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【Note】

Spill-in Effects of Multilateral Foreign Aid

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Abstract

We apply the standard Nash model of the voluntary provision of a pure public good to the analysis of multinational foreign aid. One of the well-known results of this model is that contributors free or cheap ride: a contributor reduces its donation if another donor increases its contribution. The purpose of this paper is to estimate the degree of such cheap riding in the contributions to multilateral foreign aid. Using the data for national contributions to multilateral foreign aid, we estimate the contribution functions for selected member countries of the Development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD). The countries examined are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, the United Kingdom and the United States. Among the nine countries, only Canada and Italy are found to cheap-ride. Germany and the United States do not exhibit statistically significant spill-in effects. The contributions by Belgium, France, Japan and the Netherlands are found to be complementary to those by other countries.

1 Introduction

Many developing countries rely on foreign aid to foster and sustain their economic welfare. If a donor is altruistic, improvements in the welfare of recipients positively affect the donor's welfare irrespective of the sources of the donation. Aid from a altruistic country thus benefits another, and such benefits are both nonrival and nonexcludable (e.g., Sandler 1992). In addition, if a prosperity of an economy hinges on the stable international economic regimes, a sound economic development of other economies should constitute collective benefits for all nations. Insofar as foreign aid contributes to the stable international regimes through fostering the economic welfare of other countries, its benefits should again be both nonrival and nonexcludable. Given these arguments, the literature argues that foreign aid can be regarded as an international public good and that the benefits of the contribution by one country 'spill in' other countries.

The 'spilt-in' benefits of foreign aid are not necessarily purely public, however. Bilateral foreign aid, which is transferred directly from a donor to a recipient, provides private as well as public benefits. Political scientists observe that nations actually use bilateral foreign aid as a policy instrument to achieve objectives that are not shared with other nations (e.g., Baldwin 1987). On the other hand, multilateral foreign aid could reasonably be regarded as a pure public good. Multilateral foreign aid is distributed to recipient nations after the contributions from donating countries are pooled in relevant international organizations. Since pooling funds makes their sources immaterial, donor nations can hardly use multinational foreign aid as an instrument for their private objectives.

We therefore apply the standard Nash model of the voluntary provision of a pure public good (e.g., Cornes and Sandler 1985) to the analysis of multinational foreign aid. One of the well-known results of this model is that contributors free or cheap ride: a contributor reduces its donation if another donor increases its contribution. The purpose of this paper is to estimate the degree of such cheap riding in the contributions to multilateral foreign aid. Using the data for national contributions to multilateral foreign aid, we estimate the contribution functions of selected member countries of the Development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD). The countries to be examied are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, the United Kingdom and the United States.

Despite a number of empirical studies on the contributions to international public good, there are few studies that specifically estimate the contributions to foreign aid. A notable exception is Dudley (1979). Our study distinguishes itself from Dudley (1979) on the following points. First, we use time-series data to estimate different contribution functions for different counties, while Dudley employs cross-section data so that he in effect assumes that each country has identical parameters. Second, while Dudley bases his empirical results on the Stone-Geary specification, we statistically examine the validity of the Stone-Geary specification against several alternatives. Third, while Dudley allows for the case where the contributions by other countries have negative externalities, we assumes that the contributions by others are perfect substitutes for own contributions for the reason stated above. In addition, we believe that assuming away the negative externalities is necessary to set out a base line interpretation for the cheap riding behavior of nations.

The organization of the paper is as follows. In the following section (Section 2), we set up a base model and discuss a variety of empirical specifications that are utilized in the literature. Section 3 then sets up a set of possible statistical models and performs a series of specification tests for each of the nine countries. Using the selected models, we estimate the contribution functions for the nine countries. Lastly, Section 4 tests the existence of the spill-in effects and calculates their extent. Among the nine countries, only Canada and Italy are found to cheap-ride. Germany and the United States do not exhibit significant spill-in effects. And, the contributions by Belgium, France, Japan and the Netherlands are found to be complementary to those by other countries.

2 Model specifications

We apply the standard model of the voluntary contributions to a public good to the empirical analysis of the national contributions to multilateral foreign aid. More specifically, our baseline theoretical model is set up as what is called 'the representative consumer model'. Suppose that there are N_i residents in country i. Those residents' welfare is represented by a single "average" consumer. His utility is a function of his own consumption of goods and services which are aggregated into c_i and foreign aid or donation D to poor countries: $u_i = u_i(c_i, D)$. Let us denote the foreign aid made by his government by d_i and those made by others by D_{-i}. Since we assume that the sources of foreign aid are irrelevant to his utility, we have $D = d_i + D_{-i}$. A country's contribution is equally shared by its resident so that the tax price the average consumer pays for a unit of foreign aid is $\tau_i \equiv 1/N_i$.

The government in country i maximizes its representative or "average" consumer's utility. If the government behaves Nash, the maximization problem it faces is formulated as:

$$(1) \qquad \max_{c_i, d_i} u_i(c_i, d_i + D_{-i}) \quad \textit{subject to } m_i = c_i + \tau_i d_i$$

where m_i is per-capita income in country i. Defining $F_i \equiv m_i + \tau_i D_{-i}$, we rewrite (1) as:

$$(1b) \qquad \max_{c_i, d_i} u_i(c_i, D) \qquad \textit{subject to } F_i = c_i + \tau_i D$$

Problem (1b) produces an uncompensated demand function for the total foreign aid:

$$(2) \qquad D = D_i(\tau_i, F_i)$$

With $D = d_i + D_{-i}$, we then obtain the demand for d_i, or the contribution to D by country i as $d_i = D_i(\tau_i, m_i + \tau_i D_{-i}) - D_{-i}$ or

$$(3) \qquad d_i = f_i(\tau_i, m_i, D_{-i}).$$

Estimation requires a specific functional form. There are three types of specifications that the literature has employed. The first is the constant elasticity (or log-linear) form. For example, Sandler and Murdoch (1990) employ a log-linear specification of (2):

$$(2.a) \qquad \ln(D) = \alpha_0 + \alpha_1 \ln(\tau_i) + \alpha_2 \ln(F_i).$$

whereas Gonzelez and Mehay (1990) specify (3) as:

$$(3.a) \qquad \ln(d_i) = \beta_0 + \beta_1 \ln(\tau_i) + \beta_2 \ln(m_i) + \beta_4 \ln(D_{-i}).$$

While these specifications are conceptually derived from an optimizing behavior, it is ad-hoc in the sense that they do not fully satisfy the theoretical restrictions of consumer preferences.[1] In addition, with the definition $D = d_i + D_{-i}$, (2.a) and (3.b) do conflict with each other.[2]

The second is a simple linear (level) specification:

$$(3.b) \qquad d_i = \beta_0 + \beta_1 \frac{1}{\tau} + \beta_2 \frac{m_i}{\tau_i} + \beta_3 D_{-i}$$

which is also called the linear expenditure system (LES) function. The LES specification is

1 Especially, adding up is rejected a priori in this specification unless income elasticity of demand is unity for all goods consumed. For the discussion on selection of functional form and as a general reference of the argument in this section, see Deaton and Muellbauer (1980) especially, chapters 1 and 3.

2 The constant elasticity specification can be theoretically consistent as Smith (1980, 1987) showed. His formulation includes an objective function $u = u(S_i, x_i)$ where S_i is security and x_i is civilian consumption, a budget constraint $m_i = p_x x_i + p_g g_i$, and a "security production function" $S = S(g_i, G_{-i})$. If the objective function is CES and the security function is Cobb-Douglas, then we can derive a log-linear demand for g_i.

utilized in a number of studies, which include Hilton and Vu (1991), McGuire (1990), McGuire and Groth (1985), Murdoch and Sandler (1982, 1984, 1985, 1986), Hansen et al. (1990) and Murdoch et al. (1991). The LES form is derived from a specific underlying preferences of the Stone-Geary type, which satisfies, with certain restriction on parameters, the properties the consumer theory dictates. That is, while this model is as simple as the log-linear specification, it is more satisfactory from the theoretical standpoint. However, one of its shortcomings is that the specification is restrictive. Its application should be restricted to the cases where its limitations are thought not to be serious.

The third is the linear logarithmic expenditure system (LLES) by Lau and Mitchell (1971). Okamura (1991) uses this specifications in his analysis of the voluntary contribution to military expenditures in the US-Japan alliance. The LLES is derived from the negative of a second order Taylor approximation to the log of an arbitrary indirect utility function $V(\boldsymbol{p}, F)$:

$$(4)\qquad -\ln V(\boldsymbol{p}, F) = \alpha_0 + \sum_k \alpha_k \ln\left[\frac{p_k}{F - \sum p_k\gamma_k}\right] + \frac{1}{2}\sum_k\sum_l \beta_{kl} \ln\left[\frac{p_k}{F - \sum p_k\gamma_k}\right]. \ln\left[\frac{p_l}{F - \sum p_l\gamma_l}\right]$$

where p_k represents the price of the k-th good, γ_k stands for the "subsistence level" of the k-th good, and F is income level. The approximation (4) is called a translog indirect utility function. The LLES requires α_k's and β_{ki} to satisfy $\sum \alpha_k = 1$, $\beta_{kl} = \beta_{lk}$, and $\sum_l \beta_{kl} = 0\ \forall\ k \neq l$ so that the theoretical properties of consumer preferences are maintained. The expenditure for the k-th good derived from (4) is:

$$(5)\qquad p_k x_k = p_k\gamma_k + (\alpha_k + \sum_k \beta_{kl} \ln(p_k))(F - \sum_k p_k\gamma_k)$$

where x_k is the consumption level of the k-th good.

The specification (5) embraces a set of preference specifications which are frequently used in applied works: (i) if all $\beta_{kl} = 0$, the specification reduces to the simple linear specification based on the Stone-Greary utility; (ii) if all $\gamma_k = 0$, it reduces to the demand function generated by the homogeneous translog indirect utility function by Christensen, Jorgenson, and Lau (1975); and (iii) if both all $\beta_{kl} = 0$ and $\gamma_k = 0$, the underlying direct utility function reduces to the Cobb-Douglas form.

With formula (5), our the maximization problem (1b) suggests the following demand function for the total foreign aid D:

$$(6)\qquad D_i = \overline{d}_i + (\alpha_i + \beta_i \cdot \ln(\tau_i))\frac{(F_i - \tau_i\overline{d}_i - \overline{c}_i)}{\tau_i}$$

where subscript i now indexes country. Note that c_i is a numeaire so that $\beta_{Dc} \cdot \ln(1) = 0$. $\overline{d}_i$ and $\overline{c}_i$ stand for γ_k of the foreign aid and that of the private consumption respectively. With $F_i = m_i + \tau_i D_{-i}$, $D = d_i + D_{-i}$ and $\tau_i = 1/N_i$, (6) yields:

$$(6a)\qquad d_i = \overline{d}_i + (\alpha_i - \beta_i \cdot \ln(N_i))(Y_i + D_{-i} - \overline{d}_i - \overline{c}_i N_i) - D_{-i}$$

where $Y_i \equiv m_i N_i$ is the aggregate income of country i. While (6a) is expressed as non-linear, we transform it into a function that is *linear in parameter,* i.e.:

(6.b)
$$d_i = (1-\alpha_i)\overline{d}_i + \alpha_i Y_i - \alpha_i \overline{c}_i N_i + (\alpha_i - 1)D_{-i}$$
$$-\beta_i \ln(N_i)(Y_i + D_{-i}) + \overline{d}_i \beta_i \ln(N_i) + \overline{c}_i \beta_i \ln(N_i) N_i$$

We will use (6.b) of the contributing function in the ensuing estimation.

3 Specification tests and estimation

The regression model we estimate is (6.b) with its parameters being unrestricted:

(7)
$$\text{AID}_{it} = \delta_{i0} + \delta_{i1}\,\text{GDP}_{it} + \delta_{i2}\,\text{POP}_{it} + \delta_{i3}\,\text{SPILL}_{it-1} + \delta_{i4}\ln(\text{POP}_{it})$$
$$+\delta_{i5}\ln(\text{POP}_{it})(\text{GDP}_{it} + \text{SPILL}_{it-1}) + \delta_{i6}\ln(\text{POP}_{it})\text{POP}_{it} + u_{it}$$

The variables in (7) correspond to those of (6.b): net official development assistance disbursements (AID) to foreign aid donation (d_i); gross domestic product (GDP) to aggregate income (Y); population (POP) to the number of residence (N_i); and spill-ins i.e., the sum of net official development assistance disbursements of the other countries in DAC (SPILL) to the sum of countries' donations other than country i (D_{-i}). u_{it} is the error term for the i-th country in year t. All the monetary values (i.e., AID, GDP, SPILL) are expressed in 1985 US dollars.

We estimate (7) on *country-by-country* basis, using the annual data for Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, the UK and the US. Depending on the availability of the data, sample size differs from country to county (see Table 1). The details of the data are provided in Table 2. Note that SPILL is lagged once to reflect a lag in adjustment. In the theoretical model, the equilibrium values of d_i and D_{-i} are endogenously determined in the simultaneous system of the contribution functions. However, the variable SPILL is lagged once and thus prede-

Table 1. Sample period

Sample period	Country
1958～1992	Belgium, Canada, France, Japan, the United Kingdom, the United States.
1958～1991	Germany: All the data are from the former Federal Republic.
1962～1992	Italy, the Netherlands

Table 2. Variable definition and sources

Variables	Definitions	Unit	Sources
AID_{it}	Net official development assistance disbursement of country i in year t; VS	million	DAC (v.y.)
GDP_{it}	1985-price gross domestic product of country i in year t; expressed in US dollar.	billion	IMF (v.y.)
POP_{it}	Population of country i in year t; (million)	million	IMF (v.y.)
SPILL_{it}	Net official development assistance disbursement by the DAC member countries other than country i in year t:	million	DAC (v.y.)

termined in the empirical specification. We thus simply use the least-squares estimator rather than the IV estimator.

We conduct a set of specification tests to select among the alternative forms of the regression function as well as the stochastic processes of the error term u_{it}. Since the LLES nests the LES by setting $\beta_i = 0$ in (6.b), or $\delta_{i4} = \delta_{i5} = \delta_{i6} = 0$ in (7), we can test between the LLES and the LES by imposing these restrictions. As for the error term, we first assume the AR(1) process:

$$u_{it} = \rho_i u_{it-1} + \varepsilon_{it} \qquad \varepsilon_{it} \sim iid(0,\ \omega^2) \qquad |\rho_i| < 1.$$

We then test the null hypothesis that $\rho_i = 0$. If the hypothesis is rejected, we model the errors as the AR(1) and, if it is not, we simply assume the iid errors.

Given the assumptions of the preferences and the error terms, we now have four hypotheses: (i) the LES with the AR(1) process; (ii) the LES without the AR(1) process; (iii) the LLES with the AR(1) process; and (iv) the LLES without the AR(1) process. We perform a series of hypothesis tests to select among the four hypotheses for a given country.

Note that, when the AR(1) error is assumed, we use the nonlinear least squares to estimate the parameters in (7) and ρ jointly. Let $\boldsymbol{X}_t$ be the t-th row of the matrix of the regressors of (7), $\boldsymbol{\delta}$ be a vector of the parameters, and y_t be the t-th sample of the dependent variable. Then, the original linear regression is given as $y_t = \boldsymbol{X}_t\boldsymbol{\delta} + u_t$. Since $u_t = \rho_i u_{t-1} + \varepsilon_t$ where $u_{t-1} = y_{t-1} - \boldsymbol{X}_{t-1}\boldsymbol{\delta}$, we obtain the regression:

$$y_t = \boldsymbol{X}_t\boldsymbol{\delta} + \rho(y_{t-1} - \boldsymbol{X}_{t-1}\boldsymbol{\delta}) + \varepsilon_t \qquad \varepsilon_t \sim iid(0,\ \omega^2).$$

which is easily estimated by the nonlinear least squares.

We thus translate the four models into the following regression models:

Model 1: $$\begin{aligned} \mathrm{AID}_{it} = {} & \delta_{i0} + \delta_{i1}\mathrm{GDP}_{it} + \delta_{i2}\mathrm{POP}_{it} + \delta_{i3}\,\mathrm{SPILL}_{it-1} + \delta_{i4}\ln(\mathrm{POP}_{it}) \\ & + \delta_{i5}\ln(\mathrm{POP}_{it})(\mathrm{GDP}_{it} + \mathrm{SPILL}_{it-1}) + \delta_{i6}\ln(\mathrm{POP}_{it})\mathrm{POP}_{it} \\ & + \rho_i[\mathrm{AID}_{it-1} - (\delta_{i0} + \delta_{i1}\mathrm{GDP}_{it-1} + \delta_{i2}\mathrm{POP}_{it-1} + \delta_{i3}\,\mathrm{SPILL}_{it-2} + \delta_{i4}\ln(\mathrm{POP}_{it-1}) \\ & + \delta_{i5}\ln(\mathrm{POP}_{it-1})(\mathrm{GDP}_{it-1} + \mathrm{SPILL}_{it-2}) + \delta_{i6}\ln(\mathrm{POP}_{it-1})\mathrm{POP}_{it-1})] + \varepsilon_{it} \end{aligned}$$

Model 2: $$\begin{aligned} \mathrm{AID}_{it} = {} & \delta_{i0} + \delta_{i1}\mathrm{GDP}_{it} + \delta_{i2}\mathrm{POP}_{it} + \delta_{i3}\,\mathrm{SPILL}_{it-1} + \delta_{i4}\ln(\mathrm{POP}_{it}) \\ & + \delta_{i5}\ln(\mathrm{POP}_{it})(\mathrm{GDP}_{it} + \mathrm{SPILL}_{it-1}) + \delta_{i6}\ln(\mathrm{POP}_{it})\mathrm{POP}_{it} + \varepsilon_{it} \end{aligned}$$

Model 3: $$\begin{aligned} \mathrm{AID}_{it} = {} & \delta_{i0} + \delta_{i1}\mathrm{GDP}_{it} + \delta_{i2}\mathrm{POP}_{it} + \delta_{i3}\,\mathrm{SPILL}_{it-1} \\ & + \rho_i[\mathrm{AID}_{it-1} - (\delta_{i0} + \delta_{i1}\mathrm{GDP}_{it-1} + \delta_{i2}\mathrm{POP}_{it-1} + \delta_{i3}\,\mathrm{SPILL}_{it-2})] + \varepsilon_{it} \end{aligned}$$

Model 4: $$\mathrm{AID}_{it} = \delta_{i0} + \delta_{i1}\mathrm{GDP}_{it} + \delta_{i2}\mathrm{POP}_{it} + \delta_{i3}\,\mathrm{SPILL}_{it-1} + \varepsilon_{it}$$

Table 3 lists the possible six combinations of the specification tests. The first five test are standard nested tests. Where the unrestricted model is liner, the standard F-test is employed. Where the unrestricted model is nonlinear, the Gauss-Newton regressions is used to calculate relevant LM statistics (Davidson and MacKinnon 1993; pp. 186–191). The last test (Test 6) is non-nested for which, the P_A test, a version of J_A test for non-linear model, is employed (Davidson and MacKinnon 1993; pp. 385-388). Tables 4.a ~ g list the test statistics of these six sets of tests for the nine countries.

Table 5 summarizes the results of the tests. The contribution function is modeled as Model 2 (the translog indirect utility function without the AR(1) process) for Belgium, France, Italy, Japan, and Netherlands, Model 3(the Stone-Geary utility function with the AR(1) process) for Germany, the United Kingdom, and the United States, and Model 4 (the Stone-Geary utility func-

Table 3. Specification tests

		Hypothesis Testing	Type of Testing
TEST 1	Null	Hypothesis 2	nested
	Alternative	Hypothesis 1	
TEST 2	Null	Hypothesis 3	nested
	Alternative	Hypothesis 1	
TEST 3	Null	Hypothesis 4	nested
	Alternative	Hypothesis 1	
TEST 4	Null	Hypothesis 4	nested
	Alternative	Hypothesis 2	
TEST 5	Null	Hypothesis 3	nested
	Alternative	Hypothesis 4	
TEST 6	N. A.	Hypothesis 2 vs. Hypothesis 3	non-nested

Table 4.a. Test 1: Translog indirect utility without AR(1) against translog indirect utility with AR(1)

Country	Null Distribution	Test Statistics	*P* value
Belgium	F (1, 27)	0.782	0.384
Canada	F (1, 27)	0.966	0.335
France	F (1, 27)	3.660	0.066
Germany	F (1, 26)	10.945	0.003
Italy	F (1, 23)	0.173	0.681
Japan	F (1, 27)	0.372	0.547
Netherlands	F (1, 23)	8.086	0.009
United Kingdom	F (1, 27)	4.566	0.042
United States	F (1, 27)	4.464	0.044

Table 4.b. Test 2: Stone-Geary utility with AR(1) against translog indirect utility with AR(1)

Country	Null Distribution	Test Statistics	*P* value
Belgium	F (3, 27)	2.492	0.082
Canada	F (3, 27)	1.968	0.143
France	F (3, 27)	1.658	0.199
Germany	F (3, 26)	0.265	0.850
Italy	F (3, 23)	0.615	0.612
Japan	F (3, 27)	1.295	0.296
Netherlands	F (3, 23)	3.779	0.024
United Kingdom	F (3, 27)	0.265	0.850
United States	F (3, 27)	1.197	0.330

Table 4.c. Test 3: Stone-Geary utility without AR(1) against translog indirect utility with AR(1)

Country	Null Distribution	Test Statistics	P value
Belgium	$F(4, 27)$	5.013	0.004
Canada	$F(4, 27)$	1.663	0.188
France	$F(4, 27)$	17.126	0.000
Germany	$F(4, 26)$	2.794	0.047
Italy	$F(4, 24)$	4.763	0.006
Japan	$F(4, 27)$	1.559	0.214
Netherlands	$F(4, 24)$	7.445	0.001
United Kingdom	$F(4, 27)$	2.785	0.047
United States	$F(4, 27)$	5.841	0.002

Table 4.d. Test 4: Stone-Geary utility without AR(1) against translog indirect utility without AR(1)

Country	Null Distribution	Test Statistics	P value
Belgium	$F(3, 28)$	6.573	0.002
Canada	$F(3, 28)$	2.145	0.117
France	$F(3, 28)$	18.869	0.000
Germany	$F(3, 27)$	0.076	0.972
Italy	$F(3, 24)$	6.067	0.003
Japan	$F(3, 28)$	1.954	0.144
Netherlands	$F(3, 24)$	6.103	0.003
United Kingdom	$F(3, 28)$	1.296	0.295
United States	$F(3, 28)$	5.105	0.006

Table 4.e. Test 5: Stone-Geary utility without AR(1) against Stone-Geary utility with AR(1)

Country	Null Distribution	Test Statistics	P value
Belgium	$F(1, 30)$	9.280	0.005
Canada	$F(1, 30)$	0.179	0.675
France	$F(1, 30)$	37.706	0.000
Germany	$F(1, 29)$	10.933	0.003
Italy	$F(1, 26)$	5.805	0.023
Japan	$F(1, 30)$	1.976	0.170
Netherlands	$F(1, 26)$	27.894	0.000
United Kingdom	$F(1, 30)$	9.178	0.005
United States	$F(1, 30)$	14.942	0.001

Table 4.f. Test 6-1: P_A test for translog indirect utility without AR(1)

Country	Null Distribution	Test Statistics	P value (two tailed)
Belgium	$t(29)$	−0.481	0.634
Canada	$t(29)$	0.460	0.649
France	$t(29)$	0.587	0.562
Germany	$t(28)$	−3.061	0.005
Italy	$t(25)$	−0.276	0.785
Japan	$t(29)$	−0.217	0.830
Netherlands	$t(25)$	0.158	0.876
United Kingdom	$t(29)$	−2.292	0.029
United States	$t(29)$	1.533	0.136

Table 4.g. Test 6-2: P_A test for Stone-Geary utility with AR(1)

Country	Null Distribution	Test Statistics	*P* value (two tailed)
Belgium	*t* (29)	2.483	0.019
Canada	*t* (29)	2.081	0.046
France	*t* (29)	3.236	0.003
Germany	*t* (28)	−0.742	0.464
Italy	*t* (25)	2.752	0.011
Japan	*t* (29)	1.478	0.150
Netherlands	*t* (25)	1.164	0.255
United Kingdom	*t* (29)	0.563	0.578
United States	*t* (29)	1.247	0.222

Table 5. Selected Models

Country		Model chosen
Belgium	Model 2	the translog indirect utility function without the AR(1) process
Canada	Model 4	the Stone-Geary utility function without the AR(1) process
France	Model 2	the translog indirect utility function without the AR(1) process
Germany	Model 3	the Stone-Geary utility function with the AR(1) process
Italy	Model 2	the translog indirect utility function without the AR(1) process
Japan	Model 2	the Stone-Geary utility function without the AR(1) process
Netherlands	Model 2	the translog indirect utility function with the AR(1) process
United Kingdom	Model 3	the Stone-Geary utility function with the AR(1) process
United States	Model 3	the Stone-Geary utility function with the AR(1) process

Table 6. Estimation Results

Variables	Coef.	Belgium	Canada	France	Germany	Italy
Constant	δ_{i0}	−3.03029E6 (−2.4232)	−1,157.90 (−3.4864)	1.04024E7 (2.7670)	831.443 (0.2315)	−4.18486E7 (−2.3376)
GDP_{it}	δ_{i1}	0.342796 (4.3937)	0.006957 (9.9290)	−0.176063 (−1.3310)	0.003663 (6.9893)	0.113853 (0.8548)
POP_{it}	δ_{i2}	−5.98607E6 (−2.5873)	47.8586 (1.9517)	630,583.0 (2.5698)	−20.5835 (−0.3338)	−2.43806E6 (−2.4453)
$SPILL_{it-1}$	δ_{i3}	0.336152 (4.3147)	−0.03164 (−6.3430)	−0.133911 (−0.9600)	0.033491 (2.0522)	0.076432 (0.5363)
$\ln(POP_{it})$	δ_{i4}	1.31596E8 (2.5616)	—	−5.39278E6 (2.6891)	—	2.13938E7 (2.3778)
$\ln(POP_{it}) \times (GDP_{it}+SPILL_{it-1})$	δ_{i5}	−0.147955 (−4.3334)	—	0.044935 (1.3568)	—	−0.027560 (−0.8336)
$\ln(POP_{it})(POP_{it})$	δ_{i6}	1.41540E6 (2.5955)	—	−106,501.0 (−2.5462)	—	409,292.0 (2.4592)
u_{it}	ρ	—	—	—	0.571346 (3.2671)	—
Adjusted R^2		0.903114	0.976267	0.828314	0.975704	0.729792
Sample size (d.f.)		35 (28)	35 (31)	35 (28)	34 (29)	31 (24)
Methods of Estimation		OLS	OLS	OLS	NLS	OLS

Continued

Variables	Coef.	Japan	Netherland	UK	US
Constant	δ_{i0}	968.520 (0.7832)	3.96104E6 (2.4784)	6,587.30 (1.0530)	−15,554.6 (−0.8083)
GDP_{it}	δ_{i1}	0.002885 (11.6366)	−0.264850 (−1.9349)	−0.004761 (−1.8464)	−0.004618 (−1.5052)
POP_{it}	δ_{i2}	−21.7833 (−2.00397)	2.35187E6 (2.6268)	−90.0090 (−0.7442)	190.523 (1.4285)
$SPILL_{it-1}$	δ_{i3}	0.065093 (2.88122)	−0.258526 (−1.9146)	0.048190 (2.0726)	−0.112868 (−1.0630)
$\ln(POP_{it})$	δ_{i4}	—	6.79255E6 (−2.5833)	—	—
$\ln(POP_{it})\times$ $(GDP_{it}+SPILL_{it-1})$	δ_{i5}	—	0.102689 (2.0003)	—	—
$\ln(POP_{it})(POP_{it})$	δ_{i6}	—	−513,201.0 (−2.6378)	—	—
u_{it}	ρ	—	0.663203 (4.2212)	0.454134 (2.7841)	0.627238 (3.8654)
Adjusted R^2		0.989757	0.984049	0.704553	0.425610
Sample size (d.f.)		35 (31)	31 (24)	35 (31)	35 (31)
Methods of Estimation		OLS	NLS	NLS	NLS

tion without the AR(1) process) for Canada. Table 6 shows the estimation results of the contribution functions specified as such for each of the countries.

4 Results

First, we examine whether the coefficients on the variables which involves SPILL have statistically significant effects on the national contributions to multinational foreign aid. Let us call the effects such coefficients are supposed to indicate as "spill-in effects." To test the spill-in effects, we set the coefficients on the variables which involve SPILL equal to zero and see whether the test statistics are statistically different from zero. If a country's demand function is LLES, δ_{i3} and δ_{i5} are set equal to zero and, if it is LLE, δ_{i3} is set equal to zero. The results are reported in Table 7. At the .05 level, only Belgium, Canada, Japan and the United Kingdom have statistically significant spill-in effects. On the other hand, the spill-in effects of Germany and the United States do not pass the tests, even at the 0.10 level of significance.

We then examine the direction and the degree of the spill-in effects from the estimated parameter values. What we wish to calculate is the value of the gradient:

$$\partial d_i / \partial D_{-i}$$

where $d_i = f_i(\tau_i, m_i, D_{-i})$ as in (3). The standard model implies this value should be negative. An empirical equivalent of $\partial d_i / \partial D_{-i}$ is:

Table 7. Tests for spill-in effects

Countries	Null Model	Null Distribution	Test Statistics	*P* values
Belgium***	$\delta_{i3}=\delta_{i5}=0$	F (2,28)	10.115[a]	0.000
Canada***	$\delta_{i3}=0$	F (1,31)	40.234[a]	0.000
France*	$\delta_{i3}=\delta_{i5}=0$	F (2,28)	2.679[a]	0.086
Germany	$\delta_{i3}=0$	F (1,29)	0.113[b]	0.113
Italy*	$\delta_{i3}=\delta_{i5}=0$	F (2,24)	2.998[a]	0.067
Japan***	$\delta_{i3}=0$	F (1,31)	8.300[a]	0.007
Netherlands*	$\delta_{i3}=\delta_{i5}=0$	F (2,23)	2.686[b]	0.089
United Kingdom**	$\delta_{i3}=0$	F (1,30)	4.411[b]	0.044
United States	$\delta_{i3}=0$	F (1,30)	0.999[b]	0.326

Notes: 1. *** indicates the countries with significant spill-in effects at the .01 level.
2. ** indicates the countries with significant spill-in effects at the .05 level.
3. * indicates the countries with significant spill-in effects at the .10 level.
4. *a* indicates that the test statistics are calculated according to standard F for the linear regression models.
5. *b* indicates that the test statistics are LM statistics for nonlinear least square estimator, which are based on the ordinary F statistics calculated from the relevant Gauss-Newton regression. The test statistics are asymptotically distributed as F.

Table 8. Spill-in effects

Countries	4	5	ln (POP~)	Adjustment Coef.
Belgium***	0.3362	−0.1480	2.2686	0.0005
Canada***	−0.0316	—	—	−0.0316
France*	−0.1339	0.0449	3.9504	0.3114
Germany	0.0335	—	—	0.0335
Italy*	0.0764	−0.0276	4.0099	−0.0341
Japan***	0.0651	—	—	0.0651
Netherlands*	−0.2585	0.1027	2.6170	0.0573
United Kingdom**	0.0481	—	—	0.0482
United States	0.1129	—	—	0.1129

Notes: 1. *** indicates the countries with significant spill-in effects at the .01 level.
2. ** indicates the countries with significant spill-in effects at the .05 level.
3. * indicates the countries with significant spill-in effects at the .10 level.
4. POP~is average population during the sample period.

$$\frac{\partial(\text{AID}_{it})}{\partial(\text{SPILL}_{it-1})}=\delta_{i3}+\delta_{i5}\ln(\text{POP}_{it}).$$

which can be calculated using the coefficients from the estimated functions. The results are reported in Table 8, where all of the nine countries' spill-in effects are listed although some countries' spill-in effects are not statistically significant as we have seen. For those countries with the LLES specification, the value of $\ln(\text{POP}_{it})$ is needed to obtain the estimtes. The calculation in Table 8 uses the average value of POP for the sample period for the relevant countries.

The countries with negative adjustment are only Canada and Italy. The other countries all show positive spill-in effects, although the effects for Germany and the United States are statistically insignificant. That is, only Canada and Italy are consistent with what the theory of the voluntary provision of public goods implies.

There would be several possibilities for the failure of cheap riding for the other countries. One is that some countries simply do not behave Nash. On this issue, Hayashi (2001) provides further investigation. Another issue is whether or not the spill-in benefits from multilateral foreign aid is purely public. Although we have argued otherwise in Introduction, there may be more relevant alternative models for the countries that exhibit positive effects. One candidate would be the joint-product model by Cornes and Sandler (1984, 1994) which assumes that the voluntary contributions yield the private as well as public benefits. We may follow Sandler and Murdoch (1990) to test between the pure public good model and the joint product model. Those are the issues for the further research.

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