CHRISTIAN FRIIS BACH AND ALAN MATTHEWS*

International Transfers and Food Security

INTRODUCTION

This paper uses RunAid, a global computable general equilibrium (CGE) model based on the GTAP modelling framework, to evaluate the effect of different development aid strategies in improving food security in developing countries. Food security is defined as a reduction in the numbers undernourished. The issue explored is whether the form of development aid has different impacts on food security. Three alternatives are examined: (a) untied programme aid (balance of payments support), (b) aid to promote agricultural investment in developing countries, and (c) food aid. To test the 'Food First' argument that, within the agricultural sector, promoting foodgrain production yields a bigger improvement in food security than encouraging cash or export crops, the nutrition impact of confining agricultural investment aid to foodgrains or to cash crops, respectively, is also examined. The CGE modelling framework captures both the price (food availability) and income (purchasing power) dimensions to undernutrition and thus can adjudicate on their relative importance given the particular economic structures in developing countries.

The CGE framework used is based on the GTAP applied general equilibrium model of the world economy (Hertel, 1997) and the GTAP database (version 4, with 1995 as the base year) (McDougall *et al.*, 1998). The model is solved using GEMPACK (Harrison and Pearson, 1996). The full version of the GTAP database covers 50 commodities and 45 regions. To keep the model within computational limits and focus on the issues of interest, the data are aggregated to nine regions and 15 commodities. The regions are the European Union (EU), Japan (JPN), the USA (US), sub-Saharan Africa (SSA), South Asia (SAS), East Asia (EAS), High Income Asia (HAS), Latin America (LTN) and the Rest of World (ROW). Commodities included are paddy rice, wheat, other grains, vegetables and fruit, other crops, unprocessed livestock and livestock products, natural resources, meat, vegetable oils and fats, dairy products, processed rice, sugar, other food products, manufactures and services.

To be able to capture the effects of international transfers, the standard global general equilibrium model (GTAP) has been modified in a number of ways. Development aid is introduced by simply adding a transfer variable to

*Christian Friis Bach, Royal Veterinary and Agricultural College, Denmark; Alan Matthews, Trinity College, Dublin, Ireland.

the income equations in each region. The restriction on the use of development aid to investment in agriculture is introduced as a separate equation that links the level of development aid to a capital subsidy in agriculture. Simplified, the equation becomes in the levels:

$$\sum_{cap}\sum_{agr}(pm_{cap,r} - pfe_{cap,agr,r}) \cdot qfe_{cap,agr,r} = AID_r,$$

where *pm* is the market price of capital, *pfe* the price of capital faced by the producer, *qfe* the quantity of capital endowment used in agriculture and *AID* the total aid level. The equation ensures that the total subsidy expenditure is equal to the amount of aid. The food aid experiment is modelled as an export subsidy which reduces the price of imported food to the recipient. This is intended to capture the characteristics of programme food aid in which food commodities are made available directly to recipient governments which then release them into normal marketing channels. The restriction is modelled by linking the amount of aid to the total expenditure on export subsidies on food from the donor country to the recipient:

$$\sum_{food}(pm_{food,r} - pfob_{food,r,s}) \cdot qxs_{food,r,s} = FOODAID_{r,s},$$

where *pm* is the market price of food in the donor, *pfob* is the f.o.b. price of food from donor to recipient, *qxs* the quantity exported and *FOODAID* the total amount of food aid.

The alternative development aid strategies are evaluated by their effects on nutritional status as well as by their effects on overall welfare. Nutritional status is measured by average per capita daily calorie intake. For this purpose FAO data on calories provided by different food groups have been mapped to GTAP (and subsequently RunAid) commodities. Using this mapping, average daily per capita calorie intakes are calculated using the food expenditure patterns generated in each RunAid experiment.

The advantage of the GTAP framework is that it allows simulations of alternative scenarios to be performed in an internally consistent way, and that interpretation of the results using the GTAP model can lead to a deeper understanding of the issues under investigation. A limitation of the GTAP model framework for food security analysis is that it works with a single representative household. If food-insecure households are disproportionately found among food purchasers rather than food sellers, then changes in food prices may have consequences for food security which are masked in the GTAP aggregation. Some attempt was made to account for distributional impacts, as follows.

Estimates of changes in the prevalence of malnutrition in different policy scenarios as measured by the proportion and number of people with inadequate access to food were generated using exogenous information on the distribution of food consumption. The estimates are made using the methodology devised by FAO for its *World Food Surveys*. The distribution of per capita calorie consumption within each country is assumed to be log-normal so that the levels of energy consumption throughout a population can be calculated simply from the mean and the standard deviation. Based on the average calorie intake in each country and on a value of the coefficient of variation (CV) derived from the FAO *World Food Survey*, the distribution of per capita calorie consumption for each country is generated. From this, the proportion and number of the population that consumes less than the minimum requirement is calculated. The distribution of calorie intake is assumed not to change between experiments. While this is an unsatisfactory assumption, it is the same as that used by FAO in tracking the numbers undernourished through time in successive *World Food Surveys*.

RUNAID EXPERIMENTS

Two sets of simulations are performed with the model, and within each set a number of experiments are run, as follows.

The first set investigates an approximately 20 per cent increase in EU aid to sub-Saharan Africa (SSA) amounting to $6 billion. The benchmark experiment (A1) is an unrestricted transfer of cash aid (equivalent to programme aid or pure balance-of-payments support). In other experiments, the effect of providing development aid for agricultural investment (A2) and as food aid (A3) are examined. As noted above, agricultural investment aid is modelled as providing a capital subsidy to agricultural production. In the foodgrain experiment (A2F), this subsidy is restricted to rice, wheat and other grain production, while in the cash crop experiment (A2C), it is restricted to fruit and vegetable production, other crops (including oilseeds and tropical beverages as well as pulses, roots and tubers) and livestock production. As an additional $6 billion of food aid to SSA alone would swamp existing flows (and, in modelling terms, lead to an infeasible solution), the experiment modelled is one where $1 billion of the additional aid is provided in the form of food aid and the remaining $5 billion is maintained as unrestricted aid. This relatively marginal change should be taken into account in comparing the results of this experiment with the baseline experiment of all restricted aid.

The second set of simulations distributes the increase in EU help proportionately across the four developing country regions in RunAid. This enables us to investigate the impact of economic structure in influencing the relationship between aid delivery and nutrition impact. The addition to regional income in each case amounts to 0.19 per cent of GNP. The same five experiments are performed as for the first set of simulations, with the one difference that on this occasion the food aid experiment allocates all of the additional aid to export subsidies on food from the EU.

RESULTS

The results of the experiments simulating different forms of EU assistance to SSA are shown in Table 1. Consider first the 'baseline' shock of an unrestricted

TABLE 1 *Food security impacts of EU aid on SSA*

Variable	Unrestricted aid	Agricultural investment	Food crop investment	Cash crop investment	Food aid
Experiment	A1	A2	A2F	A2C	A3
Equivalent variation ($m.)	7 707.9	7 917.4	5 938.4	7 749.6	6 948.4
Per capita utility (%)	2.75	2.83	2.12	2.77	2.48
Agric output (%)	–0.2	2.8	0.0	3.1	–0.2
Agric prices (%)	2.1	–1.3	0.3	–0.7	1.5
Food prices (%)	2.0	–1.0	–0.5	0.0	1.2
Daily calorie increase (cals)	44.2	64.6	57.0	58.3	43.5
Daily calorie increase (%)	2.0	3.0	2.6	2.7	2.0
Per cent undernourished (%)	33.4	32.4	32.8	32.7	33.4
Numbers undernourished (m.)	–12.5	–18.0	–16.0	–16.3	–12.2
Memo item EU changes:					
Equivalent variation ($m.)	–7 944.76	–7 400.85	–7 235.66	7 576.25	–8 293.93

aid transfer (experiment A1). The magnitude of the aid shock corresponds to 2.2 per cent of SSA GNP, and leads to an overall increase in per capita household utility of 2.8 per cent. Agricultural production falls slightly, despite a rise in agricultural prices of 2.1 per cent, as resources are shifted into non-agricultural production. Food prices overall rise by 2.0 per cent. However, because of higher overall incomes, there is an increase in daily calorie intake of 44 calories per head per day, or 2 per cent. This is sufficient to lift around 12.5 million people out of hunger, under the maintained assumption that the distribution of calorie intake is unchanged.

If the aid is tied to agricultural investment (experiment A2), then the overall increase in welfare and utility is slightly higher. Overall calorie intake increases by 65 calories or by 3.0 per cent and around 18 million people are moved out of hunger. From a food security perspective, tying aid to agricultural investment is a strategy preferable to allowing recipient governments to make unrestricted use of this aid. Does it make any difference if aid is directed to particular production sectors within SSA agriculture? Experiments A2F and A2C compare the consequences of restricting agricultural investment aid to food grain and cash crop production, respectively. It turns out that neither option outperforms the general investment aid experiment, this time confirming the view that restrictions reduce the value of aid to recipients.

The food aid experiment involves transferring one-sixth of the overall aid increase in the form of food aid and is thus hard to compare directly to the investment aid experiments. Compared to the baseline experiment, however, tying part of the additional aid to food aid reduces its overall welfare impact on the recipient and slightly lessens its food security impact. Domestic output of the food aid commodities declines, quite sharply in the case of wheat, which is a common criticism of programme food aid. Agricultural and food prices rise in a more restrained fashion compared with the baseline and the net impact (of a lower income increase but also of lower food price increases) is to reduce slightly the food security impact of the aid transfer.

The economic cost to the EU of making the same aid transfer in different ways also differs. In each case the cost of the transfer is greater than the transfer itself, but providing food aid turns out to be a particularly costly way for the EU to provide development assistance. This is because of the combination of the additional production distortions introduced by tying aid in this way, as opposed to making a straight transfer, together with the different general equilibrium effects of the way the different transfers are used in the recipient region.

We now turn to the second set of simulations which investigate the impact of regional economic structure on these results (Table 2). The ranking of different aid policies in terms of welfare measures is the same as in the first set of simulations. The only noteworthy feature is that, in this set, all additional aid is given as food aid and the welfare effects are very attenuated. The food security impacts are relatively slight on an annual basis. The aid shock applied is a 20 per cent increase in aid from the EU which currently accounts for about 40 per cent of all aid and is thus equivalent to an 8 per cent increase in total official development assistance (ODA). This increase leads to a maximum improvement in all developing country regions in calorie intake of about 0.35 per cent. Even if this was cumulative over a ten-year period, this amounts to an increase of just 3.5 per cent. In terms of the numbers malnourished, in some scenarios up to 9 million people could be removed from the hunger trap which again, if cumulative, would amount to 90 million people or just over 10 per cent of the estimated total malnourished in the world. Clearly, international assistance, however crucial, can only play a supporting role in meeting the World Food Summit target of a halving of the numbers malnourished by 2015. Spreading aid more widely has a smaller impact on hunger than concentrating it. The numbers removed from hunger in the second set of simulations vary between four and nine million, compared to 12–18 million if the aid increase were concentrated on SSA alone.

Given these generally minor impacts, it is important to know how the food security impact of additional aid transfers can be maximized. Unambiguously, the greatest food security impact in all regions occurs from foodgrain-focused investment aid (Latin America is an exception, where cash crop investment aid is slightly more powerful, though both are considerably more effective than other options). For SSA, this reverses the earlier conclusion that unrestricted investment aid dominates investment aid for either foodgrains or cash crops alone. This is a general equilibrium result and reflects the fact that the food security outcome is different where aid is being given to a number of competing regions simultaneously. We can hypothesize that the food security benefits

TABLE 2 *Impact of alternative EU aid strategies on four developing country regions*

Variable	Unrestricted aid	Agricultural investment	Food crop investment	Cash crop investment	Food aid
Equivalent variation (US$)					
SSA	707.19	818.47	733.55	829.46	332.32
EAS	2 313.45	2 555.46	2 513.05	2 544.85	253.13
SAS	954.30	1 101.86	1 064.04	1 110.74	139.96
LTN	3 813.10	4 154.74	4 179.88	4 127.15	480.37
Per capita utility (%)					
SSA	0.25	0.29	0.29	0.29	0.12
EAS	0.20	0.22	0.22	0.22	0.02
SAS	0.24	0.28	0.28	0.28	0.04
LTN	0.26	0.28	0.28	0.28	0.03
Daily calorie increase (cals)					
SSA	3.70	5.44	7.42	5.32	3.78
EAS	2.74	5.26	6.11	5.54	1.83
SAS	1.86	3.30	4.26	3.20	1.49
LTN	4.58	7.05	7.95	8.13	1.83
Daily calorie increase (%)					
SSA	0.17	0.25	0.34	0.24	0.17
EAS	0.11	0.22	0.25	0.23	0.07
SAS	0.08	0.14	0.18	0.14	0.06
LTN	0.17	0.26	0.29	0.30	0.07
Per cent undernourished (%)					
SSA	35.3	35.2	35.2	35.3	35.3
EAS	24.7	24.6	24.5	24.5	24.7
SAS	20.5	20.4	20.4	20.4	20.5
LTN	13.9	13.8	13.8	13.8	14.0
Nos undernourished (m.)					
SSA	−1.06	−1.56	−2.12	−1.52	−1.08
EAS	−1.86	−3.56	−4.13	−3.75	−1.24
SAS	−1.01	−1.79	−2.31	−1.74	−0.81
LTN	−0.56	−0.86	−0.97	−0.99	−0.22
Total	−4.49	−7.77	−9.53	−8.00	−3.35
Marginal increase in calorie intake per capita due to $100m. aid (cals)					
SSA	0.71	1.04	1.41	1.01	0.72
EAS	0.52	1.00	1.16	1.06	0.35
SAS	0.35	0.63	0.81	0.61	0.28
LTN	0.87	1.34	1.52	1.55	0.35
Marginal number of persons removed from hunger due to $100 m. aid (000s)					
SSA	−2.023	−2.974	−4.052	−2.907	−2.068
EAS	−3.545	−6.796	−7.879	−7.150	−2.361
SAS	−1.926	−3.412	−4.410	−3.310	−1.550
LTN	−1.063	−1.633	−1.840	−1.883	−0.425

of investing in cash crops are reduced if one's competitors are investing simultaneously, a variant of the well-known 'fallacy of composition' argument often made with respect to this kind of investment. In this set of simulations, where food aid transfers can be directly compared to all other options, food aid is clearly the worst performing option.

The results confirm that there are significant differences in food security impacts across regions. For all aid delivery options, the greatest impact on undernutrition is achieved in East Asia. This is not an obvious result. For example, it might be hypothesized that the greatest impact would be achieved by directing aid to the region with the lowest per capita calorie intake (SSA) or the region with the most equal distribution of food intake (SAS) but in neither case is this true. Exploring the reasons for the larger nutrition multipliers in East Asia is a fruitful avenue for further work.

CONCLUSIONS

This paper has examined the effectiveness of different aid strategies in combating hunger and malnutrition in developing countries. It uses the GTAP general equilibrium modelling framework and modifies it in a number of directions. First, methods are suggested to model different types of development assistance in the GTAP framework. Unrestricted development aid is introduced by adding a transfer variable to the income equations in each region. Investment aid is modelled as a capital subsidy to agriculture, and food aid is modelled as an export subsidy provided by the donor. Second, the GTAP database is extended to include a calorie database using FAO calorie intake statistics and a number of allocation rules to map these data on GTAP expenditure categories. Third, some attempt was made to overcome the drawback of the GTAP assumption of a single representative household in analysing food security, which is primarily a distributional issue, by making use of exogenous information on the distribution of food intake in each region, although the assumption had to be maintained that this initial distribution was unaffected by the changes in economic structure induced by each aid scenario.

While the inability to account fully for distributional changes is a weakness of the GTAP modelling framework in analysing food security issues, there are compensating advantages. Food security is a general equilibrium phenomenon; the net impact of a policy change on food security must take into account the impact on food availability (reflected in food prices) as well as on income. Furthermore, it would be hard to address the questions raised in this paper in an alternative framework. Some of the findings run counter to conventional wisdom, and at least provide grounds for thinking through the rationale for these findings to assess their possible relevance in real-world policy making.

An important finding is that, although international assistance may be crucial in supporting developing countries' efforts to alleviate hunger, its impact relative to the scale of the problem in the absence of structural changes in patterns of distribution can only be marginal. The results suggest that a 20 per cent increase in EU aid flows has the potential to decrease the number of hungry people by

4–9 million annually, although if this aid was concentrated on SSA alone the impact would be greater, with the numbers malnourished falling by 12–18 million. The paper estimates food security impact multipliers ranging from 1000 to 8000 persons removed from hunger (depending on region and the method of aid delivery) for every additional $100 million in aid. Taking a round figure of 800 million malnourished people in the world today, and assuming that aid impacts are cumulative over the period 1995–2015, this would necessitate an increase in aid flows by $250 billion annually – a quadrupling of aid – under the most optimistic multiplier estimate to reach the World Food Summit target of halving the numbers malnourished by the end of the period. The major effort to achieve this target, as the Summit's Rome Declaration recognized, must be made by the developing countries themselves. However, it is unlikely to be achieved without focused measures aimed at altering the distribution of food intake in favour of the poor and undernourished. In other words, investment strategies need to be geared towards resource-poor farmers or disadvantaged urban groups if alleviating malnutrition is a priority policy goal. This conclusion has been argued many times previously, most recently in the FAO's *Sixth World Food Survey*, which contains illustrative projections of the impact of different distributional assumptions on the hunger problem.

From a donor perspective, the most important finding is that nutrition impacts can be maximized by focusing development assistance on agricultural investment, and particularly investment in foodgrain production. Unfortunately, not only has development assistance in total been falling in recent years, but aid to support agricultural production has been falling even faster. The reasons for this include the poor performance of agricultural projects in the past, the rundown of agricultural expertise in major lending and donor institutions, crowding out by other sectoral uses of aid (including debt relief, the social sector and the environment) and limited political support for agricultural aid in both donor agencies and recipient governments (Matthews, 1999). This paper lends support to calls for the renewal of efforts to channel donor resources into agricultural production as the most cost-effective way of tackling hunger. The results also support the criticism of food aid in terms both of its value to recipients and of its greater cost to donors than other forms of aid transfer.

REFERENCES

FAO (1996), *Sixth World Food Survey*, Rome: FAO.

Harrison, W.J. and Pearson, K.R. (1996), 'Computing Solutions for Large General Equilibrium Models using GEMPACK', *Computational Economics*, **9**, 83–127.

Hertel, T. (ed.) (1997), *Global Trade Analysis: Modeling and Applications*, Cambridge: Cambridge University Press.

McDougall, R.A., Elbehri, A. and Truong, T.P. (1998), *Global Trade Assistance and Protection: The GTAP 4 Data Base*, Purdue University: Center for Global Trade Analysis.

Matthews, A. (1999), 'International development assistance and food security', in K. Gupta, (ed.), *Foreign Aid: New Perspectives*, London: Kluwer Academic Publishers.