The Composition of Aid and the Fiscal Sector in an Aid-Recipient Economy: A Model

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Abstract

Building on recent work in the fiscal response literature, the present paper develops a new fiscal response model, which, for the first time in the relevant literature, combines the ideas of both endogenous and disaggregated aid. We endogenised aid on the grounds that the recipient government has some influence over aid disbursements. Regarding aid disaggregation, it is argued that each of the main four categories of aid, namely project aid, programme aid, technical assistance and food aid may exert different effects on the recipient economy. Furthermore, in case the preferences of the aid-recipient government are higher for some of these types of aid, neglecting aid disaggregation would lead to aggregation bias in the results and conclusions. The model adds an important new dimension to the vast aid effectiveness literature and calls for further modelling as well as empirical work in this promising research area so that significant policy implications can be derived.

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1. Introduction

One of the key criticisms of the "aid-growth" literature is that it fails to recognise explicitly that aid is given primarily to governments in aid-recipient countries, and hence any impact of aid on the macroeconomy will depend on government behaviour, in particular how fiscal decisions on taxation and expenditure are effected by the presence of aid. This is exactly what motivates the so-called "fiscal response" literature i.e. modelling how the impact of aid is mediated by public sector behaviour.[2] Needless to say, due to widespread concern about the fungibility of aid in the donor community, the descriptive analysis of fiscal response, i.e. the fiscal behaviour of the aid-recipient country is an important task of its own. However, the analysis of fiscal response is also important because it helps to open one of the many black boxes of the "aid-growth" nexus. The World Bank report *Assessing Aid* (1998) fails to address the above important issue by not considering the 'broader context' of fiscal response (McGillivray and Morrissey, 2000, Beynon, 2002 and Mavrotas, 2002).

Long ago it was argued (Griffin, 1970) that aid, *inter alia*, may have a negative effect on recipient economies since recipient-country governments often use aid money to increase government consumption rather than directing aid flows towards developmental government investment. This argument was taken further by Boone (1996) who by using a rather problematic cross-section analysis for a group of 96 countries, within the context of a Cass-Ramsey-Koopmans type model, concluded that most of aid is consumed.[3] These potential negative effects of foreign aid could be viewed further within the context of the fungibility literature; the impact of aid on fiscal variables in the recipient economy and the related issue of aid fungibility have been the subject of a booming empirical literature in recent years. The "fiscal response"

[2] The term is attributed to White (1992).

literature, however, is not conclusive as far as the overall impact of aid on the fiscal sector of recipient countries is concerned. A careful review of the relevant literature seems to suggest that most of the studies following Heller's seminal paper (Heller, 1975) are problematic on the grounds that they try to maximise a loss function, which can not be optimised when the target values of the choice variables are achieved; this basically means that the targets cannot be truly considered as targets. Studies such as these by Gang and Khan (1991), Khan and Hoshino (1992) as well as Otim (1996) suffer from the above shortcoming. Following Heller's work, these studies try to maximize the recipient government's utility function subject to budget constraints, derive structural equations and subsequently estimate them simultaneously. Binh & McGillivray (1993) and White (1994) criticise the above approach mainly on the grounds of its faulty specification of the recipient government's utility function.[4]

A major problem with the existing empirical studies on aid effectiveness (including World Bank's *Assessing Aid*) and the fiscal response literature is their neglect of the heterogeneous character of foreign aid. One of the main features of the vast quantitative literature of the effectiveness of development aid in recipient countries has hitherto been the employment of a single figure for aid.[5] However, this is likely to provide misleading conclusions on aid effectiveness, since we can distinguish at least four different categories of aid:

- project aid with a rather lengthy gestation period,

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[3] Boone concluded that the marginal propensity to consume from permanent transfers is one; the marginal propensity to invest from transfers is zero; and the above marginal propensities do not vary with income per capita.

[4] See next section for a detailed discussion.

[5] A notable exception to the general neglect of the disaggregation of aid is a study by Levy (1987) (although in the context of a different aid-disaggregation, that is between "anticipated" and "unanticipated" aid), which gives a strong indication that if we consider the macroeconomic impact of aid in a disaggregated framework, the standard conclusions of the existing studies could be altered dramatically. In Levy's study, the reported estimates, from the estimation of a consumption function for 39 countries over the period 1970-80, indicate different tendencies of anticipated (mainly project aid) and unanticipated aid (food aid, relief aid etc.): unanticipated aid is fully consumed but more than 40 per cent

- programme aid which disburses rapidly as free foreign exchange,
- technical assistance, and
- food aid and other commodity aid which adds directly to consumption.

To the above four types of foreign aid, emergency or relief aid could be added as a separate category, given its increasing importance in recent years (Cassen, 1994; Addison, 2000).

There are three relevant points here: *firstly*, different types of aid operate in different ways (and with different lag-structure) in the recipient country thus resulting in different macro effects; *secondly*, because of different conditions relating to each in different countries (e.g. the state of aid co-ordination may vary among aid recipients), there is also an extra reason to expect different effects of aid in each country - the *ceteris paribus* assumptions of the econometrics of aid may be disturbed by such considerations; and *thirdly*, perhaps *most importantly*, within an endogenous fiscal response framework[6] if the government attaches different utility to each category of aid, using a single figure of aid would lead to aggregation bias in the results and conclusions reached.

The neglect of the aid disaggregation issue in the voluminous aid effectiveness literature was the main motivation of the model developed by Mavrotas (2002). The author provides strong empirical evidence, using time series data for Kenya and India, which clearly suggests the importance of aid disaggregation so that meaningful conclusions on the impact of aid on the fiscal sector can be derived.

In this paper we develop a fiscal response model which extends the model developed by Mavrotas (2002) on a number of grounds: firstly, a new variable, food aid, is included in the model, apart from project aid, programme aid and technical

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of anticipated assistance is invested, thus contributing significantly to the growth process in recipient countries (Levy 1987).

[6] This means that aid is endogenised in the government utility function.

assistance; secondly, all four aid variables used in the model are endogenised following Franco-Rodriguez *et al*. (1998); thirdly, also following Franco-Rodriguez *et al.* (1998) we specify the budget constraints in a way to avoid over-restriction and full fungibility. Fourthly, we derive, in addition to the structural equations, the reduced form equations, which allow us to evaluate the total impact of the different components of aid on the public sector of the recipient.

The rest of the paper is structured as follows. Section 2 deals with the settings of the elements of the model. Section 3 is concerned with the derivation of the model solution. To support further the argument for aid disaggregation we develop, in Section 4, a model where aid is aggregated and then we derive both structural and reduced form equations so that the two results (disaggregation *versus* aggregation) are comparable. The last section concludes the paper.

2. Modelling the Impact of Disaggregated Aid on the Fiscal Sector

The model assumes that the recipient government aims at maximising a utility function that can be represented as:

$$U = f(I_g, G, T, B, A_1, A_2, A_3, A_4) \qquad [1]$$

where Ig is public investment capital expenditure, T represents tax and non-tax revenue, B is government borrowing from all sources, G is government recurrent expenditure, A_1 is project aid from all donors, A_2 represents programme aid from all sources, A_3 stands for technical assistance and A_4 is food aid from all donors.

It is assumed that the government is a rational utility-maximiser setting annual targets for each fiscal variables and tries to reach these targets. Following Mosley *et al*.

(1987), Binh and McGillivray (1993) and more recently Mavrotas (2002) this behaviour can be represented by a utility function without the linear terms, as below:

$$\begin{aligned} U = \alpha_0 &- \frac{\alpha_1}{2}(I_g - I_g^*)^2 - \frac{\alpha_2}{2}(G - G^*)^2 - \frac{\alpha_3}{2}(T - T^*)^2 \\ &- \frac{\alpha_4}{2}(A_1 - A_1^*)^2 - \frac{\alpha_5}{2}(A_2 - A_2^*)^2 - \frac{\alpha_6}{2}(A_3 - A_3^*)^2 \\ &- \frac{\alpha_7}{2}(A_4 - A_4^*)^2 - \frac{\alpha_8}{2}(B - B^*)^2 \end{aligned} \qquad [2]^7$$

where the starred variables represent the exogenous target variables, $\alpha_i \succ 0$ for i = 1,…,8. The $\alpha_i's$ represent the relative weights given to different terms in the utility function and, without loss of generality, may be normalised so that they sum up to unity. If the government meets all its targets, the maximum unconstrained would be α_0.

A distinctive feature of the above model is that it endogenises the four main components of foreign aid (project aid, programme aid, technical assistance and food aid). Aid variables are endogenised following Franco-Rodriguez *et al*. (1998) who rightly argued that aid disbursement is influenced by the recipient and, therefore, should be considered as a government policy variable.

We then assume, following Franco-Rodriguez *et al*. (1998) that the government maximises utility function [2] subject to the following budget constraints:

$$I_g + G = B + T + A_1 + A_2 + A_3 + A_4 \qquad [3]$$

$$G \leq \rho_1 T + \rho_2 A_1 + \rho_3 A_2 + \rho_4 A_3 + \rho_5 A_4 + \rho_6 B \qquad [4]$$

where $0 \leq \rho_i \leq 1$ and i = 1,2,…,6. The assumption underlying the budget constraint represented by Equation [3] is that government total spending (investment +

consumption) must equal the sum of borrowing, tax and non-tax revenues and the different types of foreign aid. In other words, the government is assumed to run a balanced-budget. The rationale for the second constraint (Equation [4]) is that external forces (donors or domestic interest groups) will determine the way the government allocates it resources i.e. the ρs in Equation [4] will be imposed on the government or those setting the targets and allocating revenue. Consequently, there will be no guarantee that the targets are met even if total revenue equals total expenditure (Franco-Rodriguez *et al*, 1998).

Contrary to many previous studies in the fiscal response literature, we also include borrowing in the specification of the second budget constraint. Some previous studies have assumed that the government prefers not to borrow for consumption purposes, as it is costly in relative terms. However, such restriction, in our view, should be the outcome of the estimation results i.e. if the government does not borrow to finance consumption then the coefficient of B in equation [4] would not be significantly different from zero (i.e. $\rho_6 = 0$).

3. Deriving the Model Solution

In this section, the model solution is derived. This involves deriving both structural and reduced form equations. For this purpose, the Lagrangean is applied to the maximisation problem, as below:

[7] It is clear from this equation that the government utility is maximised when all targets are met, with the maximum being α_0.

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\begin{aligned}
L = \alpha_0 &- \frac{\alpha_1}{2}(I_g - I_g^*)^2 - \frac{\alpha_2}{2}(G - G^*)^2 - \frac{\alpha_3}{2}(T - T^*)^2 \\
&- \frac{\alpha_4}{2}(A_1 - A_1^*)^2 - \frac{\alpha_5}{2}(A_2 - A_2^*)^2 - \frac{\alpha_6}{2}(A_3 - A_3^*)^2 \\
&- \frac{\alpha_7}{2}(A_4 - A_4^*)^2 - \frac{\alpha_8}{2}(B - B^*)^2 \\
&+ \lambda_1(I_g + G - B - T - A_1 - A_2 - A_3 - A_4) \\
&+ \lambda_2(G - \rho_1 T - \rho_2 A_1 - \rho_3 A_2 - \rho_4 A_3 - \rho_5 A_4 - \rho_6 B
\end{aligned}
\qquad [5]
$$

where λ_1 and λ_2 are the Lagrange multipliers.

Turning the inequality sign into an equality and taking the first derivatives with respect to the endogenous variables and the multipliers leads to the following first order conditions:

$$\frac{\partial L}{\partial I_g} = -\alpha_1(I_g - I_g^*) + \lambda_1 = 0 \qquad [6]$$

$$\frac{\partial L}{\partial G} = -\alpha_2(G - G^*) + \lambda_1 + \lambda_2 = 0 \qquad [7]$$

$$\frac{\partial L}{\partial T} = -\alpha_3(T - T^*) - \lambda_1 - \lambda_2 \rho_1 = 0 \qquad [8]$$

$$\frac{\partial L}{\partial A_1} = -\alpha_4(A_1 - A_1^*) - \lambda_1 - \lambda_2 \rho_2 = 0 \qquad [9]$$

$$\frac{\partial L}{\partial A_2} = -\alpha_5(A_2 - A_2^*) - \lambda_1 - \lambda_2 \rho_3 = 0 \qquad [10]$$

$$\frac{\partial L}{\partial A_3} = -\alpha_6(A_3 - A_3^*) - \lambda_1 - \lambda_2 \rho_4 = 0 \qquad [11]$$

$$\frac{\partial L}{\partial A_4} = -\alpha_7(A_4 - A_4^*) - \lambda_1 - \lambda_2 \rho_5 = 0 \qquad [12]$$

$$\frac{\partial L}{\partial B} = -\alpha_8(B - B^*) - \lambda_1 - \lambda_2 \rho_6 = 0 \qquad [13]$$

$$\frac{\partial L}{\partial \lambda_1} = I_g + G - B - T - A_1 - A_2 - A_3 - A_4 = 0 \qquad [14]$$

$$\frac{\partial L}{\partial \lambda_2} = G - \rho_1 T - \rho_2 A_1 - \rho_3 A_2 - \rho_4 A_3 - \rho_5 A_4 - \rho_6 B = 0 \qquad [15]$$

Like Heller (1975), Mosley *et al*. (1987) Gang and Khan (1991) and others we assume *ex ante* that the target for borrowing (B*) is equal to zero. Solving the first order conditions yields to following system of structural equations:

$$\begin{aligned}
I_g = {} & (1-\rho_1)\beta_1 I_g^* + (1-\rho_1)\beta_2 G^* \\
& +(1-\rho_1)[1-(1-\rho_1)\beta_1 - \rho_1\beta_2]T^* \\
& +[(1-\rho_2)-(1-\rho_1)(1-\rho_2)\beta_1 - (1-\rho_1)\rho_2\beta_2]A_1 \\
& +[(1-\rho_3)-(1-\rho_1)(1-\rho_3)\beta_1 - (1-\rho_1)\rho_3\beta_2]A_2 \\
& +[(1-\rho_4)-(1-\rho_1)(1-\rho_4)\beta_1 - (1-\rho_1)\rho_4\beta_2]A_3 \\
& +[(1-\rho_5)-(1-\rho_1)(1-\rho_5)\beta_1 - (1-\rho_1)\rho_5\beta_2]A_4 \\
& +[(1-\rho_6)-(1-\rho_1)(1-\rho_6)\beta_1 - (1-\rho_1)\rho_6\beta_2]B
\end{aligned} \qquad [16]$$

$$\begin{aligned}
G = {} & \rho_1\beta_1 I_g^* + \rho_1\beta_2 G^* + \rho_1[1-(1-\rho_1)\beta_1 - \rho_1\beta_2]T^* \\
& +[\rho_2 - \rho_1(1-\rho_2)\beta_1 - \rho_1\rho_2\beta_2]A_1 \\
& +[\rho_3 - \rho_1(1-\rho_3)\beta_1 - \rho_1\rho_3\beta_2]A_2 \\
& +[\rho_4 - \rho_1(1-\rho_4)\beta_1 - \rho_1\rho_4\beta_2]A_3 \\
& +[\rho_5 - \rho_1(1-\rho_5)\beta_1 - \rho_1\rho_5\beta_2]A_4 \\
& +[\rho_6 - \rho_1(1-\rho_6)\beta_1 - \rho_1\rho_6\beta_2]B
\end{aligned} \qquad [17]$$

$$\begin{aligned}
T = {} & \beta_1 I_g^* + \beta_2 G^* + [1-(1-\rho_1)\beta_1 - \rho_1\beta_2]T^* \\
& -[(1-\rho_2)\beta_1 + \rho_2\beta_2]A_1 \\
& -[(1-\rho_3)\beta_1 + \rho_3\beta_2]A_2 \\
& -[(1-\rho_4)\beta_1 + \rho_4\beta_2]A_3 \\
& -[(1-\rho_5)\beta_1 + \rho_5\beta_2]A_4 \\
& -[(1-\rho_6)\beta_1 + \rho_6\beta_2]B
\end{aligned} \qquad [18]$$

$$\begin{aligned}
A_1 = {} & \beta_3 I_g^* + \beta_4 G^* - [(1-\rho_1)\beta_3 + \rho_1\beta_4]T \\
& +[1-(1-\rho_2)\beta_3 - \rho_2\beta_4]A_1^* \\
& -[(1-\rho_3)\beta_3 + \rho_3\beta_4]A_2 \\
& -[(1-\rho_4)\beta_3 + \rho_4\beta_4]A_3 \\
& -[(1-\rho_5)\beta_3 + \rho_5\beta_4]A_4 \\
& -[(1-\rho_6)\beta_3 + \rho_6\beta_4]B
\end{aligned} \qquad [19]$$

$$\begin{aligned} A_2 = {} & \beta_5 I_g^* + \beta_6 G^* - [(1-\rho_1)\beta_5 + \rho_1\beta_6]T \\ & -[(1-\rho_2)\beta_5 + \rho_2\beta_6]A_1 \\ & +[1-(1-\rho_3)\beta_5 - \rho_3\beta_6]A_2^* \\ & -[(1-\rho_4)\beta_5 + \rho_4\beta_6]A_3 \\ & -[(1-\rho_5)\beta_5 + \rho_5\beta_6]A_4 \\ & -[(1-\rho_6)\beta_5 + \rho_6\beta_6]B \end{aligned} \qquad [20]$$

$$\begin{aligned} A_3 = {} & \beta_7 I_g^* + \beta_8 G^* - [(1-\rho_1)\beta_7 + \rho_1\beta_8]T \\ & -[(1-\rho_2)\beta_7 + \rho_2\beta_8]A_1 \\ & -[(1-\rho_3)\beta_7 + \rho_3\beta_8]A_2 \\ & +[1-(1-\rho_4)\beta_7 - \rho_4\beta_8]A_3^* \\ & -[(1-\rho_5)\beta_7 + \rho_5\beta_8]A_4 \\ & -[(1-\rho_6)\beta_7 + \rho_6\beta_8]B \end{aligned} \qquad [21]$$

$$\begin{aligned} A_4 = {} & \beta_9 I_g^* + \beta_{10} G^* - [(1-\rho_1)\beta_9 + \rho_1\beta_{10}]T \\ & -[(1-\rho_2)\beta_9 + \rho_2\beta_{10}]A_1 \\ & -[(1-\rho_3)\beta_9 + \rho_3\beta_{10}]A_2 \\ & -[(1-\rho_4)\beta_9 + \rho_4\beta_{10}]A_3 \\ & +[1-(1-\rho_5)\beta_9 - \rho_5\beta_{10}]A_4^* \\ & -[(1-\rho_6)\beta_9 + \rho_6\beta_{10}]B \end{aligned} \qquad [22]$$

$$\begin{aligned} B = {} & \beta_{11} I_g^* + \beta_{12} G^* - [(1-\rho_1)\beta_{11} + \rho_1\beta_{12}]T \\ & -[(1-\rho_2)\beta_{11} + \rho_2\beta_{12}]A_1 \\ & -[(1-\rho_3)\beta_{11} + \rho_3\beta_{12}]A_2 \\ & -[(1-\rho_4)\beta_{11} + \rho_4\beta_{12}]A_3 \\ & -[(1-\rho_5)\beta_{11} + \rho_5\beta_{12}]A_4 \end{aligned} \qquad [23]$$

with

$$\beta_1 = \frac{\alpha_1(1-\rho_1)}{\theta_1}, \beta_2 = \frac{\alpha_2\rho_1}{\theta_1}, \beta_3 = \frac{\alpha_1(1-\rho_2)}{\theta_2}; \beta_4 = \frac{\alpha_2\rho_2}{\theta_2}; \beta_5 = \frac{\alpha_1(1-\rho_3)}{\theta_3}; \beta_6 = \frac{\alpha_2\rho_3}{\theta_3};$$
$$\beta_7 = \frac{\alpha_1(1-\rho_4)}{\theta_4}; \beta_8 = \frac{\alpha_2\rho_4}{\theta_4}; \beta_9 = \frac{\alpha_1(1-\rho_5)}{\theta_5}; \beta_{10} = \frac{\alpha_2\rho_5}{\theta_5}; \beta_{11} = \frac{\alpha_1(1-\rho_6)}{\theta_6}; \beta_{12} = \frac{(\alpha_2\rho_6)}{\theta_6}$$

where

$\theta_1 = \alpha_1(1-\rho_1)^2 + \alpha_2\rho_1^2 + \alpha_3; \theta_2 = \alpha_1(1-\rho_2)^2 + \alpha_2\rho_2^2 + \alpha_4;$
$\theta_3 = \alpha_1(1-\rho_3)^2 + \alpha_2\rho_3^2 + \alpha_5; \theta_4 = \alpha_1(1-\rho_4)^2 + \alpha_2\rho_4^2 + \alpha_6;$
$\theta_5 = \alpha_1(1-\rho_5)^2 + \alpha_2\rho_5^2 + \alpha_7; \theta_6 = \alpha_1(1-\rho_6)^2 + \alpha_2\rho_6^2 + \alpha_8$

However, the above structural equations only capture the partial effects of the aid variables to the extent that they ignore the indirect feedbacks, operating through the simultaneous system formed by Equations [16] to [23]. To capture the total impacts (direct and indirect), which are crucial for policy purposes, it is important to derive the reduced form equations. Simultaneously solving the preceding structural equations and expressing each endogenous variable in terms of the exogenously determined variables the reduced form equation can be obtained as follows:

$$I_g = \delta_1 I_g^* + \delta_2 G^* + \delta_3 T^* + \delta_4 A_1^* + \delta_5 A_2^* + \delta_6 A_3^* + \delta_7 A_4^* \quad [24]$$

$$G = \delta_8 I_g^* + \delta_9 G^* + \delta_{10} T^* + \delta_{11} A_1^* + \delta_{12} A_2^* + \delta_{13} A_3^* + \delta_{14} A_4^* \quad [25]$$

$$T = \delta_{15} I_g^* + \delta_{16} G^* + \delta_{17} T^* + \delta_{18} A_1^* + \delta_{19} A_2^* + \delta_{20} A_3^* + \delta_{21} A_4^* \quad [26]$$

$$A_1 = \delta_{22} I_g^* + \delta_{23} G^* + \delta_{24} T^* + \delta_{25} A_1^* + \delta_{26} A_2^* + \delta_{27} A_3^* + \delta_{28} A_4^* \quad [27]$$

$$A_2 = \delta_{29} I_g^* + \delta_{30} G^* + \delta_{31} T^* + \delta_{32} A_1^* + \delta_{33} A_2^* + \delta_{34} A_3^* + \delta_{35} A_4^* \quad [28]$$

$$A_3 = \delta_{36} I_g^* + \delta_{37} G^* + \delta_{38} T^* + \delta_{39} A_1^* + \delta_{40} A_2^* + \delta_{41} A_3^* + \delta_{42} A_4^* \quad [29]$$

$$A_4 = \delta_{43} I_g^* + \delta_{44} G^* + \delta_{45} T^* + \delta_{46} A_1^* + \delta_{47} A_2^* + \delta_{48} A_3^* + \delta_{49} A_4^* \quad [30]$$

$$B = \delta_{50} I_g^* + \delta_{51} G^* + \delta_{52} T^* + \delta_{53} A_1^* + \delta_{54} A_2^* + \delta_{55} A_3^* + \delta_{56} A_4^* \quad [31]$$

where[8]

$$\delta_4 = \left[\frac{\gamma_3 - \rho_2\gamma_2}{\alpha_1(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_5 = \left[\frac{\gamma_3 - \rho_3\gamma_2}{\alpha_1(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_6 = \left[\frac{\gamma_3 - \rho_4\gamma_2}{\alpha_1(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_7 = \left[\frac{\gamma_3 - \rho_5\gamma_2}{\alpha_1(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{11} = \left[\frac{(\gamma_3 - \gamma_2) + \rho_2(\gamma_1 - \gamma_2)}{\alpha_2(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{12} = \left[\frac{(\gamma_3 - \gamma_2) + \rho_3(\gamma_1 - \gamma_2)}{\alpha_2(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{13} = \left[\frac{(\gamma_3 - \gamma_2) + \rho_4(\gamma_1 - \gamma_2)}{\alpha_2(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{14} = \left[\frac{(\gamma_3 - \gamma_2) + \rho_5(\gamma_1 - \gamma_2)}{\alpha_2(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{18} = -\left[\frac{(\gamma_3 - \rho_1\gamma_2) + \rho_2(\rho_1\gamma_1 - \gamma_2)}{\alpha_3(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{19} = -\left[\frac{(\gamma_3 - \rho_1\gamma_2) + \rho_3(\rho_1\gamma_1 - \gamma_2)}{\alpha_3(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{20} = -\left[\frac{(\gamma_3 - \rho_1\gamma_2) + \rho_4(\rho_1\gamma_1 - \gamma_2)}{\alpha_3(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{21} = -\left[\frac{(\gamma_3 - \rho_1\gamma_2) + \rho_5(\rho_1\gamma_1 - \gamma_2)}{\alpha_3(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{25} = \left[1 - \frac{(\gamma_3 - \rho_2\gamma_2) + \rho_2(\rho_2\gamma_1 - \gamma_2)}{\alpha_4(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{26} = -\left[\frac{(\gamma_3 - \rho_2\gamma_2) + \rho_3(\rho_2\gamma_1 - \gamma_2)}{\alpha_4(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{27} = -\left[\frac{(\gamma_3 - \rho_2\gamma_2) + \rho_4(\rho_2\gamma_1 - \gamma_2)}{\alpha_4(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{28} = -\left[\frac{(\gamma_3 - \rho_2\gamma_2) + \rho_5(\rho_2\gamma_1 - \gamma_2)}{\alpha_4(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{32} = -\left[\frac{(\gamma_3 - \rho_3\gamma_2) + \rho_2(\rho_3\gamma_1 - \gamma_2)}{\alpha_5(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{33} = \left[1 - \frac{(\gamma_3 - \rho_3\gamma_2) + \rho_3(\rho_3\gamma_1 - \gamma_2)}{\alpha_5(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{34} = -\left[\frac{(\gamma_3 - \rho_3\gamma_2) + \rho_4(\rho_3\gamma_1 - \gamma_2)}{\alpha_5(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{35} = -\left[\frac{(\gamma_3 - \rho_3\gamma_2) + \rho_5(\rho_3\gamma_1 - \gamma_2)}{\alpha_5(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{39} = -\left[\frac{(\gamma_3 - \rho_4\gamma_2) + \rho_2(\rho_4\gamma_1 - \gamma_2)}{\alpha_6(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{40} = -\left[\frac{(\gamma_3 - \rho_4\gamma_2) + \rho_3(\rho_4\gamma_1 - \gamma_2)}{\alpha_6(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{41} = \left[1 - \frac{(\gamma_3 - \rho_4\gamma_2) + \rho_4(\rho_4\gamma_1 - \gamma_2)}{\alpha_6(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{42} = -\left[\frac{(\gamma_3 - \rho_4\gamma_2) + \rho_5(\rho_4\gamma_1 - \gamma_2)}{\alpha_6(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{46} = -\left[\frac{(\gamma_3 - \rho_5\gamma_2) + \rho_2(\rho_5\gamma_1 - \gamma_2)}{\alpha_7(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{47} = -\left[\frac{(\gamma_3 - \rho_5\gamma_2) + \rho_3(\rho_5\gamma_1 - \gamma_2)}{\alpha_7(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{48} = -\left[\frac{(\gamma_3 - \rho_5\gamma_2) + \rho_4(\rho_5\gamma_1 - \gamma_2)}{\alpha_7(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{49} = \left[1 - \frac{(\gamma_3 - \rho_5\gamma_2) + \rho_5(\rho_5\gamma_1 - \gamma_2)}{\alpha_7(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{53} = -\left[\frac{(\gamma_3 - \rho_6\gamma_2) + \rho_2(\rho_6\gamma_1 - \gamma_2)}{\alpha_8(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

---

[8] Given the large number of parameters involved we only report the parameters of interest i.e. those related to the aid coefficients. Further, these parameters are not needed in the estimation stage. Full details are available by the authors upon request.

$$\delta_{54} = -\left[\frac{(\gamma_3 - \rho_6\gamma_2) + \rho_3(\rho_6\gamma_1 - \gamma_2)}{\alpha_8(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{55} = -\left[\frac{(\gamma_3 - \rho_6\gamma_2) + \rho_4(\rho_6\gamma_1 - \gamma_2)}{\alpha_8(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{56} = -\left[\frac{(\gamma_3 - \rho_6\gamma_2) + \rho_5(\rho_6\gamma_1 - \gamma_2)}{\alpha_8(\gamma_1\gamma_3 - \gamma_2^2)}\right]$$

where

$$\gamma_1 = \frac{1}{\alpha_2} + \frac{1}{\alpha_2} + \frac{1}{\alpha_3} + \frac{1}{\alpha_4} + \frac{1}{\alpha_5} + \frac{1}{\alpha_6} + \frac{1}{\alpha_7} + \frac{1}{\alpha_8};$$

$$\gamma_2 = \frac{1}{\alpha_2} + \frac{\rho_1}{\alpha_3} + \frac{\rho_2}{\alpha_4} + \frac{\rho_3}{\alpha_5} + \frac{\rho_4}{\alpha_6} + \frac{\rho_5}{\alpha_7} + \frac{\rho_6}{\alpha_8};$$

$$\gamma_3 = \frac{1}{\alpha_2} + \frac{\rho_1^2}{\alpha_3} + \frac{\rho_2^2}{\alpha_4} + \frac{\rho_3^2}{\alpha_5} + \frac{\rho_4^2}{\alpha_6} + \frac{\rho_5^2}{\alpha_7} + \frac{\rho_6^2}{\alpha_8}$$

From the estimation of each δ_i above we could deduce the total impact of aid of each type of aid on the other endogenous variables. This requires that we first estimate the structural equations and then insert these estimates into the reduced-form equations.

In view of the centrality of the aid disaggregation approach in the present paper, it will be also useful to present the results of the same model, but, this time, with aggregated aid, so that useful comparisons can be drawn. This is the focus of next section.

4. The Model with Aggregated Aid

The model retains the same assumptions as the previous one; the only difference being that now it is assumed that aid is aggregated rather than disaggregated. It is, therefore, assumed that the government maximises the following utility function:

$$U = \alpha_0 - \frac{\alpha_1}{2}(I_g - I_g^*)^2 - \frac{\alpha_2}{2}(G - G^*)^2 - \frac{\alpha_3}{2}(T - T^*)^2 - \frac{\alpha_4}{2}(A - A^*)^2 - \frac{\alpha_5}{2}(B - B^*)^2 \quad [32]$$

with $\alpha_i \succ 0$.

Similarly, this utility function is maximised subject to the following two constraints:

$$I_g + G = B + T + A \qquad [33]$$

$$G \leq \rho_1 T + \rho_2 A + \rho_3 B \qquad [34]$$

with $0 \leq \rho_i \leq 1$.

Turning the inequality in [33] into an equality sign, applying the Lagrangean to the maximisation problem and partially differentiating it with respect to each endogenous variable and the two Lagrange multipliers gives the following set of first-order conditions:

$$\frac{\partial L}{\partial I_g} = -\alpha_1(I_g - I_g^*) + \lambda_1 = 0 \qquad [35]$$

$$\frac{\partial L}{\partial G} = -\alpha_2(G - G^*) + \lambda_1 + \lambda_2 = 0 \qquad [36]$$

$$\frac{\partial L}{\partial T} = -\alpha_3(T - T^*) - \lambda_1 - \lambda_2 \rho_1 = 0 \qquad [37]$$

$$\frac{\partial L}{\partial A} = -\alpha_4(A - A^*) - \lambda_1 - \lambda_2 \rho_2 = 0 \qquad [38]$$

$$\frac{\partial L}{\partial B} = -\alpha_5(B - B^*) - \lambda_1 - \lambda_2 \rho_3 = 0 \qquad [39]$$

$$\frac{\partial L}{\partial \lambda_1} = I_g + G - B - T - A = 0 \qquad [40]$$

$$\frac{\partial L}{\partial \lambda_2} = G - \rho_1 T - \rho_2 A_1 - \rho_3 B = 0 \qquad [41]$$

Assuming that the borrowing target is set equal to zero we can derive the structural equations as follows[9]:

$$
\begin{aligned}
I_g = {} & (1-\rho_1)\beta_1 I_g^* + (1-\rho_1)\beta_2 G^* \\
& +(1-\rho_1)[1-(1-\rho_1)\beta_1 - \rho_1\beta_2]T^* \\
& +[(1-\rho_2)-(1-\rho_1)(1-\rho_2)\beta_1 - (1-\rho_1)\rho_2\beta_2]A \\
& +[(1-\rho_3)-(1-\rho_1)(1-\rho_3)\beta_1 - (1-\rho_1)\rho_3\beta_2]B
\end{aligned} \qquad [42]
$$

$$
\begin{aligned}
G = {} & \rho_1\beta_1 I_g^* + \rho_1\beta_2 G^* + \rho_1[1-(1-\rho_1)\beta_1 - \rho_1\beta_2]T^* \\
& +[\rho_2 - \rho_1(1-\rho_2)\beta_1 - \rho_1\rho_2\beta_2]A \\
& +[\rho_3 - \rho_1(1-\rho_3)\beta_1 - \rho_1\rho_3\beta_2]B
\end{aligned} \qquad [43]
$$

$$
\begin{aligned}
T = {} & \beta_1 I_g^* + \beta_2 G^* + [1-(1-\rho_1)\beta_1 - \rho_1\beta_2]T^* \\
& -[(1-\rho_2)\beta_1 + \rho_2\beta_2]A \\
& -[(1-\rho_3)\beta_1 + \rho_3\beta_2]B
\end{aligned} \qquad [44]
$$

$$
\begin{aligned}
A = {} & \beta_3 I_g^* + \beta_4 G^* - [(1-\rho_1)\beta_3 + \rho_1\beta_4]T \\
& +[1-(1-\rho_2)\beta_3 - \rho_2\beta_4]A^* \\
& -[(1-\rho_3)\beta_3 + \rho_3\beta_4]B
\end{aligned} \qquad [45]
$$

$$
\begin{aligned}
B = {} & \beta_5 I_g^* + \beta_6 G^* - [(1-\rho_1)\beta_5 + \rho_1\beta_6]T \\
& -[(1-\rho_2)\beta_5 + \rho_2\beta_6]A
\end{aligned} \qquad [46]
$$

where

$$\beta_1 = \frac{(\alpha_1-\rho_1)}{\theta_1}, \beta_2 = \frac{\alpha_2\rho_1}{\theta_1}, \beta_3 = \frac{\alpha_1(1-\rho_2)}{\theta_2}; \beta_4 = \frac{\alpha_2\rho_2}{\theta_2}; \beta_5 = \frac{\alpha_1(1-\rho_3)}{\theta_3}$$

and

$$\theta_1 = \alpha_1(1-\rho_1)^2 + \alpha_2\rho_1^2 + \alpha_3; \theta_2 = \alpha_1(1-\rho_2)^2 + \alpha_2\rho_2^2 + \alpha_4;$$

$$\theta_3 = \alpha_1(1-\rho_3)^2 + \alpha_2\rho_3^2 + \alpha_5$$

[9] It is, perhaps, worth mentioning that some of the parameters reported here are different to those reported in Franco-Rodriguez *et al*. (1998). However, recent work by McGillivray and Ahmed (1999), Franco-

The system of structural equations [42] to [46] can then be solved through to obtain the reduced form equations as follows:

$$I_g = \delta_1 I_g^* + \delta_2 G^* + \delta_3 T^* + \delta_4 A^* \qquad [47]$$

$$G = \delta_5 I_g^* + \delta_6 G^* + \delta_7 T^* + \delta_8 A^* \qquad [48]$$

$$T = \delta_9 I_g^* + \delta_{10} G^* + \delta_{11} T^* + \delta_{12} A^* \qquad [49]$$

$$A = \delta_{13} I_g^* + \delta_{14} G^* + \delta_{15} T^* + \delta_{16} A^* \qquad [50]$$

$$B = \delta_{17} I_g^* + \delta_{18} G^* + \delta_{19} T^* + \delta_{20} A^* \qquad [51]$$

where[10]

$$\delta_4 = \left[\frac{\gamma_3 - \rho_2\gamma_2}{\alpha_1(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_8 = \left[\frac{(\gamma_3 - \gamma_2) + \rho_2(\gamma_1 - \gamma_2)}{\alpha_2(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{12} = -\left[\frac{(\gamma_3 - \rho_1\gamma_2) + \rho_2(\rho_1\gamma_1 - \gamma_2)}{\alpha_3(\gamma_1\gamma_3 - \gamma_2^2)}\right];$$

$$\delta_{16} = \left[1 - \frac{(\gamma_3 - \rho_2\gamma_2) + \rho_2(\rho_2\gamma_1 - \gamma_2)}{\alpha_4(\gamma_1\gamma_3 - \gamma_2^2)}\right]; \delta_{20} = -\left[\frac{(\gamma_3 - \rho_3\gamma_2) + \rho_2(\rho_3\gamma_1 - \gamma_2)}{\alpha_5(\gamma_1\gamma_3 - \gamma_2^2)}\right].$$

and

$$\gamma_1 = \frac{1}{\alpha_2} + \frac{1}{\alpha_2} + \frac{1}{\alpha_3} + \frac{1}{\alpha_4} + \frac{1}{\alpha_5};$$

$$\gamma_2 = \frac{1}{\alpha_2} + \frac{\rho_1}{\alpha_3} + \frac{\rho_2}{\alpha_4} + \frac{\rho_3}{\alpha_5};$$

$$\gamma_3 = \frac{1}{\alpha_2} + \frac{\rho_1^2}{\alpha_3} + \frac{\rho_2^2}{\alpha_4} + \frac{\rho_3^2}{\alpha_5}$$

Rodriguez (2000) and more recently McGillivray (2002) confirm that the structural equations [41] to [45] are rightly derived.

[10] As in the previous case of the model with disaggregated aid we only report the parameters related to the coefficients of aid.

5. Conclusions

Building on recent developments in fiscal response modelling (Franco-Rodriguez *et al*. (1998)) as well as on recent work by Mavrotas (2002) which focused on the important, though neglected in the aid effectiveness literature, aid disaggregation issue, the present paper develops a new fiscal response model, which, for the first time in the relevant literature, endogenises the main four components of foreign aid.

We endogenised aid variables on the grounds that the disbursement of each category of aid is a government policy choice. With regard to aid disaggregation, there is an argument that each of the four main categories of aid, namely project aid (A1), programme aid (A2), technical assistance (A3) and food aid (A4) may exert different effects on the recipient economy. Furthermore, and more importantly, in case the preferences of the recipient government are higher for some of these types of aid, not disaggregating aid might lead to aggregation bias in the results and conclusions and hence lead to misleading policy recommendations.

Specifying the budget constraints as in Franco-Rodriguez *et al*. (1998), the model is then solved to obtain both the structural equations (capturing the direct impacts on the endogenous variables) and the reduced form equations (which capture the total impacts).

A second model in which aid is included in aggregated form is also presented and both the structural and reduced form equations were derived. This will allow the disaggregated model to be tested in the empirical stage and ensure that the bias associated to most aid effectiveness studies is highlighted. Moreover, presenting both models could help other researchers interested in future empirical work to compare results of aggregated aid and disaggregated aid models so that significant policy implications can be derived.

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