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Monetization of Public Goods Provision: A possible solution for the free-rider problem

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The government makes a particular public good the specie of money and commits itself to buy the public good at a predetermined nominal price and adjust money supply so that the ratio between the public good reserve and money supply equals a predetermined reserve ratio. In a two-country model, in which one country issues international currency and the other issues domestic currency, we show that if the government that issues the international currency adopts a monetization policy, it can attain both the optimal level of public goods provision and equal cost sharing for the public goods provision between the two countries by choosing the nominal price of the public good and the reserve ratio appropriately. In this case, the international free-rider problem is completely resolved.

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– A Possible Solution for the Free-Rider Problem –

(Incomplete and preliminary)

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May 22, 2008

Abstract

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1 Introduction

In this short paper we propose a new method of public goods provision, monetization, and show that monetization can possibly resolve the international free-rider problem.

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We show that monetization can attain the socially optimal level of public goods provision, and therefore it is at least as good as the existing methods for the public goods provision, such as quantity regulation and price regulation (taxation). When we consider the application of various methods of a public goods provision to global climate change policy, what is crucial is the free-rider problem between countries that reduce emissions of greenhouse gases and those that do not.[1] (Public goods in this context are, for example, forests that absorb carbon dioxide.) We argue that if the country that issues international currency adopts monetization of the public goods, the international free-rider problem can be mitigated. In the simple two-country setting that we describe below, the free-rider problem is completely resolved.

Monetization in this paper[2] is the following policy regime: The government sets a particular public good as the specie of money and sets money supply proportional to the reserve of the public good in the central bank; and the government commits itself to buy the public good at a prespecified price.[3] This monetization scheme is therefore a variant of commodity-reserve currency (see Friedman 1951, Luke 1975, Barro 1979, and references therein).

To illustrate the intuition of monetization, let us consider a closed economy, in which money demand is determined by $PY = M^d V$, where P is the nominal price, Y is output, i.e., the gross domestic product, V is the velocity of money, and M^d is money demand.[4]

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[1] Aldy, Barrett, and Stavins (2003) survey the Kyoto protocol and 13 alternative policy architechtures for reduction of greenhouse gas emissions. They conclude that almost all of them are undermined by the international free-rider problem.

[2] Kobayashi (2008) proposes a different method of monetization, in which the public good itself is circulated as a means of payment in the economy.

[3] Among the 13 policy architectures surveyed in Aldy et al. (2003), Bradford (2002) is the closest to the scheme of monetization in this paper. Bradford's scheme is that a new international organization, which is financed by contributions from the international community, buys emission permits from countries at a prespecified price.

[4] In the formal model in Section 2, we use a variant of the cash-in-advance model (Lucas 1980; Lucas and Stokey 1983, 1987) to induce money demand: Agents need to hold a cash reserve of international currency to purchase tradable goods, while they need a cash reserve of domestic currency to purchase domestic goods.

Suppose that the government adopts the following money supply rule: $M^s = \theta R s$, where s is the reserve of the public good, i.e., specie, in the central bank, R is the prespecified price of s, θ is the inverse of the reserve ratio, and M^s is money supply. If the public good is produced competitively in the market, the price must equal the marginal cost. Therefore, $R/P = c'(s)$, where $c(s)$ is the cost for producing s in terms of the consumer goods. The equilibrium condition that money supply equals money demand implies $Y/V = \theta c'(s)s$. On the premise that Y/V is exogenously given for the government, the last condition shows that the government can make s at a targeted value by setting θ appropriately. If we extend the model into a dynamic setting, it is easily shown that the government can set the seigniorage revenue at a targeted level by setting R appropriately. Control over the amount of seigniorage is crucial in resolving the free-rider problem in a stylized two-country model in the following section.

2 Model

There exist two countries: Country A and Country B. Each country is populated with a continuum of identical consumers whose measure is normalized to one. Each country has a government that can freely issue any amount of the national currency within the country and give it to domestic consumers as a lump-sum subsidy: Government A (B) issues Currency A (B). In this economy, time is discrete and continues from zero to infinity: $t = 0, 1, 2, \cdots, \infty$. Consumers in both countries live indefinitely and are endowed with y units of the domestic goods and z units of tradable goods at each date t. The consumers in Country A (B), henceforth Consumer A (B), have identical preferences:$\sum_{t=0}^{\infty} \beta^t (\ln d_t + \ln c_t)$, where β $(0 < \beta < 1)$ is the time discount factor, d_t is consumption of the domestic goods at date t, and c_t is consumption of tradable goods (international goods) at date t. We will denote a variable for Consumer B by putting an asterisk on it. Therefore, we denote Consumer B's consumptions of the domestic goods and of tradable goods by d_t^* and c_t^*, respectively. The domestic goods are traded only within each country, and the total supply of the domestic goods in each country at each date is y. The tradable goods are traded internationally, and the total world supply of tradable goods is $2z$, which is (unequally) divided between Consumers A and B.

We assume that a public good, s_t, can be produced from $c(s_t)$ units of tradable goods, where $c(s_t)$ is the cost function that satisfies $c'(s) > 0$ and $c''(s) > 0$. The public good has an external effect that the endowment of tradable goods increases by an amount equal to the social level of the public goods provision. Suppose that Consumer A (B) produces s_t (s_t^*) units of the public good. In this case, Consumer A's (B's) endowment of tradable goods becomes $z - c(s_t) + \overline{s}_t$ ($z - c(s_t^*) + \overline{s}_t$), where $\overline{s}_t$ is the social level of the public goods, which is perceived by Consumer A (B) as exogenously given, whereas $\overline{s}_t = (s_t + s_t^*)/2$ in equilibrium. All these features of the public good are assumed for simplicity of calculation. Since the world supply of tradable goods is $2z + 2\overline{s_t} - c(s_t) - c(s_t^*) = 2z + s_t + s_t^* - c(s_t) - c(s_t^*)$, it is obvious that an efficient level of the public goods provision is the solution to the problem: $\max_{s,s^*} s + s^* - c(s) - c(s^*)$, which is determined by

$$c'(s_t) = c'(s_t^*) = 1. \tag{1}$$

We assume that Currency A is the international currency that can be used for payments in international trade. We denote the amount of Currency A that Consumer B set aside at date $t-1$ by M_t^*. We assume that Government A can freely set the sequence $\{X_t\}_{t=0}^{\infty}$, where X_t is the cash injection of Currency A to Consumer A. We also assume that Government B can freely set the sequence $\{Y_t^*\}_{t=0}^{\infty}$, where Y_t^* is the cash injection of Currency B to Consumer B.

2.1 Economies without monetization

We first consider the case where the governments adopt no policy for the public goods provision. The representative consumer's problems for both countries are written as follows. The problem for Consumer A is

$$\max_{d_t, c_t, s_t, M_{t+1}} \sum_{t=0}^{\infty} \beta^t (\ln d_t + \ln c_t)$$

subject to

$$P_t d_t + Q_t c_t + M_{t+1} \leq P_t y + Q_t\{z + \overline{s}_t - c(s_t)\} + M_t + X_t, \tag{2}$$

$$P_t d_t + Q_t c_t \leq M_t + X_t, \tag{3}$$

while the problem for Consumer B is

$$\max_{d_t^*, c_t^*, s_t^*, M_{t+1}^*, N_{t+1}^*} \sum_{t=0}^{\infty} \beta^t (\ln d_t^* + \ln c_t^*)$$

subject to

$$e_t P_t^* d_t^* + Q_t c_t^* + M_{t+1}^* + e_t N_{t+1}^* \leq e_t P_t^* y + Q_t\{z + \overline{s}_t - c(s_t^*)\} + M_t^* + e_t(N_t^* + Y_t^*), \tag{4}$$

$$Q_t c_t^* \leq M_t^*, \tag{5}$$

$$P_t^* d_t^* \leq N_t^* + Y_t^*, \tag{6}$$

where P_t (P_t^*) is the price of domestic goods in Country A (B) in terms of Currency A (B), d_t (d_t^*) is consumption of domestic goods by Consumer A (B), Q_t is the (international) price of tradable goods in terms of Currency A, c_t (c_t^*) is consumption of the tradable goods by Consumer A (B), M_{t+1} (M_{t+1}^*) is cash of Currency A held by Consumer A (B), N_{t+1}^* is cash of Currency B held by Consumer B, and e_t is the exchange rate of Currency B in terms of Currency A.

The equilibrium conditions are

$$d_t = d_t^* = y, \tag{7}$$

$$c_t + c_t^* = 2z + 2\overline{s}_t - c(s_t) - c(s_t^*), \tag{8}$$

$$\overline{s}_t = (s_t + s_t^*)/2, \tag{9}$$

$$M_{t+1} + M_{t+1}^* = M_t + M_t^* + X_t, \tag{10}$$

$$N_{t+1}^* = N_t^* + Y_t^*. \tag{11}$$

Denoting the Lagrange multipliers for (2), (3), (4), (5), and (6) by λ_t, η_t, λ_t^*, η_t^*, and ξ_t^* respectively, the first order conditions (FOCs) for Consumer A except for those with respect to s_t are

$$\frac{\beta^t}{d_t} = (\lambda_t + \eta_t)P_t, \tag{12}$$

$$\frac{\beta^t}{c_t} = (\lambda_t + \eta_t)Q_t, \tag{13}$$

$$\lambda_t = \lambda_{t+1} + \eta_{t+1}, \tag{14}$$

while those for Consumer B except for those with respect to s_t^* are $\frac{\beta^t}{d_t^*} = (\lambda_t^* + \xi_t^*)e_t P_t^*$, $\frac{\beta^t}{c_t^*} = (\lambda_t^* + \eta_t^*)Q_t$, $\quad \lambda_t^* = \lambda_{t+1}^* + \eta_{t+1}^*$, $\quad e_t\lambda_t^* = e_{t+1}(\lambda_{t+1}^* + \xi_{t+1}^*)$. Since $\overline{s}_t$ is exogenous for both Consumers A and B, it is obvious that

$$s_t = s_t^* = 0. \tag{15}$$

Note that since Currency B is relevant only to the domestic goods in Country B, P_t^* is determined independently from international trade and e_t is determined so that P_t^* and other variables satisfy the FOCs for Consumer B. Equations (12), (13), and (3) imply

$$P_t d_t = Q_t c_t = \frac{1}{2}(M_t + X_t). \tag{16}$$

In a steady-state equilibrium where money supplies do not change, i.e., $X_t = Y_t^* = 0$, the equilibrium outcomes are $M = 2M^*$, $Pd = Qc = Qc^* = M^*$, $d = d^* = y$, and $c = c^* = z$. This competitive equilibrium is not socially efficient, since the efficiency is attained when $s_t = s_t^* = s^o$, where s^o is determined by $c'(s^o) = 1$. If the governments of both countries introduce regulation such that $s_t = s_t^* = s^o$, the efficiency (and equity) is attained. If Government A introduces regulation such that $s_t = s^o$ and Government B does not, Country B becomes a free-rider since Consumer B's endowment of tradable goods increases to $z + \overline{s}_t = z + \frac{s^o}{2}$, while Consumer B pays no cost for the public goods provision.

2.2 Monetization by International Currency Issuer

Next, we consider the case where Government A adopts the policy scheme of monetization of public goods provision. We will show that Government A can make $s_t = s_t^* = s^o$ and $c_t = c_t^*$, while the first condition is for social efficiency and the second is for no free-rider.

We assume that Government A sets the public good as the specie of Currency A and commits itself to buying the public good at the nominal price R_t and setting the total money supply of Currency A at the end of period t at $\theta_t R_t s_t$, where s_t is the reserve in the central bank and θ_t is the inverse of the reserve ratio. R_t and θ_t are the policy instruments and Government A chooses the values of these instruments to pursue its policy objectives. Note that Government A pays $R_t s_t$ with cash of Currency A when it buys s_t from Consumers A and B in the international market. Under this policy scheme, the problem for Consumer A becomes

$$\max_{d_t, c_t, s_t, M_{t+1}} \sum_{t=0}^{\infty} \beta^t (\ln d_t + \ln c_t)$$

subject to

$$P_t d_t + Q_t c_t + M_{t+1} \leq P_t y + Q_t \{z + \overline{s}_t - c(s_t)\} + R_t s_t + M_t + X_t, \tag{17}$$

$$P_t d_t + Q_t c_t \leq M_t + R_t s_t + X_t, \tag{18}$$

while the problem for Consumer B is

$$\max_{d_t^*, c_t^*, s_t^*, M_{t+1}^*, N_{t+1}^*} \sum_{t=0}^{\infty} \beta^t (\ln d_t^* + \ln c_t^*)$$

subject to

$$e_t P_t^* d_t^* + Q_t c_t^* + M_{t+1}^* + e_t N_{t+1}^* \leq e_t P_t^* y + Q_t \{z + \overline{s}_t - c(s_t^*)\} + R_t s_t^* + M_t^* + e_t (N_t^* + Y_t^*), \tag{19}$$

$$Q_t c_t^* \leq M_t^* + R_t s_t^*, \tag{20}$$

$$P_t^* d_t^* \leq N_t^* + Y_t^*. \tag{21}$$

The equilibrium conditions are (7)–(9), (11), with the following law of money evolution instead of (10):

$$M_{t+1} + M_{t+1}^* = M_t + M_t^* + R_t (s_t + s_t^*) + X_t, \tag{22}$$

and the following money supply rule:

$$M_{t+1} + M_{t+1}^* = \theta_t R_t (s_t + s_t^*). \tag{23}$$

Competition in the public goods production implies

$$R_t/Q_t = c'(s_t) = c'(s_t^*), \tag{24}$$

which directly implies that $s_t = s_t^*$ in equilibrium.

Control of the public goods provision and consumptions by policy tools: It is shown below that Government A can control $s_t(= s_t^*)$ and c_t/c_t^* by setting R_t and θ_t appropriately. Equations (22) and (23) imply

$$X_t = 2(\theta_t - 1)R_t s_t - M_t - M_t^*. \tag{25}$$

The FOCs and CIA constraint, (18), imply $P_t d_t = Q_t c_t = (M_t + R_t s_t + X_t)/2$. This condition and (20) imply

$$\frac{c_t}{c_t^*} = \frac{(M_t + R_t s_t + X_t)/2}{M_t^* + R_t s_t}. \tag{26}$$

Equations (25) and (26) imply

$$\frac{c_t}{c_t^*} = \frac{(2\theta_t R_t s_t - R_t s_t - M_t^*)/2}{M_t^* + R_t s_t}. \tag{27}$$

The CIA constraints, (18) and (20), and the global resource constraint for tradable goods imply

$$Q_t\{2z + 2s_t - 2c(s_t)\} = M_t^* + R_t s_t + (M_t + R_t s_t + X_t)/2. \tag{28}$$

Equations (24), (25), and (28) imply

$$\frac{R_t}{c'(s_t)}\{z + s_t - c(s_t)\} = \frac{1}{4}\{(2\theta_t + 1)R_t s_t + M_t^*\}. \tag{29}$$

Given $\{M_t, M_t^*, R_t, \theta_t\}$, equation (29) determines $s_t(= s_t^*)$ and equation (27) determines c_t/c_t^*. See Appendix for other variables.

Optimal policy: The conditions for optimality, $s_t = s^o$ and $c_t/c_t^* = 1$, determines the optimal values of $R_t = R_t^o$ and $\theta_t = \theta^o$. Substituting the optimal values of s_t and

c_t/c_t^* for equations (27) and (29), we get

$$R_t^o = \frac{M_t^*}{z - c(s^o)}, \tag{30}$$

$$\theta^o = 3\left(\frac{z - c(s^o)}{s^o} + 1\right). \tag{31}$$

Under these optimal values of the policy tools, Consumers A and B consume the same amounts of tradable goods:

$$c_t = c_t^* = z + s^o - c(s^o). \tag{32}$$

This result shows that the cost of the public goods is equally shared by Consumers A and B. The international free-rider problem is completely resolved. The intuitive explanation for the resolution of the free-rider problem is as follows: Government A can obtain international seigniorage revenue from Consumer B because it can give X_t units of cash injection to Consumer A selectively; and by setting R_t and θ_t appropriately, it can make the amount of seigniorage as large as half of the total cost of public goods provision. An apparent disadvantage of this solution to the free-rider problem is that Government A cannot freely adjust the inflation rate in Country A when it sets the optimal policy, (30) and (31). Equations (30) and (37) in Appendix imply that the gross inflation rate $\pi_t = P_{t+1}/P_t = Q_{t+1}/Q_t$ under the optimal policy (R_t^o and θ^o) is determined by

$$\pi_t = 1 + \frac{s^o}{z - c(s^o)}. \tag{33}$$

Therefore, Government A loses freedom in the conduct of monetary policy when it solves the international free-rider problem by monetization of public goods.[5]

Automatic Stabilizer Effect: Monetization has another feature that can be called the automatic stabilizer effect, that is, under monetization the supply of public goods

[5]The steady-state inflation rate is uniquely determined by parameters on preference and technology if the agents can store the tradable goods intertemporally. In this case, the optimal policy for Government A is to impose a once-for-all seigniorage on Country B at the time it starts the policy by a lump-sum cash injection. Introducing investment and production can change the model substantially. We need to study further on the extension of our model.

increases in response to an increase in economic activities. This is because the economic boom induces an increase in money demand, which increases the public goods in turn through the money supply rule of monetization policy. This is easily confirmed from equation (29). Suppose that z, the endowment of tradable goods, is a stochastic variable. If z at period t increases, (29) implies that s_t also increases, given that R_t and θ_t are predetermined. Concerning the global warming problem, an economic boom is associated with an increase in greenhouse gas emissions. Monetization policy will increase the supply of the public good, e.g., forests, that absorbs the greenhouse gas in response to an economic boom due to the automatic stabilizer effect.

2.3 Discussion

In monetization of the public goods provision, the government purchases the public goods in a competitive market and finances them by seigniorage revenue. Since the government that issues international currency can impose seigniorage on foreign agents and transfer the revenue to domestic agents by cash injection, this policy regime is effective to mitigate or resolve international free-riding by foreigners. It must be noted that this mechanism of monetary solution for the international free-rider problem is applicable to general methods of the public goods provision. For example, the government that issues international currency can provide the public goods by orthodox quantity regulations or price regulations and finance some of the cost by international seigniorage from foreigners by adjusting the amount of its currency. In this case the international free-rider problem can also be resolved. Moreover, if the government can arbitrarily choose the path of money supply, it can impose all costs of public goods provision on the foreigners and it can free ride on the international seigniorage revenue. In this paper, we implicitly assumed that Government A is a global social planner that cares about not only Consumer A but also Consumer B. We should note that if Governement A only cares about Consumer A, it can impose all costs on Consumer B by adjusting X_t appropriately.

3 Conclusion

We proposed a new method of public goods provision: monetization. It was shown that monetization is at least as good as existing methods of public goods provision (quantity regulation and price regulation), since it can attain a socially efficient amount of public goods. Moreover, if the country that issues the international currency adopts monetization, it can resolve the international free-rider problem, since the country can collect the cost of public goods provision as international seigniorage from other countries by appropriately adjusting the money supply. The apparent disadvantage of this solution to the free-rider problem is that the government loses the freedom to control the inflation rate: in order to resolve the free-rider problem, the government (of Country A) needs to set the money supply at a certain value, which induces suboptimal inflation in general. Exploring a method to restore the freedom of monetary policy is a topic of our future research.

Appendix

Given the initial values $\{M_0, M_0^*\}$, the policy sequence $\{R_t, \theta_t\}_{t=0}^{\infty}$ determines the economic variables in the two-country model as follows. $s_t (= s_t^*)$ is determined by (29) and c_t/c_t^* is determined by (27). The resource constraint, $c_t + c_t^* = 2\{z + s_t - c(s_t)\}$, and (27) implies that c_t^* is determined by

$$c_t^* = \frac{c'(s_t)\{(2\theta_t + 1)R_t s_t + M_t^*\}}{2R_t(1 + c_t/c_t^*)}. \tag{34}$$

Then c_t, Q_t, M_{t+1}^*, and M_{t+1} are determined by

$$c_t = (c_t/c_t^*)c_t^*, \tag{35}$$

$$Q_t = \frac{R_t}{c'(s_t)}, \tag{36}$$

$$M_{t+1}^* = Q_t\{z + s_t - c(s_t) - c_t^*\} + R_t s_t + M_t^*, \tag{37}$$

$$M_{t+1} = \frac{1}{2}\{M_t + R_t s_t + X_t\} + Q_t\{z + s_t - c(s_t)\} + R_t s_t. \tag{38}$$

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