extracted by Firm f more elastic. Thus, in terms of the direct price effect, Firm f has an incentive to decrease the resource price in the second period, and accordingly, increase the supply in the second period. However, as noted above, the supply-shifting effect is assumed to work to increase the resource price in the second period. Then, which effect dominates the other depends on the shape of the demand curve for final goods. When the demand curve for final goods is concave, $\partial p_{r,1} / \partial R_1$ becomes greater as the supply in the first period increases.

On the other hand, when the demand curve for final goods is convex, $\partial p_{r,1} / \partial R_1$ becomes smaller as the supply in the first period increases. Therefore, Firm f has less incentive to shift the resource supply from the second to the first periods when the demand curve for final goods is concave than when it is convex. Consequently, when the demand curve is concave, the direct price effect necessarily dominates the supply-shifting effect, whereas when the demand curve is convex, the supply-shifting effect may dominate the direct price effect.

Let us now turn to the case where $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} < 0$. This case is possible when considering investments in resources. For example, consider the exploration of oil fields in a certain area. The resource extraction increases given the resource price as the number of pits/platforms increases by investments. However, because the oil reserve in a certain area is finite, an additional pit/platform gives rise to negative externalities in the extraction of existing pits/platforms in the same area. In such a case, the marginal cost of extraction rapidly increases when the stock becomes small. Thus, an additional investment may decrease the marginal increase of extraction in response to an increase in the resource price. This type of shift of a supply curve is depicted in Figure 6. In this case, it follows from (6) that a decrease in the resource price in the second period is smaller when $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} < 0$ than when $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} > 0$. An increase in the investment may even increase the resource price in the second period. This is because the demand for the resource supplied by Firm f becomes less elastic. In particular, from (8) and (9), we obtain the following proposition.

Proposition 3. *Suppose that* $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} < 0$ *holds. Then, If the direct price effect is positive (*$\partial \hat{p}_{r,2} / \partial I > 0$*), an increase in the mines owned by Firm h necessarily increases the resource price in the second period, and decreases it in the first period.*

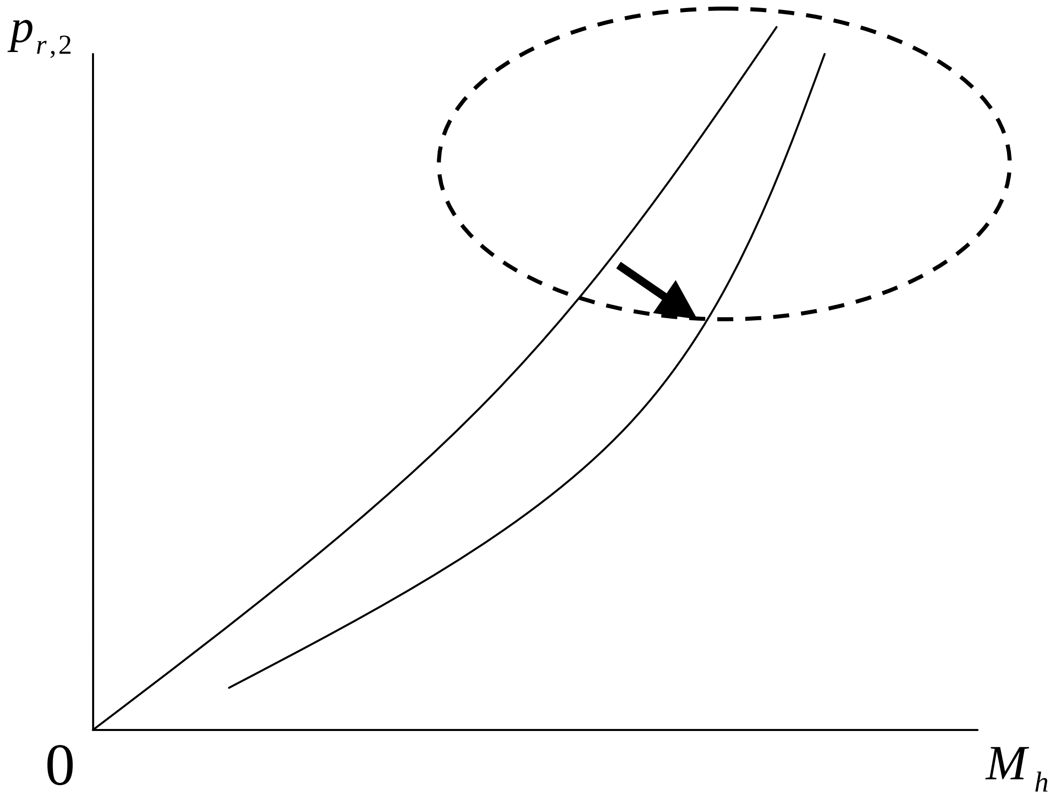


Fig.6. The shift of the supply curve by Firm h when $\partial \hat{M}_h / \partial I \partial p_{r,2} < 0$

Both the direct price and supply-shifting effects work in the same direction with respect to the price in the second period. The resource supply by Firm f in the second period decreases, while that in the first period increases. Note from (5) that the necessary condition for $\partial \hat{p}_{r,2} / \partial I > 0$ to hold is $\partial^2 \hat{M}_h / \partial I \, \partial p_{r,2} < 0$. And, this inequality is specific to the shift of a resource supply curve as a result of investment in exploration.

Having examined the effects of an increase in mines owned by Firm h on the resource prices, we obtain important policy implications. The support by the government of a resource-importing country does not necessarily have an effect on the resource price as intended, if the government aims to lower the resource price. In some cases, the support leads to an increase in the present resource price, and in other cases it may lead to an increase in the future resource price. The results depend on the demand and cost structures.

5. Acquisition Policy and Resource Prices – An Empirical Evidence –

In this section, assuming Governments' acquisition policy always encourage the final good firms' resource acquisition behavior, we analyze the effects of the policy on resource prices by dynamic panel analysis. Practically, we analyze the effects of the government policy on crude oil price in oil importing countries.

Modeling the real oil price is difficult in a way that as Hamilton (2009, p. 1) indicates, "changes in the real price of oil have historically tended to be (i) permanent, (ii) difficult to predict, and (iii) governed by very different regimes at different points in time." The oil price change affects the economy for several years, which gives feedback to oil price itself.

Hereby we start with the framework of dynamic panel analysis. Basically, individual-specific-effects for the scalar dependent variable $p_{r(it)}$ specifies that

$$p_{r(it)} = \alpha_i + \mathbf{x}_{it}'\boldsymbol{\beta} + \varepsilon_{it} \tag{12}$$

where i = 1, …, N denotes individuals, t = 1, …, T denotes time, $\mathbf{x}_{it}$ are regressors, α_i are random individual-specific effects, and ε_{it} is an idiosyncratic error.[7] When we set the dependent variable $p_{r(it)}$ as the oil price, we should note that it depends in part on its values in previous periods.

To form an autoregressive model of order k in $p_{r(it)}$, we include $p_{r(i,t-1)},\cdots p_{r(i,t-k)}$ as regressors such that,

$$p_{r(i,t)} = \gamma_1 p_{r(i,t-1)} + \cdots + \gamma_k p_{r(i,t-k)} + \mathbf{x}_{it}'\boldsymbol{\beta} + \alpha_i + \varepsilon_{it}, \quad t = k+1, \ldots, T \tag{13}$$

where α_i is assumed to be a fixed effect here. The possible reasons of correlation in p_r overtime are (i) true state dependence (direct correlation through past p_r), (ii) observed heterogeneity (through observables $\mathbf{x}$), and (iii) unobserved heterogeneity (through the time-invariant individual effect α_i.) When lagged regressors are introduced, within estimator is

[7] See Cameron and Trivedi (2009) for detailed explanation.

inconsistent.

We adopt first-difference (FD) model with appropriate lags of $p_{r(it)}$ as instruments to obtain consistent parameter estimates. The model is

$$\Delta p_{r(it)} = \gamma_1 \Delta p_{r(i,t-1)} + \cdots + \gamma_k \Delta p_{r(i,t-k)} + \Delta \mathbf{x}'_{it} \boldsymbol{\beta} + \Delta \varepsilon_{it}\ , \quad t = k+1,\ \ldots,\ T \tag{14}$$

and OLS estimator here becomes inconsistent parameter because the regressor $\Delta p_{r(i,t-1)} = p_{r(i,t-1)} - p_{r(i,t-2)}$ is correlated with the error $\Delta \varepsilon_{it} = \varepsilon_{it} - \varepsilon_{i,t-1}$, even if ε_{it} are serially uncorrelated. As proposed by Anderson and Hsiao (1981), we can use $\Delta p_{r(i,t-2)}$, which are uncorrelated with $\Delta \varepsilon_{it}$, as an instrument for $\Delta p_{r(i,t-1)}$. Alleno and Bond (1991) propose tests of the key assumption that ε_{it} are serially uncorrelated. Moreover, Arellano and Bover (1995) and Blundell and Bond (1998) suggest using additional moment conditions to obtain an estimator with improved precision and better finite-sample properties. We use this Arellano-Bover and Blundell-Bond estimator, setting the real oil price in each oil-importing country as dependent variables.

5.1 Data

Among various resources, we chose petroleum because the data constraint is relatively weak. Dependent variables are calculated from the futures price of West Texas Intermediates (WTI). We derive real WTI (WTI deflated by U.S. consumer price index) using purchasing power parity (PPP) and indexed to make the prices at year 2000 equal to 100. Another candidate for the price variable is the import price of petroleum. The data of import prices can be extracted easily. However, we adopt the real price of oil faced by each country because we should take into consideration domestic production of each country.

We selected four explanatory variables, including one variable that represent the governments' natural resource strategy. Since there is no perfect variable that directly stands for governments' strategy, a proxy variable is set.

Table 1 Source of Data

Real price of oil in each country $RIOilP\_PPP_{it}$	WTI: *IEA World Oil Statistics 2011*, Crude oil, spot price. CPI of the U.S.: U.S. Bureau of Labor Statistics, U.S. Department of Labor. Consumer Price Index--All Urban Consumers, U.S. All items, 1982-84=100, - *CUUR0000SA0* downloaded from http://data.bls.gov PPP: Alan Heston, Robert Summers and Bettina Aten, *Penn World Table Version 7.1*, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, July 2012. Purchasing Power Parity, *ppp*.
Oil production per capita in each country $OilProdpc_{it}$	Production of oil: *IEA World Oil Statistics 2011* Population: *Penn World Table Version 7.1*, Population, *pop*
Proxy of natural resource strategy -- Military expenditure per capita $RMilpc_{it}$	Military expenditure: T*he SIPRI Military Expenditure Database*, Military expenditure by country in 2010 constant US dollars, 1988-2010, http://milexdata.sipri.org. Population: *Penn World Table Version 7.1*, Population, *pop*
World oil demand $WOilD_t$	Demand for oil and oil products: *World Oil Statistics 2011*, Sum of refined products - ethane, LPG, naphtha, motor gasoline, aviation gasoline, jet gasoline, jet kerosene, gas/diesel oil, other kerosene, residual fuel oil, and other products. *DTOTOIL*. Demand refers to net deliveries (including refinery fuel, international marine bunkers and international aviation bunkers).
Stocks of oil in the United States $OilS\_US_t$	Stocks : *EIA*, U.S. Ending Stocks of Crude Oil (Million Barrels)
Instrumental Variables Number of patents $PatT_{it}$ Real GDP per capita	Patents: OECD Patent database downloaded from http://www.oecd.org/sti/innovationinsciencetechnologyandindustry/oecdpatentdatabases.htm Real GDP per capita : PPP Converted GDP Per Capita (Laspeyres), derived from growth rates of consumption,

$rgdpl_{it}$	government consumption and investment, at 2005 constant prices

The first variable is the proxy, and it is each country's military expenditure (in 2010 constant dollars) per capita. It closely relates to resource nationalism, and also, the importance of national defense increases for each country as it exploits and drills more resources, since resources are sometimes exploited around national border, such as the Exclusive Economic Zone.[8] The second variable is oil production per capita, $OilProdpc_{it}$. Due to the data constraint, the production includes natural gas liquids (NGL). The third is the worldwide oil and oil product demand, $WOilD_t$, and the fourth is U.S. Stocks of Crude Oil, $OilS\_US_t$. We used number of patents seemingly relating to resource industry, $PatT_{it}$, and real GDP per capita $rgdpl_{it}$ as instrumental variables other than lagged dependent variables (Table 1).

The "oil importing country" is defined as the country that net import is positive in the 90% of the years observed. Among the 174 countries that give oil price data from 1988 to 2010, oil-importing countries are 124, but due to the lack of patent data, we make the estimation for 62 countries.

Oil price is known to have serial correlations. To check them, we tried OLS including the same independent variables used in dynamic panel estimation, except for lagged independent variables, and metered the depth of the lag. The result in Table 3 shows that relatively strong correlations exist in one to four lags, and we decided to include from one to four years lagged dependent variables in the equation.

We formulate the equation with lagged independent variables and oil production being

[8] It is possible that military expenditure represents political instability. However, in terms of nationalism, military expenditure and expenditure for acquisition of foreign resources can be considered to have common trend. Thus, we adopt this variable in this estimation.

endogenous variables; and military expenditure, world oil demand and U.S. stock change as exogenous variables. Each country's oil demand that could be one of the determinants of each country's oil price theoretically, was actually correlated to the price, and including it to the estimation only made the coefficient insignificant.

Table 2 Descriptive Statistics of Data for All Oil Importing Countries

Variable		Mean	Std. Dev.	Min	Max	Observations
lnIROil_PPP	overall	4.314234	1.612563	-24.49759	7.224044	N = 2586
	between		0.5783334	0.765854	4.913124	n = 115
	within		1.50752	-20.94921	10.40795	T-bar = 22.487
lnWOilD	overall	15.07035	0.0926277	14.93837	15.21176	N = 2845
	between		0.0014858	15.06429	15.0707	n = 124
	within		0.0926163	14.93802	15.21141	T-bar = 22.9435
lnOilProdpc	overall	3.345799	2.188703	-2.224929	7.528642	N = 1027
	between		2.167125	-1.877598	7.242876	n = 54
	within		0.6290663	-0.131212	6.171933	T-bar = 19.0185
D.lnOilUS	overall	0.0079515	0.0317326	-0.051941	0.0578966	N = 2721
	between		2.25E-06	0.0079509	0.0079606	n = 124
	within		0.0317326	-0.05195	0.0578971	T-bar = 21.9435
lnRMilpc	overall	4.093995	1.827341	-0.923423	8.074403	N = 2198
	between		1.812494	0.0363623	7.753311	n = 110
	within		0.3319757	2.340071	5.931787	T-bar = 19.9818
lnrgdpl	overall	8.355375	1.408044	5.080144	11.29247	N = 2586
	between		1.384714	5.951696	10.98969	n = 115
	within		0.2326405	6.580455	9.804125	T-bar = 22.487
lnPatTpc	overall	8.313723	2.653945	0.0711719	13.31114	N = 1201
	between		2.474404	1.91264	12.317	n = 65
	within		1.133288	3.441618	11.01347	T = 18.4769

Note: Variable x_{it} is decomposed into between ($\bar{x}_i$) and within ($x_{it} - \bar{x}_i + \tilde{x}$, the global mean $\tilde{x}$ being added back in make results comparable).

Table 3 Serial Correlations in Estimating Real Oil Price

lag 1	0.936
lag 2	0.828
lag 3	0.716
lag 4	0.585
lag 5	0.430
lag 6	0.270

5.2 Estimation Result

In order to seize general feature and to compare with the dynamic panel estimators, we present the pooled OLS estimators of (13) in Table 4.

$$
\begin{aligned}
\ln RIOilP\_PPP_{i,t} = {} & \gamma_1 \ln RIOilP\_PPP_{i,t-1} + \gamma_2 \ln RIOilP\_PPP_{i,t-2} + \gamma_3 \ln RIOilP\_PPP_{i,t-3} + \gamma_4 \ln RIOilP\_PPP_{i,t-4} \\
& + \beta_1 \ln Oil\,Prodpc_{i,t} + \beta_2 \ln RMilpc_{i,t} + \beta_3 \ln RMilpc_{i,t-1} + \beta_4 \ln WOild_t + \beta_5 \Delta \ln OilS\_US_t + \varepsilon_{it} \\
& t = 5, \cdots, T \qquad (13)
\end{aligned}
$$

Table 4 Pooled OLS Estimator

Dependent variable : *lnIROilP_PPP*	lag	Coefficient	Standard Err.	z	P>|z|	[95% Conf. Interval]	
lnIROilP_PPP	1	0.8818889	0.0445473	19.80	0.000	0.7932702	0.9705076
	2	-0.2920933	0.0397385	-7.35	0.000	-0.3711459	-0.2130407
	3	0.2457658	0.0307912	7.98	0.000	0.1845122	0.3070193
	4	-0.0946225	0.0185077	-5.11	0.000	-0.1314401	-0.0578049
lnOilProdpc	0	0.0052792	0.0032389	1.63	0.107	-0.0011639	0.0117223
lnRMilpc	0	0.0192944	0.0292457	0.66	0.511	-0.0388846	0.0774734
	1	-0.0310925	0.0294557	-1.06	0.294	-0.0896892	0.0275042
lnWOilD	0	2.5765980	0.1459008	17.66	0.000	2.2863550	2.8668410
lnOilS_US	(0-1)	-1.8673750	0.1164717	-16.03	0.000	-2.0990750	-1.6356760
Constant		-37.572920	2.102005	-17.87	0.000	-41.75448	-33.39136

N=1,408 R^2=0.9344

Arellano-Bover and Blundell-Bond estimator is formulated as (14). Patents and GDP are instrumental variables and not directly shown in (14).

$$\begin{aligned}\Delta \ln RIOilP\_PPP_{i,t} &= \gamma_1 \Delta \ln RIOilP\_PPP_{i,t-1} + \gamma_2 \Delta \ln RIOilP\_PPP_{i,t-2} + \gamma_3 \Delta \ln RIOilP\_PPP_{i,t-3} + \gamma_4 \Delta \ln RIOilP\_PPP_{i,t-4} \\ &+ \beta_1 \Delta \ln Oil\,Prodpc_{i,t} + \beta_2 \Delta \ln RMilpc_{i,t} + \beta_3 \Delta \ln RMilpc_{i,t-1} + \beta_4 \Delta \ln WOild_t + \beta_5 \Delta^2 \ln OilS\_US_t + \Delta\varepsilon_{it} \\ & t = 5, \cdots, T \qquad (14)\end{aligned}$$

Here, robust cluster variance estimator $\mathbf{V_{cluster}} = \left(\mathbf{X}'\mathbf{X}\right)^{-1} * \sum_{j=1}^{n_c} \mathbf{u_j}' * \mathbf{u_j} * \left(\mathbf{X}'\mathbf{X}\right)^{-1}$, where $\mathbf{u_j} = \sum_{j_{\text{cluster}}} \mathbf{e_i} * \mathbf{x_i}$ (n_C is total number of the cluster, and $\mathbf{e}_i$ is the residual) is shown in Table 5.

We conduct two tests to the result above. One is to test that the error be serially uncorrelated, named the Arellano-Bond test for zero autocorrelation in first-differenced errors. When $\varepsilon_{i,t}$ is serially uncorrelated, $\Delta\varepsilon_{i,t}$ are correlated only with $\Delta\varepsilon_{i,t-1}$, and not correlated with $\Delta\varepsilon_{i,t-j}$ ($j \geq 2$). The result is shown in Table 6.

The other is a test of overidentifying restrictions, which are also called Hansen's test, Sargan's test and Hansen-Sargan test. When $p > 0.05$, we do not reject the null hypothesis to find that the overidentifying restriction is valid. In our case, as shown in Table 7, we conclude that the overidentifying restriction is valid and the population moment conditions are correct.

Our theoretical analysis in the previous sections concluded that resource importing countries' increase in resource interest and exploitation leads to their resource price increase under certain conditions. Considering military expenditure solely as a proxy for the resource strategy that closely relates to the nationalism, we estimated the effect of the strategy change on resource price. Domestic production may not be a good proxy because foreign company can raise production within the country, or domestic company can exploit more in foreign countries.

Table 5 Arellano-Bover and Blundell-Bond Estimator

System dynamic panel-data estimation (Two step results)

Number of obs		=	1,045
Number of groups		=	62
Obs per group:	min	=	6
	avg	=	16.85484
	max	=	18
Number of instruments		=	77
Wald chi2 (9)		=	4843.34
Prob > chi2		=	0.0000

Dependent variable: *lnIROilP_PPP*

	lag	Coefficient	WC-robust Standard Err.	z	P>|z|	[95% Conf. Interval]	
lnIROilP_PPP	1	0.849891	0.083039	10.23	0.000	0.6871372	1.0126450
	2	-0.531903	0.068013	-7.82	0.000	-0.6652065	-0.3986002
	3	0.533857	0.063665	8.39	0.000	0.4090755	0.6586384
	4	-0.199792	0.033402	-5.98	0.000	-0.2652590	-0.1343257
lnOilProdpc	1	-0.083807	0.032779	-2.56	0.011	-0.1480523	-0.0195613
lnRMilpc	0	0.147496	0.089472	1.65	0.099	-0.0278673	0.3228582
	1	-0.219982	0.082910	-2.65	0.008	-0.3824826	-0.0574818
lnWOilD	0	3.307630	0.388343	8.52	0.000	2.546492	4.068768
lnOilS_US	(0-1)	-0.980529	0.201798	-4.86	0.000	-1.3760450	-0.5850131
Constant		-47.713120	5.683661	-8.39	0.000	-58.85289	-36.57335

Instruments for differenced equation

GMM-type: L(2/2).lnIROilP_PPP

Standard: D.lnOilProdpc LD.lnOilProdpc D.lnRMilpc LD.lnRMilpc D2.lnOilS_US

D.lnWOilD lnrgdpl L.lnrgdpl lnPatTpc L.lnPatTpc

Instruments for level equation

GMM-type: LD.lnIROilP_PPP

Standard: _cons

Table 6 Arellano-Bond Test for Zero Autocorrelation in First-Differenced Errors

H0: No autocorrelation

Order	z	Prob > z
1	-3.8763	0.0001
2	-0.20058	0.8410
3	1.3412	0.1798
4	-0.03888	0.9690
5	-1.3593	0.1740

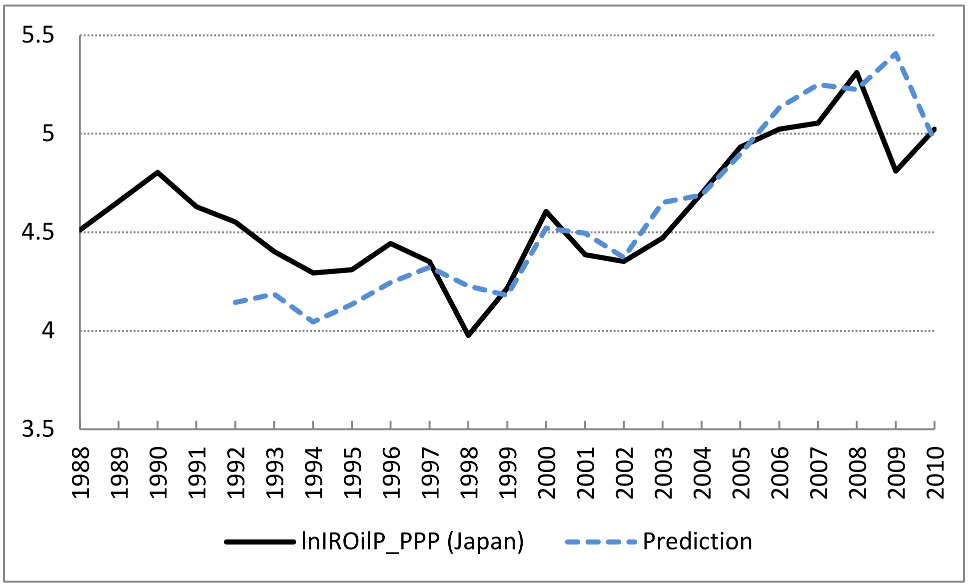
Table 7 Sargan Test of Overidentifying Restrictions

$\chi^2(67)$	= 61.91848
Prob > χ^2	= 0.6527

The result tells us that 1 percentage point (pp) rise in military expenditure from a year ago to this year leads to 0.15 pps increase in the oil price, whereas 1 pp rise in the expenditure from two years ago to a year ago let the price 0.21 pps. One ppt rise in military expenditure for two consecutive years leads to 0.06 ppt decline in the price. Therefore, we find that increase in military expenditure, i.e., strengthening of resource strategy raise the domestic oil price in the first year, but lower it in the second year. This supports our Proposition 1, and the assumptions there are general for importing countries.

To confirm if the dynamic panel result applies well to Japan, we plot in Figure 7 actual Japanese domestic oil price and estimated price. These two lines are not diverted much, and the result in Proposition 1 could be applied to Japan.

Figure 7 Japan's actual oil price and prediction



6. Conclusion

This paper examined the effect of acquisition of mines by final goods producers located in resource importing countries on the present and future resource prices. We investigated the price changes both theoretically and empirically. Theoretically, we found that an increase in acquisition of mines may increase the resource price in either the present or future period. Strategic behavior of the resource extraction firm, demand structure for final goods, and the extraction costs of final goods producers play key roles in determining the price change.

Our empirical result supports one of our theoretical results: an increase in acquisition of mines increases the present oil price and decreases the future oil price. In terms of policy implication, if the degree of price decrease in the second period is large, the policy which supports the acquisition activities of firms located in the domestic country is justified, because consumer surplus increases sufficiently in the long run.

If the data which directly represent the government's acquisition strategy is created, the price variation is estimated more precisely.

Appendix. Proof of Proposition 2

From (4), it is obtained that

$$\frac{d^2\Pi_f}{dp_{r,1}^2} = \left(2-(1-\delta)C''_{f,1}\hat{R}'_1\right)\hat{R}'_1 + \left(p_{r,1}-(1-\delta)C'_{f,1}-\delta C'_{f,2}\right)\hat{R}''_1 - \delta C''_{f,2}\hat{R}''^2_1\left(1+\frac{\partial\hat{R}_2}{\partial p_{r,2}}\frac{\partial\hat{p}_{r,2}}{\partial R_1}\right) \quad \text{(A.1)}$$

Moreover, from (7), the supply shifting effect in (8) can be rewritten as follows.

$$\frac{\partial\hat{p}_{r,2}}{\partial I}\cdot\frac{\delta C''_{f,2}\hat{R}'^2_1}{\Lambda}\cdot\left(\frac{\partial\hat{R}_2}{\partial p_{r,2}}\frac{\partial\hat{p}_{r,2}}{\partial R_1}-\frac{\partial\hat{M}_h/\partial I\cdot\partial\hat{p}_{r,2}/\partial R_1}{\partial\hat{p}_{r,2}/\partial I}\right) \quad \text{(A.2)}$$

Moreover, from (5) and (9), it is obtained that

$$-\frac{\partial\hat{M}_h/\partial I\cdot\partial\hat{p}_{r,2}/\partial R_1}{\partial\hat{p}_{r,2}/\partial I} = \frac{C''_{f,2}\,\partial\hat{R}_2/\partial p_{r,2}\cdot\partial\hat{M}_h/\partial I}{-\partial\hat{M}_h/\partial I + C''_{f,2}\,\partial\hat{R}_2/\partial p_{r,2}\cdot\partial\hat{M}_h/\partial I-\left(\hat{p}_{r,2}-C'_{f,2}\right)\partial^2\hat{M}_h/\partial I\partial p_{r,2}} \quad \text{(A.3)}$$

Therefore, when $\partial^2\hat{M}_h/\partial I\,\partial p_{r,2} > 0$, it holds that

$$0 < -\frac{\partial\hat{M}_h/\partial I\cdot\partial\hat{p}_{r,2}/\partial R_1}{\partial\hat{p}_{r,2}/\partial I} < 1$$

Thus, if $d\hat{R}_2/dI < 0$,

$$0 < \frac{\partial\hat{R}_2}{\partial p_{r,2}}\frac{\partial\hat{p}_{r,2}}{\partial R_1}-\frac{\partial\hat{M}_h/\partial I\cdot\partial\hat{p}_{r,2}/\partial R_1}{\partial\hat{p}_{r,2}/\partial I} < 1+\frac{\partial\hat{R}_2}{\partial p_{r,2}}\frac{\partial\hat{p}_{r,2}}{\partial R_1} \quad \text{(A.4)}$$

Holds. From (A.1)through (A.4), if $R''_1 < 0$, $\partial^2\hat{M}_h/\partial I\,\partial p_{r,2} > 0$, and $d\hat{R}_2/dI < 0$ hold, the absolute value of (A.2) is smaller than that of the direct price effect ($\partial\hat{p}_{r,2}/\partial I$).

On the other hand, if $R''_1 > 0$,

$$\frac{\delta C''_{f,2}\hat{R}'^2_1}{\Lambda}\cdot\left(\frac{\partial\hat{R}_2}{\partial p_{r,2}}\frac{\partial\hat{p}_{r,2}}{\partial R_1}-\frac{\partial\hat{M}_h/\partial I\cdot\partial\hat{p}_{r,2}/\partial R_1}{\partial\hat{p}_{r,2}/\partial I}\right)$$

may be greater than one. Thus, the supply shifting effect may be greater than the direct price effect.

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