6. Twenty-worlds models: the optimal geographical distribution of development assistance

6.1 A SIMPLIFIED GEOGRAPHICAL PICTURE OF THE NON-COMMUNIST WORLD

In this chapter the optimal distribution of development assistance over donor countries will be studied.

Development co-operation in the restricted sense as considered in this book is a policy with national governments as policy makers. The number of the world's nations is 159 and their size is very different. A model of intergovernmental development co-operation, in order to be treatable, must work with a smaller number of geographical units. Again we owe to Kravis and his collaborators (Kravis *et al.*, 1978) a collection of figures that enables us to work with twenty geographical units, each with close to 5 per cent of the population of W1 + W3. From Table 6 of their article we derive the survey of Table 6.11.

Table 6.11 Twenty geographical areas with approximately equal populations, 1970

Developed areas Country groups	Population per cent of total		Underdeveloped areas Country groups	Population per cent of total	
North America	9.4	(2)	African	13.6	(3)
European Community	10.4	(2)	Asian	44.6	(9)
Other Europe	4.9	(1)	Latin American	11.2	(2)
Rest of developed world	6.0	(1)			
Total	30.7	(6)		69.4	(14)

Figures in parentheses indicate number of 5 per cent areas used in our simplified geographical picture.

It is with satisfactory approximation that the population percentages can be rounded to multiples of 5 per cent: the deviations from such multiples being, respectively, 6, 4, 2, 20, 9, 1 and 2, and the average deviation 4.1 per cent. Below we develop models with twenty areas of 5 per cent of the population of W1 + W3.

6.2 OPTIMAL DEVELOPMENT ASSISTANCE IN A TWENTY-WORLDS MODEL WITH LOGARITHMIC WELFARE FUNCTIONS

Developed areas will be indicated by an index i $(1, 2, \ldots, I)$ and developing areas by an index j $(1, 2, \ldots, J)$, with $I + J = 20$ (6.21)
Assistance paid will be indicated by v_{i0} and assistance received by v_{0j}; evidently

$$\sum^{I} v_{i0} = \sum^{J} v_{0j} \tag{6.22}$$

Further restrictions are:

$$(\mathrm{R}i)\quad x_i = y_i + v_i \qquad i = 1, 2, \ldots, I \tag{6.23}$$

$$(\mathrm{R}j)\quad x_j = y_j - v_j \qquad j = 1, 2, \ldots, J \tag{6.24}$$

Maximizing world welfare under the restrictions enumerated then requires the maximization of:

$$\Omega = \sum_i \ln (y_i + 1) + \sum_j \ln (y_j + 1) + \sum_i \lambda_i (x_i - y_i - v_i)$$

$$+ \sum_j \lambda_j (x_j - y_j + v_j) + \mu (\sum_i v_i - \sum_j v_j)$$

The maximum conditions are:

$$1/(y_i + 1) - \lambda_i = 0 \tag{6.25}$$

$$1/(y_j + 1) - \lambda_j = 0 \tag{6.26}$$

$$-\lambda_i + \mu = 0 \tag{6.27}$$

$$\lambda_j - \mu = 0 \tag{6.28}$$

It follows that all y_i = all $y_j = c$, say.
Addition of all (Ri) and (Rj) then yields:

$$\sum_i x_i + \sum_j x_j = (I + J)\, c = 20c \tag{6.29}$$

Table 6.21 *Calculation of $y_i = y_j = c$ and of development assistance v_{i0} and v_{0j} for the twenty areas of the non-communist world (in descending order of x_i, x_j), as set out in text,* per capita *in 1975 US$*

Areas	*Per cap.* product x	v_{i0}, v_{0j}	Total[1] transfers	% of x_i
North America	$x_1 = x_2 = 4708$	3377(= 4708 – 1371)	2 × 3337 = 6674	71
European Community	$x_3 = x_4 = 3185$	1814(= 3185 – 1371)	2 × 1814 = 3628	57
Developed outside Amer. and Eur.	$x_5 = 2641$	1270(= 2641 – 1371)	1270	41
Other European developed	$x_6 = 1913$	542(= 1913 – 1371)	541	28
Latin American underdeveloped	$x_7 = x_8 = 1191$	180(= 1371 – 1191)	2 × 180 = 360	
African underdeveloped	x_9 to $x_{11} = 412$	959(= 1371 – 412)	3 × 959 = 2877	
Asian underdeveloped	x_{12} to $x_{20} = 384$	987(= 1371 – 384)	9 × 987 = 8883	

$X + \Sigma x_i + \Sigma x_j = 27414$ Upper part: donor areas

$c = 27414/20 = 1371$ Lower part: receiving areas

[1]Total: transfers (donated or received) by all units of 5 per cent of area considered, if each unit is represented by one person. In order to obtain actual total transfers all figures must be multiplied by 5 per cent of 'world' population.

Table 6.22 *Calculation of $y_i = y_j = c$ and of development assistance v_{i0} and v_{0j} for the twenty areas of the non-communist world (in descending order of x_i, x_j), in nominal $*

Areas	*Per cap.* product x	v_{i0}, v_{0j}	Total transfers	% of x_i	
North America	$x_1 = x_2 = 4705$	3683(= 4705 – 1022)	2 × 3683 = 7368	78	
European Community	$x_3 = x_4 = 2464$	1442(= 2464 – 1022)	2 × 1442 = 2884	59	65
Developed outside Amer. and Eur.	$x_5 = 1825$	803(= 1825 – 1022)	803	44	
Other European developed	$x_6 = 1325$	303(= 1325 – 1022)	303	23	
			11358		
Latin American underdeveloped	$x_7 = x_8 = 585$	437(= 1022 – 585)	2 × 437 = 874		
African underdeveloped	x_9 to $x_{11} = 176$	846(= 1022 – 176)	3 × 846 = 2538		
Asian underdeveloped	x_{12} to $x_{20} = 139$	883(= 1022 – 139)	9 × 883 = 7947		
			11359		

$X = \Sigma x_i + \Sigma x_j = 17488 + 2549 = 20437$ Upper part: donor areas

$c = 20437/20 = 1022$ Lower part: receiving areas

Average percentage of income spent on development assistance: 65

Hence

$$c = \frac{X}{20}$$

where X is total income of W1 + W3.

The development assistance to be given and to be received follows for each i and j from (Ri) and (Rj):

$$v_{i0} = x_1 - c \qquad i = 1, 2, \ldots, I$$
$$v_{0j} = c - x_j \qquad j = 1, 2, \ldots, J$$

The value of I is the number of areas for which $x_i > c$, and the value of J is the number of areas for which $c > x_j$. Their values are unknown *a priori* but follow from the value of c. In Table 6.21 the calculation of c and of the v_{i0} and v_{0j} is shown.

The most important new feature of the development assistance figures found is that they are not equal percentages of national product. The figures on national product are expressed in purchasing power, which is more equitable than using nominal incomes. With nominal incomes the figures of Table 6.21 would have been as indicated in Table 6.22. This would mean a heavier burden on the high-price donor nations and a lower burden on the low-price donor countries.

6.3 PARABOLIC WELFARE FUNCTIONS

Maximum world (W1 + W3) welfare will be obtained if

$$\Omega = \sum_i (y_{oi} - y_i)^2 + \sum_j (y_{oj} - y_j)^2 = 0 \qquad (6.31)$$

under the restrictions:

$$x_i = y_i + v_{i0} \quad (i = 1, 2, \ldots, I) \qquad (I \text{ equations}) \qquad (6.32)$$
$$x_j = y_j - v_{0j} \quad (j = 1, 2, \ldots, J) \qquad (J \text{ equations}) \qquad (6.33)$$
$$\sum v_{i0} = \sum v_{0j} \qquad (1 \text{ equation}) \qquad (6.34)$$

Maximum conditions are now:

$$y_{0i} = y_i \qquad (i = 1, 2, \ldots, I) \qquad (I \text{ equations}) \qquad (6.35)$$
$$y_{0j} = y_j \qquad (j = 1, 2, \ldots, J) \qquad (J \text{ equations}) \qquad (6.36)$$

The number of unknown variables is 60: 20 y_{i0} and y_{0j} the satiation values, 20y_i and y_j and 20 v_{i0} and v_{0j}. The number of equations so far amounts to 41, leaving us with 19 degrees of freedom. We choose 19 equity equations. In their simplest form, assuming that the degree of schooling of the population of each area is the same, these equity conditions might be

$$y_i = y_j = c \quad \text{for all } i \text{ and } j \qquad \text{(19 equations)}$$

We shall deal with a more sophisticated form below.

The solution of our present version of the optimum problem is obtained by addition of all (6.32) and (6.33), leading to:

$$X = \Sigma x_i + \Sigma x_j = \Sigma y_i \quad \Sigma y_j = 20c \tag{6.37}$$

$$\text{or:} \quad c = X/20 \tag{6.38}$$

From equations (6.32) and (6.33) we obtain all v_{i0} and v_{0j}.

This solution is identical to the solution of Section 6.2, where welfare functions are logarithmic. Table 6.21 shows this solution.

An alternative solution is obtained if we choose a more sophisticated set of equity conditions, namely:

$$y_i = \eta x_i + \eta_0, \ \eta < 1 \tag{6.39}$$

This reflects the assumption that populations with a higher production *per capita* must have a higher level of ability, obtained by schooling, experience and scientific research. The value of η has not been estimated, as far as the author knows. Its measurement constitutes an interesting research programme. As an example, to show the consequences it has been assumed that $\eta = 0.3$.

The solution of our optimum problem starts again with the equation (6.37) which now takes the form

$$X = \Sigma x_i + \Sigma x_j = \eta(\Sigma x_i + \Sigma x_j) + 20\,\eta_0$$

and hence

$$(1 - \eta)\,X = 20\,\eta_0 \tag{6.310}$$

If $\eta = 0.3$ we find that $\eta_0 = 0.7 \times 27414 = 19190$ and $\eta_0 = 959.5$. Table 6.31 gives the complete solution of this more refined approach.

Table 6.31 Calculation of y_i and y_j and the development assistance variables v_{io} and v_{oj} for the twenty areas of the non-communist world if levels of schooling and research differ

Areas[1]	x	n[2]	0.3x	$y=\eta_0+0.3x$	$v=x-y$	nv	nx	v/x in %
NA	4708	2	1412	2372	2336	4672	9416	50
EC	3185	2	956	1916	1269	2538	6370	40
OAE	2641	1	792	1752	889	889	2641	34
OE	1913	1	574	1534	379	379	1913	20
LA	1191	2	357	1317		–126	–252	
Af	412	3	124	1084		–672	–2016	
As	384	9	115	1075		–691	–6219	
$X = \Sigma x_i + \Sigma x_j =$ 27414; $\eta_o = 959.5$						8478	–8487	20340

[1]See Table 6.21
[2]Number of Areas
[3]Average v as a percentage of x:48

Table 6.31 shows that total transfers donated are equal to total transfers received (within an error by rounding of 0.1 per cent) and that the percentages of income to be transferred by donor countries are considerably lower than in Table 6.21.

It seems interesting to ask what values of η and η_0 would be needed in order to attain as the optimal level of development assistance the wellknown 0.7 per cent of the average donor country. Using the formulae (6.32), (6.33), (6.34), (6.39) and (6.310), we obtain

$$v_{i0} = (1-\eta)(x_i - X/20)$$

and $$\eta_0 = (1-\eta)\, X/20$$

Requiring that $\Sigma_i v_{i0} = 0.007\ \Sigma_i x_i$ we obtain from the x_i in Table 6.21:

$$0.007 = (1-\eta) \times 0.60$$

which, for the six donor areas, yields:

$v_{10} = v_{20} =$	$0.01167 \times 3337 = 39$,	as a percentage of x_i	0.83
$v_{30} = v_{40} =$	$0.01167 \times 1814 = 21$,		0.66
$v_{50} =$	$0.01167 \times 1270 = 15$,		0.57
$v_{60} =$	$0.01167 \times 542 = 6$,		0.28

The figures refer to North America, the European Community, the developed countries outside America and Europe and the other European countries respectively. They illustrate the differentiation of an average of 0.7 per cent development assistance over donor areas with different incomes.

We conclude this chapter with some figures about the actual net flows as a percentage of GNP of official development assistance and of private capital in 1975/7 and in 1986 (last available figures) to developing countries, compiled by the Development Assistance Committee of the Organization of Economic Co-operation and Development (OECD) published in its 1987 Report (OECD, 1988) reproduced here as Table 6.32.

Table 6.32 Net flows (as a percentage of GNP) to developing countries of official development assistance and private capital

	Official development ass.		Private capital	
	1975/7	1986	1975/7	1986
North America				
USA	0.25	0.23	0.47	0.03
Canada	0.50	0.48	0.51	–0.03
European Community				
France	0.60	0.72	0.67	0.43
Germany, F.R.	0.36	0.43	0.78	0.26
Italy	0.10	0.40	0.63	–0.10
Netherlands	0.79	1.01	0.96	0.54
United Kingdom	0.40	0.32	2.23	0.92
Other European countries				
Norway	0.70	1.20	0.57	1.61
Sweden	0.84	0.85	0.58	0.11
Switzerland	0.19	0.30	3.12	0.49
Other continents				
Japan	0.21	0.29	0.25	0.50

Source: OECD, Development Co-operation, 1987 Report (Paris, 1988) pp. 200, 201.

6.4 A FURTHER REFINEMENT OF THE MODEL ON THE DONOR COUNTRIES' SIDE

The method discussed in the preceding sections can be refined relatively easily. It seems interesting to do so in particular for the donor countries' side, in order to find the optimal amounts of development assistance and, in addition, to specify the optimal spreading of the 0.7 per cent figure with more precision. In this section we shall take the large donor countries individually and group the smaller donor countries so as to form areas of 1 per cent of the 'world', i.e. W1 + W3. In contrast we leave the receiving countries as before, and group them by continent. In Table 6.41 the refined model is shown: it contains 14 donor countries or groups of countries and three underdeveloped areas. The units of population each contain 1 per cent of the total population (in 1970). The largest donor country, the USA, consists of 9 units, the second largest, Japan, 4, and the third largest, the Federal Republic of Germany, 3. In addition, the UK, Italy and France consist of two units each, Canada and Spain of one. The remaining donor nations have been grouped into relatively homogeneous groups of about 1 per cent. These groups are (1) the three poorest EC-member countries: Greece, Ireland and Portugal, (2) the Benelux, (3) the Scandinavian countries: Denmark, Finland, Norway and Sweden, (4) two neutral countries (Austria and Switzerland), (5) Australia and New Zealand and (6) Israel and South Africa, a somewhat peculiar remnant. We tried to stay as close as possible to the Kravis *et al.* approach of 1978, the source on which this chapter is mainly based, but some deviations crept in for lack of information or of data. These deviations are minor. Table 6.41 shows the composition of the groups, their population and real income in 1970, expressed, respectively, in millions and in 1975 $. For comparison some of the main figures of the Kravis *et al.* (1978) article have been added. Because of rounding the differences are larger than in our other chapters, but the main structure clearly is close to the Kravis *et al.* structure.

With the aid of these data we are going to make two calculations. First, in Table 6.42, we propose to estimate the optimal amounts to be spent on development assistance, assuming that an equitable redistribution requires that an individual producing x_i may keep for himself $0.4\,x_i + 0.856$. This implies that she or he must pay a 'tax' $v_{io} = 0.6\,x_i - 856$, or a marginal tax rate of 0.6 and a 'negative tax' if the income is below 1427. The marginal tax rate is in the neighbourhood of tax systems (including contributions for social security) applied in Europe.

The optimal figures for development assistance again are high, al-

Table 6.41 Composition of the market economy country groups, their population, in millions and in per cent of total population, per capita *real income, total income in 1975 US$ purchasing power, for 1970 and some comparable figures of Kravis* et al. *(1978)*

Countries	Population (000,000)		%	No. of Units	Real income (1975 $) *Per cap.*	Total	Kravis figures Pop. (m)	%	Inc. *p. cap.*
USA	206		8.51	9	4758	42,822			
Canada	21		0.89	1	4234	4,234			
North Amer.	227		9.40	10	4706	47,056	226.2	9.4	4708
Germany F.R.	62		2.59	3	3701	11,103			
UK	56		2.31	2	3021	6,042			
Italy	54		2.22	2	2598	5,196			
France	51		2.10	2	3497	6,994			
Spain	33		1.37	1	1917	1,917			
Greece	9				1970				
Ireland	3	21*	0.89	1	2198	1,755			
Portugal	10				1423				
Belgium	10				3338				
Netherlands	13	23	0.95	1	3221	3,289			
Denmark	5				3763				
Finland	5	23	0.92	1	3073	3,649			
Norway	5				3559				
Sweden	8				4372				
Austria	7	14*	0.57	1	2793				
Switzerland	6				3787	3,251			
Europe (W)	335		13.87	14	3085	43,196	368.8	15.2	2781
Japan	103		4.27	4	2769	11,076			
Australia	13	15	0.64	1	3611	3,521			
New Zealand	3				3059				
Israel	3	24	0.98	1	2788	1,645			
South Africa	21				1484				
Non. Amer. Eur	142		5.87	6	2707	16,242	145.4	6.0	2641
Totals									
Developed	705		29.14	30	3551	106,494	740.5	30.6	3343
Africa				14	412	5,768		13.6	
Asia				45	384	17,280		44.6	
Latin America				11	1191	13,101		11.2	
Underdeveloped				70	516	36,149		69.4	520
'World' W1 + W3				100	1427	142,643		100.0	1383

*Deviations due to rounding

though not as high as obtained in Section 6.2 or, for North America, in Section 6.3. The figures of Table 6.42 indicate what level development assistance would have to have, if the same redistribution were to be applied as is judged desirable inside Western European countries.

The second calculation we made is based on the assumption that development assistance of 0.7 per cent of national income is considered to

Table 6.42 Income per capita x_i *of countries, country groups or units, number* n_i *of units, 'tax' (i.e. development assistance)* $v_i = 0.6x_i - 856$ *per capita, total development assistance* $n_i v_i$ *and percentage* $100\ v_i/x_i$ *for fourteen developed and three developing countries or country groups. Figures in [ ] are total incomes of developed countries by continents*

Countries (group)	x_i	n_i	$0.6x_i - 856 = v_i$	$n_i v_i$	$100\ v_i/x_i$
USA	4758	9	2855	1999	17991	42.0
Canada	4234	1	2540	1684	1684	39.8
North America	[47056]	10			19675	41.8
Germany F.R.	3701	3	2221	1365	4095	36.9
United Kingdom	3021	2	1813	957	1914	31.7
Italy	2598	2	1559	703	1406	27.1
France	3497	2	2098	1242	2484	35.5
Spain	1917	1	1150	294	294	15.3
Three poorest EC members	1755	1	1053	197	197	11.2
Benelux	3289	1	1973	1117	1117	34.0
Scandinavia	3649	1	2189	1333	1333	36.5
Two neutral Eur. countr.	3251	1	1951	1095	1095	33.7
Europe (Western)	[43196]	14			13935	32.3
Japan	2769	4	1661	805	2415	29.1
Australia & New Zealand	3521	1	2113	1257	1257	35.7
Israel and S. Africa	1645	1	987	131	131	8.0
Non America, Europe	[16242]	6			3803	23.4
Developed world (W1)	[106494]	30			37413	35.1
African developing nations	412	14	247	–609	–8526	
Asian developing nations	384	45	230	–626	–28152	
Lat. Amer. dev. nations	1191	11	715	–141	–1351	
Developing world (W3)		70			–38229	
'World' (W1 + W3)			100		–816	

be optimal as an average for all donor countries, but distributed over donor countries by a formula

$$v_{io} = 0.0117\, x_i - 16.69 \tag{6.41}$$

which follows from the conditions that (i) development assistance is linearly dependent on the donor country's income *per capita*, (ii) the assistance received by the underdeveloped countries is obtained (as a negative income tax) by the same formula, (iii) assistance paid in total equals assistance received in total, and (iv) total assistance equals 0.7 per cent of the donor countries' total income. Table 6.43 shows the results.

Table 6.43 Development assistance to be paid by the fourteen donor countries or country groups, according to the principles set out in the text

Country or country groups	Income	Assistance	Ass. as % of income
USA	42822	350.8	0.82
Canada	4234	32.9	0.78
Germany, F.R.	11103	79.8	0.72
United Kingdom	6042	37.3	0.62
Italy	5196	27.4	0.53
France	6994	48.4	0.69
Spain	1917	5.7	0.30
3 poorest EC members	1755	3.8	0.22
Benelux	3289	21.8	0.66
Scandinavian nations	3649	26.0	0.71
2 neutral Eur. nations	3251	21.4	0.66
Japan	11076	47.1	0.57
Australia and N.Z.	3521	24.5	0.70
Israel and S. Africa	1645	2.6	0.16

Income of donor countries has been approached by the real income *per capita* in 1970, multiplied by the integer number of units mentioned in Table 6.41 and not by the exact number of the population percentage mentioned in that same table. Since the amount of assistance has also been computed in the same way, the assistance expressed as a percentage of income (last column of Table 6.43) is accurate. A weak point is, of course, that the real income figures refer to 1970.

The main result of this second calculation, therefore, is that the

Table 6.44 Actual flows of Official Development Assistance (ODA) in 1986 and 1987 as reported by the Development Assistance Committe (DAC) of the Organization of Economic and Development Co-operation (OECD), expressed as a percentage of GNP (national income) and 'optimal' figures adding up to 0.7 per cent

Country	ODA		'Optimal'	Actual/'Optimal'	
	1986	1987		1986	1987
Australia	0.47	0 33	0.70	0.66	0.47
Austria	0.21	0.17	0.66	0.37	0.26
Belgium	0.49	0.49	0.66	0.72	0.74
Canada	0.48	0.46	0.78	0.62	0.59
Denmark	0.89	0.88	0.71	1.22	1.24
Finland	0.45	0.50	0.71	0.71	0.70
France	0.72*	0.75*	0.69	1.04*	1.09*
Germany, F.R.	0.43	0.39	0.72	0.60	0.54
Ireland	0.28	0.20	0.22	0.68	0.91
Italy	0.40	0.32	0.53	0.75	0.60
Japan	0.29	0.31	0.57	0.51	0.54
Netherlands	1.01	0.98	0.66	1.55	1.48
New Zealand	0.30	0.21	0.70	0.48	0.30
Norway	1.20	1.10	0.71	1.71	1.55
Sweden	0.85	0.85	0.71	1.08	1.20
Switzerland	0.30	0.30	0.66	0.41	0.45
United Kingdom	0.32	0.28	0.62	0.52	0.45
United States	0.23	0.20	0.82	0.28	0.24
Average	0.35	0.34	0.70	0.50	0.49

*Inclusive of French 'Overseas Territories'. If these are excluded, the figures are about 30% lower.

development assistance should not be uniformly 0.7 per cent of national income, but a percentage dependent on the donor country's income *per capita*. The scale to be applied may be a matter for further discussion.

As Table 6.43 shows, this varies from 0.16 per cent for the Israel/South Africa group to 0.82 per cent for the USA. Since the Israel/South Africa group is so heterogeneous, we may add that for Israel alone the percentage

should be 0.57. A more homogeneous group is that of the three poorest EC countries and their percentage should be, according to the principle set out, 0.22 per cent. The Scandinavian countries and Australia and New Zealand remain very close to the 0.7 target.

We conclude this section with a comparison between the 1986 and 1987 flows of Official Development Assistance as reported by the Development Assistance Committee (DAC) of OECD and the figures for all individual countries, comparable to those of our Table 6.43, shown in Table 6.44.

The last two columns may be considered as 'scores for good behaviour' in matters of development co-operation. Generally the small countries are scoring better than the larger donor countries, but this does not apply to Switzerland and Austria. The bad score of the USA is related to the heavy defence burden of that superpower.

REFERENCES

Kravis, I. B. *et al.* (1978), 'Real GDP *Per Capita* for More Than One Hundred Countries', *Economic Journal*, vol. 88, pp. 215–42.

OECD (1988), *Development Co-operation*, 1987 Report (OECD, Paris) pp. 200, 201.