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The International Comparison Project as a Source of Private Consumption Data for a Global Input-Output Model

by

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ABSTRACT

In 1989 a major project entitled "Strategies for Environmentally Sound Economic Decelopment" was inaugurated under the sponsorship of the United Nations. This project is designed to identify ways of alleviating pressures on the global environment and, at the same time, raise the standard of living of the poorest countries. The central component of its analytical framework is a dynamic global input-output model (GIOM) that describes trade between 15 regions in about 50 commodities, taking as its starting point the well known 1977 World Input-Output Model of Leontief, Carter and Petri.

The purpose of the present paper is twofold. Firstly, it describes a contribution to the compilation of a database for the GIOM. In particular, it draws on data collected by the United Nations' International Comparison Project (ICP) to provide estimates of private consumption expenditure for 1980, the base period for the model. Secondly, it uses these estimates as a case study to examine the implications of using different price systems for each country, rather than a common set of prices, to determine expenditures on composite commodities. In preparing data for multisectoral global models, it is common practice to collect expenditure data evaluated in local (national) prices and convert to world prices using published exchange rates. The analysis of this paper suggests that, when commodities produced in different countries are treated as perfect substitutes in the model, the practice may seriously compromise the model's results.

J.E.L. Classification Numbers: C67, C81, F10, O21

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THE INTERNATIONAL COMPARISON PROJECT AS A SOURCE OF PRIVATE CONSUMPTION DATA FOR A GLOBAL INPUT-OUTPUT MODEL

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1. Introduction

In the mid-1970's, the United Nations sponsored the development of an input-output model of the world economy (Leontief et al., 1977) designed to investigate the interrelationships between environmental and other economic policies proposed for the remainder of the 20th century. The Leontief model can be regarded as the forerunner of a string of other global multisectoral models, including the computable general equilibrium (CGE) models of Whalley (1985), Deardorf and Stern (1986), Mercenier and Waelbroeck (1986), Burniaux et al. (1989) and Zeitsch et al. (1991). More directly, it provided the starting point for the recent work, also sponsored by the United Nations, of Duchin et al. (1992, 1994) on strategies for environmentally sound economic development. The central component of their analytical framework is a dynamic global input-output model (GIOM) specified in the first instance as a revised version of the Leontief model.

A common feature of all these models is that they incorporate international trade in composite commodities produced in different countries. Hence the construction of their databases involves the use of price systems whereby expenditures on unlike components are added together to obtain expenditures on the specified composites. For want of an alternative, it is usual to employ each country's own price system to determine composite expenditures in local currency. These expenditures are then converted to a common currency using published exchange rates.

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* The author is indebted to Faye Duchin and Brian Parmenter for comments on previous versions of this paper. One such version appeared as Seminar Paper No. 12/91, Depatrment of Economics, Monash University.

The purpose of the present paper is twofold. Firstly, it describes a contribution to the compilation of a database for the GIOM of Duchin et al. In particular, it draws on data collected by the United Nations' International Comparison Project (ICP) to provide estimates of private consumption expenditure for 1980, the base period for the model. Secondly, it uses these estimates as a case study to examine the implications of using different price systems for each country, rather than a common set of prices, to determine expenditures on composite commodities. While the estimates themselves may be too outdated to be of direct use for other purposes, the procedures employed in their construction and the issues raised by the differences between them are of continuing importance.

The balance of the paper is organized as follows. Section 2 describes the ICP database and the methodology for converting it to the commodity classification of the GIOM. It then employs data from the United Nations' Macroeconomic Data System (MEDS) to convert the ICP data to the GIOM regional classification. The consumption estimates resulting from these procedures incorporate the domestic prices of the ICP countries converted to US dollars using published exchange rates. In Section 3, two alternative estimates are described, one based on a set of average world prices computed as part of the ICP and the other based on sets of average prices for the GIOM regions. In Section 4, the various estimates are interpreted and assessed. Section 5 contains some brief concluding remarks.

2. Estimates of GDP Based on Domestic Prices

2.1 The ICP Data

The International Comparison Project has been producing estimates of purchasing power parities (PPPs) and of real gross domestic product (GDP) and its components for the last 20 years. The project has proceeded through five phases corresponding to the reference years 1970, 1973, 1975, 1980 and 1985, respectively.[1] The consumption estimates reported in this paper are derived from

[1] A comprehensive report on Phase III, together with references to earlier work, is contained in Kravis, Heston and Summers (1982). A detailed assessment of the ICP methodology has been conducted by Hill (1982), and a recent review of the project is contained in Kravis and Lipsey (1990).

unpublished Phase IV data supplied by the ICP Section of the United Nations Statistical Office.[2]

The data was supplied in the form of five tables which will be referred to as Tables IV.1 to IV.5. The first contains estimates E_{in} of expenditure of type i in country n for 60 countries and 151 expenditure types (or "basic headings"). If the expenditures E_{in} are summed over expenditure types, one obtains the GDP of country n. The expenditures in Table IV.1 are expressed in domestic currencies, but they can be converted to US dollars using exchange rates included in Table IV.4 (see below).

Table IV.2 contains the price ratios or purchasing power parities

$$\hat{P}_{in} = P_{in} / P_{i,US} \qquad (i=1,...,151;\ n=1...,60)$$

where P_{in} is the price of expenditure type or "commodity" i in country n. When an element of Table IV.1 is divided by the corresponding element of Table IV.2, one obtains the expenditure

$$\hat{Q}_{in} = P_{i,US}\, Q_{in}$$

where Q_{in} is the amount of commodity i purchased in country n. Note that

$$E_{in} = \hat{P}_{in}\, \hat{Q}_{in} = P_{in}\, Q_{in} \ .$$

Table IV.3 contains per capita expenditures E^I_{in} / N_n, where N_n is the population of country n and the expenditures E^I_{in} are expressed in terms of a set P^I_i of world prices whose derivation is discussed in Section 3. Table IV.4 contains values of the exchange rate R_n with respect to the US dollar, the population N_n and a so-called "supercountry weight" W_n for each country. The final table of the database, Table IV.5, contains the information required to aggregate to the

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[2] Some Phase IV results appear in two reports published by the United Nations in 1986 and 1987. The unpublished data used in the present Report is referred to in reference 4, page 6 of the former UN report.

commodity classification used in the reports published by the United Nations (1986 and 1987). Table IV.5 is not used for any purpose in this study.

2.2 Conversion of the ICP Data to the GIOM Commodity Classification

The GIOM classification of commodities consists of the first 47 categories of the expenditure classification set out in Table 1. Each of the commodity groups 1 to 44 is an aggregation of commodities defined at the 6-digit level of the International Standard Industrial Classification (ISIC).[3] Commodities 45 to 47 are not defined in ISIC, but are included in the GIOM to facilitate aspects of environmental modelling. These 47 categories are designed to cover all uses of commodities in the GIOM, i.e., intermediate usage, capital formation, private consumption, government consumption and international trade. However, bearing in mind the requirements of mobilizing the ICP data and the focus of the present study on private consumption, it is convenient to define separate categories for uses other than private consumption, i.e., to include the expenditure categories 48 to 53. This treatment means that many of the standard GIOM commodities (namely, all those that are not directly consumed by the private sector) do not appear in the analysis that follows.

The task of converting the ICP data to the GIOM commodity classification, then, consists of assigning each of the 151 ICP basic headings to one or more of the 53 expenditure types in Table 1. The procedure involves three steps, the first of which is to assign ISIC categories to the basic headings. The assignment was based on a comparison of verbal descriptions of the basic headings published by EUROSTAT (1983) with verbal descriptions of the ISIC categories contained in two United National publications (1971a and 1971b). The ICP tables themselves also contain verbal descriptions of the basic headings but they are often too terse to be useful for the current purpose.

Once the basic headings have been associated with ISIC categories, they can be assigned to GIOM expenditure types using the appropriate classification conversion (see footnote 3). This assignment constitutes step two of the conversion procedure.

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[3] The conversion between GIOM and ISIC commodities has been published in various places, including Meagher (1991), Table 2. Note that commodity 17 *Food processing* is further disaggregated into *Processed livestock and dairy*, *Processed oil crops*, *Processed grain*, *Processed fish* and *Miscellaneous processed foods* in the GIOM.

Table 1. The GIOM Expenditure Classification

No.	Description	No.	Description
	Private consumption:		Private consumption (continued):
1	Livestock and dairy	31	Motor vehicles
2	Oil crops	32	Other transportation equipment
3	Grain	33	Aircraft and parts
4	Root crops	34	Heating equipment
5	Forestry and other agriculture		Other metal products
6	Fishing	35	Farm equipment
7	Copper ore	36	Electronic components
8	Bauxite		Computers
9	Nickel ore		Household appliances
10	Zinc ore		Lighting equipment
			Other electrical machinery
11	Lead ore	37	Scientific instruments
12	Iron and other ores	38	Miscellaneous manufacturing
13	Crude petroleum	39	Electric, gas and water utilities
14	Natural gas	40	Construction
15	Bitumous/anthracite coal		
	Lignite/peat	41	Trade
	Fuel wood	42	Transportation services
16	Other mining	43	Communication services
17	Food processing	44	Other services
18	Gasoline, napthas and kerosene	45	Carbon
19	Primary metal processing	46	Sulphur oxides
20	Textiles and apparel	47	Nitrogen oxides
21	Wood and cork products		Capital formation:
22	Furniture and fixtures		
23	Paper and paper products	48	Equipment
24	Printing and publishing	49	Construction
25	Rubber products	50	Change in stocks
26	Industrial chemicals		
27	Fertilizer and agricultural chemicals		Government consumption:
28	Miscellaneous chemicals		
29	Cement	51	Education
30	Glass, stone and clay products	52	General public services
		53	Balance of trade surplus

Unfortunately, the procedure described thus far does not always result in a clear correspondence between ICP basic headings and GIOM expenditure types. In a number of cases, the basic heading corresponds to more than one GIOM category and a further allocation is required. Occasionally, the basic heading is so broadly defined that the corresponding GIOM categories are not obvious; basic heading 107, for example, is described as *Musical instruments, boats and other major durable good*s. The third step in the conversion procedure, therefore, is to resolve these ambiguities on the basis of informed judgment. In this case, the author's judgment was informed by discussions with Professor Alan Heston at the University of Pennsylvania (one of the originators of the ICP) and with Professor Faye Duchin and her team at New York University (who are responsible for the development of GIOM), as well as by his own experience in multi-sectoral modelling. The allocations performed at step 3 are summarized in Table 2.

The outcome of the three-step procedure is a table (not reported here) containing the expenditures E_{in} / R_n (i.e., the expenditures of Table IV.1 converted to US dollars), where the commodity index i now runs over the 53 expenditure types of Table 1 rather than the 151 types of Table IV.1.

2.3 Conversion of the ICP Data to the GIOM Regional Classification

The GIOM regional classification groups 189 countries into the 15 regions set out in Table 3.[4] The conversion of the expenditure data derived in section 2.2 from the 60 country ICP classification to the GIOM's 15 regions is based on information from the United Nation's MEDS database. Specifically, the MEDS database contains estimates of GDP in 1980 for 135 market economies which can be aggregated to obtain corresponding estimates for the GIOM regions. There are two things to note about this aggregation. First, the MEDS database contains no data for the centrally-planned economies of regions 6, 7 and 8. Second, even among the market economies, not all the countries belonging to the GIOM regions are included in MEDS. However, in the latter case, the countries omitted are quite small and the coverage in terms of regional GDP is high.

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[4] The assignment of countries to regions in the GIOM has been published in various places, including Meagher (1991), Table 1.

Table 2. Judgemental Allocation Rules Employed in the Commodity Classification Conversion

Type	Description	Number of Cases	Comment
1	One hundred per cent allocations	7	For this type, the contributions of the ICP category to all but one of the corresponding GIOM categories are deemed to be so small that they can be ignored.
2	Fixed allocations of less than 100 percent	6	In the ICP classification, expenditure on the rental of or repairs to a commodity is generally included with expenditure on the purchase of the same commodity, whereas, in the GIOM classification, all rentals and repairs are gathered togrether in category 44 *Other services*. Hence a fixed percentage (usually 10 per cent) of such ICP categories is allocated to *Other services*.
3	Pro rata allocations	2	For this type, expenditure on the ICP category is allocated between GIOM categories in proportion to the expenditures on GIOM categories that pertain after the completion of step 2 of the conversion procedure. Thus, for example, ICP basic heading 107 *Musical instruments, boats and other major durable goods* is allocated pro rata between GIOM categories 32, 33, 36, 37 and 38.
4	Combined fixed and pro rata allocations	3	For this type, a fixed proportion of the ICP expenditure is allocated to GIOM category 44 *Other services* to represent rentals or repairs, and the remainder is allocated pro rata in the same manner as Type 2.
5	Country specific allocations	1	Expenditure on ICP basic heading 14 *Fish - fresh, frozen or deep frozen* is allocated between GIOM category 6 (for fresh fish) and GIOM category 17 (for frozen fish) in different proportions depending on the stage of economic development of the country concerned. This is the only example of an allocation rule that does not apply equally in all ICP countries.
6	Miscellaneous allocations	1	The final type of allocation applies only to water charges, which are taken to be 5 per cent of expenditure on electricity.

Table 3. The GIOM Classification of Regions

Region	Code	Description	Number of Countries
1	NAH	High-income North America	5
2	LAM	Newly-industrializing Latin America	5
3	LAL	Low-income Latin America	40
4	WEH	High-income Western Europe	23
5	WEM	Medium-income Western Europe	8
6	EEM	Eastern Europe	7
7	RUH	Soviet Union	1
8	CPA	Centrally-planned Asia	3
9	JAP	Japan	1
10	ASL	Other Asia	23
11	OIL	Major oil producers	15
12	AAF	Other Middle-East and Northern Africa	16
13	SSA	Sub-Saharan Africa	37
14	SAF	Southern Africa	2
15	OCH	Oceania	3
		All regions	189

Table 4. Gross Domestic Product, MEDS Data, 1980, USx10^6$, Region LAM

No.	Country	MEDS Code	ICP Code	GDP
1	Argentina	3	44	154011
2	Brazil	13	46	238490
3	Chile	23	47	27949
4	Mexico	79		194762
5	Venezuela	129	59	59171
	Total			674383

To achieve the regional conversion, each ICP country is assigned a "supercountry weight", W_n^*. Then the expenditure on commodity i in region m is determined as a weighted sum of the corresponding expenditures in the ICP countries belonging to region m. The method is illustrated for the second GIOM region, *Newly-industrializing Latin America (LAM)*, which contains the five countries shown in Table 4. Four of these countries , i.e., all except Mexico, are ICP countries so expenditure on commodity i in region LAM is given by

$$E_{i,44}\, W_{44}^* + E_{i,46}\, W_{46}^* + E_{i,47}\, W_{47}^* + E_{i,59}\, W_{59}^* \ .$$

The supercountry weight is the same for each ICP country in the region and is given by the ratio of the regional GDP to the sum of the GDPs of all the ICP countries belonging to the region[5], i.e.,

$$W_{44}^* = W_{46}^* = W_{47}^* = W_{59}^*$$

$$= 674383 / 47962 = 1.406 \ .$$

Values of the supercountry weights are calculated in this manner for all the ICP countries except the centrally planned economies of Hungary and Poland which are not included in the MEDS database.

Table 5 contains estimates of GDP and its components in the desired categories of the GIOM. Only 10 of the 15 regions appear in the table, reflecting the fact that regions RUH (Soviet Union), CPA (Centrally-Planned Asia), SAF (Southern Africa) and OCH (Oceania) do not contain any ICP countries. The region EEM (Eastern Europe) contains two ICP countries - Hungary and Poland - but, as already mentioned, no supercountry weights are available for these countries from the databases considered in the present study.

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[5] Note that while the ICP nomenclature has been adopted with regard to supercountry weights, the W_n^* calculated here are not the same as the W_n included in Table IV.4 which have a different purpose. See Kravis, Heston and Summers (1982) for a full discussion of the latter weights.

Table 5. Gross Domestic Product, Weighted ICP Data, 1980, Domestic Prices, $US x 10^7

GIOM Expenditure Category	Region 1 NAH	2 LAM	3 LAL	4 WEH	5 WEM	9 JAP	10 ASL	11 OIL	12 AAF	13 SSA
Private consumption										
1 Livestock & dairy	566	353	112	717	321	210	198	183	38	23
4 Root crops	353	540	167	732	236	82	630	2471	42	107
5 Forestry & other agric.	2282	2246	613	4421	1089	1425	2551	1334	298	222
6 Fishing	185	142	49	351	303	304	651	760	26	94
15 Solid fuels	430	112	38	633	74	69	915	149	79	76
17 Processed food	27223	15683	2784	40149	7708	12827	15413	13316	2564	2282
18 Gasoline, etc.	10523	1565	233	8585	1130	1653	464	203	144	100
20 Textiles & apparel	14965	4033	801	19373	3108	5214	3213	2148	592	604
22 Furniture & fixtures	2721	747	82	5563	802	281	179	221	106	67
24 Printng & publishng	1715	224	41	2836	324	888	116	268	56	37
25 Rubber products	1209	801	74	1073	67	431	37	21	15	13
26 Industrial chemicals	813	335	83	304	148	116	34	59	42	13
28 Miscellaneous chemicals	6074	2040	317	9247	1339	1533	771	438	173	171
30 Glass products, etc.	221	81	15	885	46	111	67	114	22	5
31 Motor vehicles	6995	228	31	7129	704	537	103	195	75	79
32 Other transport equipment	1995	359	52	668	57	140	171	132	46	33
34 Heating equipment, etc.	80	110	22	468	18	143	113	116	5	4
36 Electrical goods	7707	977	180	8050	858	2255	1024	631	231	100
37 Scientifc instruments	1978	509	127	2272	147	211	150	307	43	44
38 Misc. manufacturing	1790	1793	442	2380	172	643	372	123	47	28
39 Utilities	5538	405	123	5636	356	1058	334	249	96	34
40 Construction	2242	355	131	2230	150	232	450	440	291	74
41 Transportation services	3447	610	347	5260	866	2390	1539	492	259	312
42 Communication services	3366	830	100	2560	196	563	115	162	47	20
44 Other services	79916	11161	2104	69426	7846	27298	5341	4341	1707	858
Capital accumulation										
48 Equipment	24014	5873	1087	27811	3412	11098	4954	3457	926	800
49 Construction	30339	9924	1321	39981	5705	22164	6635	8182	1441	1026
50 Change in stocks	-889	524	166	4020	1091	701	1626	412	83	204
Government consumption										
51 Education	13991	1989	298	12983	708	3889	1503	498	529	245
52 General public services	37783	4997	1016	33060	3536	6515	3558	3878	2164	1098
53 Balance of trade	-1472	-687	-185	-2025	-2332	-947	-1418	504	-1199	-683
Total	288109	68870	12785	316790	40196	104045	51819	45816	11002	8102

3. Estimates of GDP Based on International and Regional Prices

Table IV.3 of the ICP database, when adjusted for population size, yields expenditures

$$E^I_{in} = \hat{P}^I_{in}\,\hat{Q}_{in} = P^I_{in}\,Q_{in}$$

for 151 basic headings and 60 countries. The set of average international price ratios

$$\hat{P}^I_i = P^I_i / P_{i,US}$$

is obtained by solving the set of equations[6]

$$\hat{P}^I_i = \sum_{n=1}^{60} (\hat{P}_{in}\,\hat{Q}_{in}\,W_n / \hat{P}^I_n) \;/\; \sum_{m=1}^{60} \hat{Q}_{im}\,W_m \qquad (i=1,...,151)$$

$$\hat{P}^I_n = \sum_{i=1}^{151} \hat{P}_{in}\,\hat{Q}_{in}\,W_n \;/\; \sum_{i=1}^{151} \hat{P}^I_i\,\hat{Q}_{in}\,W_n \qquad (n=1,...,60)\ ,$$

where all country-specific variables other than $\hat{P}^I_n$ have been defined in section 2. It follows that

$$\hat{P}^I_n = P^I_n\ ,$$

where

$$P^I_n = \sum_{i=1}^{151} P_{in}\,Q_{in} \;/\; \sum_{i=1}^{151} P^I_i\,Q_{in}$$

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6 Although the equations presented here represent the essence of the ICP calculation, some further adaptations were required by the nature of the data. See Kravis, Heston and Summers (1982), p.90 for details.

is the purchasing power parity of the currency of country n. The set of equations is solved for $\hat{P}_i^I$ (i=1,...,151) and $\hat{P}_n^I$ (n=1,..,60) for given values of the $\hat{P}_{in}$, $\hat{Q}_{in}$ and W_n.

This system is an adaptation of the Geary/Khamis system[7] and can be interpreted as follows. According to the first set equations, the international price of the ith commodity is the quantity-weighted average of purchasing-power-adjusted prices of the ith commodity in the 60 countries (or, more correctly, supercountries). The second set of equations maintains that the purchasing power of a country's currency is equal to the ratio of the cost of its total bill of goods at national prices to the cost at world prices. One equation in the system is redundant in the sense that it can be derived from the others, and the system is closed by imposing the normalization rule

$$\sum_{i=1}^{151} \hat{P}_i^I \hat{Q}_{i,US} = \sum_{i=1}^{151} \hat{P}_{i,US} \hat{Q}_{i,US} .$$

Prices derived in this manner have a number of desirable properties including base-country invariance, transitivity, matrix consistency and transactions equality.[8]

Table 6 contains estimates of GDP valued at world prices and expressed in world currency ($I). It is derived from the expenditures E_{in}^I in much the same way as Table 5 is derived from the expenditures E_{in}. As all expenditures E_{in}^I are already measured in international dollars, no exchange rate conversion is required in this case.

Just as the adapted Geary/Khamis system can be employed to generate a set of average world prices, it can be applied region by region to generate sets of average regional prices. In particular, for GIOM region m, say, the equations

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7 See Geary (1958) and Khamis (1967, 1970 and 1972).

8 These properties are discussed in Kravis, Heston and Summers (1982), p.71.

Table 6. Gross Domestic Product, Weighted ICP Data, 1980, International Prices, $I x 10^7

GIOM Expenditure Category	Region 1 NAH	2 LAM	3 LAL	4 WEH	5 WEM	9 JAP	10 ASL	11 OIL	12 AAF	13 SSA
Private consumption										
1 Livestock & dairy	1066	612	162	697	368	272	295	82	40	14
4 Root crops	282	543	244	790	360	42	1586	1213	28	80
5 Forestry & other agric.	2284	2979	917	4557	1539	720	5880	983	631	285
6 Fishing	177	288	145	279	269	213	1598	857	56	186
15 Solid fuels	125	70	81	222	36	21	3066	64	78	66
17 Processed food	34824	26402	4571	38426	10668	11066	29820	9644	3668	2625
18 Gasoline, etc.	14382	2030	397	6322	851	1202	580	579	195	134
20 Textiles & apparel	17460	3985	1459	18040	3226	5553	6611	2261	773	766
22 Furniture & fixtures	3639	928	209	4507	669	327	393	248	164	101
24 Printng & publishng	1740	173	66	2226	336	1107	223	147	61	26
25 Rubber products	1708	807	90	862	64	469	45	25	24	19
26 Industrial chemicals	481	293	352	180	226	105	63	124	83	17
28 Miscellaneous chemicals	7098	4223	929	6966	1389	1155	1127	169	157	97
30 Glass products, etc.	210	101	27	903	45	89	136	170	52	10
31 Motor vehicles	7990	519	64	6238	522	896	110	119	34	47
32 Other transport equipment	2472	252	50	516	41	358	320	70	26	16
34 Heating equipment, etc.	75	78	31	453	26	204	193	259	20	12
36 Electrical goods	9345	1729	250	7880	841	2245	1680	435	181	66
37 Scientifc instruments	2004	656	134	1901	164	213	331	177	46	39
38 Misc. manufacturing	1434	3698	893	1772	170	529	780	207	90	61
39 Utilities	6601	405	368	3847	351	757	743	178	76	20
40 Construction	1850	344	251	1681	190	288	1099	304	563	110
41 Transportation services	2336	707	780	2683	752	2473	5558	420	285	205
42 Communication services	4456	1298	227	1458	240	362	118	114	34	21
44 Other services	66599	14789	4020	60861	9409	23891	13796	5090	2681	1572
Capital accumulation										
48 Equipment	29649	5431	911	27567	4216	14624	5693	3070	942	744
49 Construction	32151	17127	2795	34124	6662	22980	13716	4540	1143	756
50 Change in stocks	-889	524	166	4019	1091	701	1628	413	83	204
Government consumption										
51 Education	9787	4142	1144	6901	585	2479	8433	491	703	405
52 General public services	30048	4144	2078	26538	4529	3022	13959	5938	3587	2257
53 Balance of trade	-1472	-687	-185	-2025	-2332	-948	-1417	505	-1199	-683
Total	289921	98601	23636	271403	47516	97427	118177	38910	15321	10288

$$\hat{P}_i^R = \sum_{n\varepsilon N(m)} (\hat{P}_{in}\,\hat{Q}_{in} / \hat{P}_n^R) \;/\; \sum_{l\varepsilon N(m)} \hat{Q}_{il} \qquad (i=1,...,151)$$

$$\hat{P}_n^R = \sum_{i=1}^{151} \hat{P}_{in}\,\hat{Q}_{in} \;/\; \sum_{i=1}^{151} \hat{P}_i^R\,\hat{Q}_{in} \qquad (n\varepsilon N(m))$$

can be solved to yield the regional prices $\hat{P}_i^R$ and currency PPPs $\hat{P}_n^R$. Here N(m) is the set of sequence numbers for countries belonging to region m. Unlike the system for computing the world prices $\hat{P}_i^I$, these equations do not include supercountry weights. Thus, for the regional prices calculated in this study, non-ICP countries within the region are not associated with a particular ICP country. As before, one equation in the system is redundant and the normalization rule

$$\sum_{i=1}^{151} \hat{P}_i^R\,\hat{Q}_{i,US} = \sum_{i=1}^{151} \hat{P}_{i,US}\,\hat{Q}_{i,US}$$

is imposed. Eleven sets of regional prices $\hat{P}_i^R$ (i=1,...,151) can be computed in this manner, one for each of the eleven GIOM regions which contain at least one ICP country.

When an element E_{in} of Table IV.1 is divided by the corresponding element $\hat{P}_{in}$ of Table IV.2, the quantity $\hat{Q}_{in}$ is obtained. Hence a matrix E_{in}^R of expenditures based on average regional prices and expressed in regional dollars ($R) can be generated by multiplying the $\hat{Q}_{in}$ by the average price $\hat{P}_i^R$ of commodity i in the region to which country n belongs. Once the matrix E_{in}^R is assembled, estimates of GDP valued at regional prices can be derived in the usual manner. These estimates are reported in Table 7.

Given the normalization rule imposed in the derivation of the international and regional price systems, the purchasing power of one US dollar is equal to the purchasing power of one international dollar and to any one of the regional dollars.

Table 7. Gross Domestic Product, Weighted ICP Data, 1980, Regional Prices, $R x 10^7

GIOM Expenditure Category	Region 1 NAH	2 LAM	3 LAL	4 WEH	5 WEM	9 JAP	10 ASL	11 OIL	12 AAF	13 SSA
Private consumption										
1 Livestock & dairy	572	349	167	583	337	146	357	78	35	22
4 Root crops	356	476	248	595	253	57	1180	1058	40	105
5 Forestry & other agric.	2294	1980	889	3843	1152	991	4639	571	289	212
6 Fishing	186	151	77	294	326	211	1176	325	28	84
15 Solid fuels	432	122	56	495	85	48	1728	63	90	72
17 Processed food	27342	14887	4128	32668	8285	8920	28970	5703	2574	2143
18 Gasoline, etc.	10551	1342	341	6873	1198	1149	849	87	143	93
20 Textiles & apparel	15025	3987	1198	15691	3281	3626	5908	920	589	541
22 Furniture & fixtures	2733	782	123	4346	850	195	315	94	106	63
24 Printng & publishng	1722	230	61	2271	341	617	208	114	57	34
25 Rubber products	1214	688	113	859	72	299	72	9	15	13
26 Industrial chemicals	815	280	122	261	158	81	57	25	41	11
28 Miscellaneous chemicals	6107	1865	466	7449	1389	1066	1364	187	179	153
30 Glass products, etc.	223	66	22	722	51	77	121	49	21	5
31 Motor vehicles	7033	234	47	5703	736	373	187	83	82	66
32 Other transport equipment	2005	273	77	544	60	97	320	56	45	27
34 Heating equipment, etc.	81	85	32	418	20	99	189	49	6	4
36 Electrical goods	7710	956	266	6374	926	1568	1803	270	214	90
37 Scientifc instruments	1990	531	191	1750	151	147	246	131	42	38
38 Misc. manufacturing	1807	1817	674	1931	178	447	606	52	48	23
39 Utilities	5530	371	184	4439	386	735	588	107	89	30
40 Construction	2266	296	202	1785	160	161	830	188	280	67
41 Transportation services	3468	513	542	4193	910	1662	2714	211	253	263
42 Communication services	3379	835	149	2015	207	391	194	69	44	19
44 Other services	80260	11167	3134	55803	8256	18984	9585	1859	1607	807
Capital accumulation										
48 Equipment	24119	5748	1625	22325	3709	7718	8862	1480	880	743
49 Construction	30521	8782	1929	31807	6109	15414	11480	3504	1352	929
50 Change in stocks	-894	525	247	3535	1205	488	3082	176	80	201
Government consumption										
51 Education	14056	1800	444	10586	742	2704	2580	213	484	239
52 General public services	37898	4264	1496	26658	3791	4531	6509	1661	1981	994
53 Balance of trade	-1443	-643	-193	-2039	-2644	-659	-2746	216	-1097	-677
Total	289371	64772	19068	254791	42694	72358	93988	19622	10611	7424

Thus, if the exchange rates between the US, international and regional currencies are taken to be determined by purchasing power parity, the rates are all unity and Tables 5, 6 and 7 are effectively expressed in a common currency.

4. Interpretation and Assessment of the GDP Estimates

In the GIOM, an international commodity balance or market clearing constraint is imposed for each traded commodity. That is, the model does not differentiate between traded commodities of a particular type (e.g., *Textile and apparel*) produced in different regions. Hence, for a traded commodity, the model's database should include estimates of private consumption in each region measured in a common physical unit. This requirement usually presents two kinds of difficulty.

Firstly, even within a region, a GIOM commodity (such as *Textiles and apparel*) typically represents a collection of unlike items (such as shirts and shoes) which cannot simply be added together. The usual solution is to define the unit of measurement to be the fraction of total consumption of *Textiles and apparel* in the region in the base period that could have been purchased with one dollar. Thus, the physical unit of *Textiles and apparel* becomes a bundle of unlike items combined in the same proportions as they were in base period consumption. For a multiregion model, however, there is no presumption that the base period proportions will be the same in each region, or even that the same items will always be represented in the bundles. That is, the physical unit of *Textiles and apparel* will not generally be the same in all regions. This problem can be alleviated, but not eliminated, by increasing the level of disaggregation employed in the model. Whatever level is finally implemented, residual differences in the composition of the base period bundle across regions will always remain and one can only abstract from their implications.

The other kind of difficulty arises because the relative prices of commodities differ between regions in the base period. Thus, even if the base period bundle of *Textiles and apparel* combines its constituent items in the same proportions in all regions, a base period dollar that is common to all regions (such as the $US in Table 5) will purchase a bigger bundle in a region where *Textiles and apparel* is relatively cheap than it will in a region where it is relatively expensive. This source of error is

embodied in the estimates of Table 5 (which are based on the domestic prices of each country), but not in the estimates of Table 6 (which are base on a common set of world prices).

Table 6, then, shows 1980 expenditures on various commodities measured in world prices and expressed in world currency. But it also shows the physical purchases of those commodities, the physical unit being the amount that could have been purchased for one international dollar in the base period. Thus, for example, the private sector in *High-income North America* (region NAH) consumed 17460 x 10^7 units of *Textiles and apparel* in 1980, more than 22 times the amount (766 x 10^7) consumed in *Sub-Saharan Africa* (region SSA). With this convention, the base period international price of a commodity expressed in world currency is always one dollar.

Now, assuming that US currency, world currency and all regional currencies exchange according to purchasing power parity, Table 7 can be interpreted equally well as being expressed in international dollars or in regional dollars. In that case, Table 7 determines the base period regional prices of commodities corresponding to the system of physical units established in Table 6. For example, the regional base period price in world currency of *Textiles and apparel* in *High-income North America* is

15052 / 17460 = 0.86 dollars,

whereas the corresponding price in *Sub-Saharan Africa* is

541 / 766 == 0.71 dollars.

i.e., the regional prices are similar in the base period.

For input-output models, where prices play a relatively minor role, the data in Table 7 is of limited significance. However, for multiregion CGE models, where the behaviour of economic agents is typically specified in terms of nominal variables, Tables 6 and 7 are of comparable importance as data sources. In particular, Table 7 provides the kind of observations required to estimate independent consumer demand systems in each region.

The practical importance of mobilizing the ICP data to determine estimates of private consumption for the GIOM can be guaged from Table 8. This table shows the deviations

$$D_{in} = 100 (| E_{in} | - | E^{I}_{in} |) / | E^{I}_{in} |$$

of the absolute values of the expenditures E_{in} (from Table 5) from the absolute values of the corresponding expenditures E^{I}_{in} (from Table 6), expressed as percentages of the latter. In other words, the table shows the "errors" that occur when expenditures in physical units are derived via the standard approach (represented by Table 5) rather than the ICP approach (represented by Table 6). The deviations can only be regarded as very large for many expenditure categories.[9] Moreover, the pattern of the deviations across categories and across regions is quite erratic. The relevant comparison here is between the magnitudes of the deviations and the magnitudes of the policy (or otherwise) -induced changes in expenditure that models like the GIOM are designed to analyse. Clearly, for many policies of interest, the former magnitudes will often be at least as large as the latter, posing a serious methodological weakness for the standard approach to data preparation.

While expenditures on interregionally traded commodities should be evaluated in terms of a common set of prices in preparing the GIOM database, the same requirement does not hold for commodities that are traded only within a region. For the latter type, the commodity balance constraint is region specific, and the commodity *Other services* produced and consumed in region NAH, say, is treated as a different commodity to *Other services* produced and consumed in region SSA. Thus it does not matter whether expenditure in region NAH on *Other services* is

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[9] Note, however, that the deviations are not so large as to be inconsistent with other experience from the International Comparison Project. Kravis and Lipsey (1990, p.1), for example, offer the following assessment:

> "The predominant method of meeting the need for comparative data on real GDP and related macrovariables is to convert own-currency value aggregates to a numeraire currency, usually the US dollar, via exchange rates....Exchange rate conversion is still the common practice despite clear evidence that exchange rates fail to reflect the purchasing power of currencies, sometimes being off by a factor of 3 or more, even for output as a whole and still more for individual products".

Table 8. Expenditure Deviations D_{in}, Per Cent

GIOM Expenditure Category	Region 1 NAH	2 LAM	3 LAL	4 WEH	5 WEM	9 JAP	10 ASL	11 OIL	12 AAF	13 SSA
Private consumption										
1 Livestock & dairy	-46.87	-42.24	-30.31	2.84	-12.61	-22.57	-33.04	122.13	-3.74	58.62
4 Root crops	25.27	-0.57	-31.70	-7.40	-34.59	95.95	-60.26	103.64	47.40	34.21
5 Forestry & other agric.	-0.10	-24.60	-33.13	-2.98	-29.22	97.89	-56.62	35.64	-52.66	-22.09
6 Fishing	4.45	-50.54	-65.59	25.99	12.49	42.44	-59.22	-11.37	-53.44	-49.22
15 Solid fuels	242.95	61.29	-52.21	184.20	105.80	230.48	-70.15	132.19	1.27	16.52
17 Processed food	-21.83	-40.60	-39.08	4.49	-27.75	15.92	-48.31	38.07	-30.10	-13.08
18 Gasoline, etc.	-26.83	-22.89	-41.29	35.80	32.77	37.46	-20.05	-64.84	-26.46	-25.26
20 Textiles & apparel	-14.29	1.20	-45.09	7.39	-3.65	-6.11	-51.39	-5.00	-23.37	-21.17
22 Furniture & fixtures	-25.22	-19.55	-60.70	23.41	19.87	-13.94	-54.42	-10.84	-35.54	-33.07
24 Printng & publishng	-1.43	30.00	-37.88	27.37	-3.65	-19.76	-47.92	82.39	-9.39	45.77
25 Rubber products	-29.21	-0.83	-17.20	24.37	3.70	-8.26	-18.86	-15.56	-34.58	-28.80
26 Industrial chemicals	69.17	14.28	-76.19	68.58	-34.44	11.04	-45.98	-52.05	-49.52	-18.71
28 Miscellaneous chemicals	-14.42	-51.69	-65.81	32.75	-3.58	32.73	-31.54	158.30	9.82	75.31
30 Glass products, etc.	5.32	-19.69	-44.28	-2.00	0.87	24.03	-50.84	-32.51	-57.03	-47.62
31 Motor vehicles	-12.45	-56.03	-50.78	14.28	34.83	-40.07	-5.91	63.35	121.35	65.83
32 Other transport equipment	-19.32	42.11	5.59	29.44	36.69	-60.90	-46.58	87.69	72.49	106.13
34 Heating equipment, etc.	6.76	40.49	-28.16	3.38	-31.72	-30.18	-41.19	-55.03	-71.84	-65.29
36 Electrical goods	-17.53	-43.50	-28.03	2.17	1.98	0.42	-39.07	44.81	27.98	50.15
37 Scientifc instruments	-1.29	-22.36	-4.99	19.49	-10.35	-1.17	-54.45	73.14	-6.61	12.15
38 Misc. manufacturing	24.83	-51.53	-50.43	34.32	1.23	21.54	-52.34	-40.67	-47.07	-53.01
39 Utilities	-16.11	0.00	-66.41	46.52	1.59	39.63	-55.04	39.92	25.39	71.00
40 Construction	21.17	3.28	-47.65	32.68	-21.25	-19.33	-59.04	44.77	-48.32	-32.33
41 Transportation services	47.57	-13.69	-55.55	96.00	15.23	-3.37	-72.31	17.17	-9.10	51.75
42 Communication services	-24.46	-36.01	-56.06	75.56	-18.09	55.66	-3.11	41.78	37.61	-4.29
44 Other services	20.00	-24.53	-47.66	14.07	-16.61	14.26	-61.28	-14.71	-36.32	-45.44
Capital accumulation										
48 Equipment	-19.01	8.14	19.24	0.89	-19.09	-24.11	-12.97	12.61	-1.70	7.63
49 Construction	-5.63	-42.06	-52.71	17.16	-14.36	-3.55	-51.63	80.19	26.04	35.66
50 Change in stocks	0.01	-0.06	0.12	0.02	0.00	-0.01	-0.15	-0.29	0.12	-0.05
Government consumption										
51 Education	42.95	-51.97	-73.93	88.14	20.95	56.89	-82.17	1.26	-24.79	-39.48
52 General public services	25.74	20.58	-51.09	24.57	-21.93	115.59	-74.51	-34.69	-39.67	-51.36
53 Balance of trade	-0.01	0.10	-0.05	0.00	0.00	-0.05	0.13	-0.28	-0.02	0.01
Total	-0.62	-30.15	-45.91	16.72	-15.41	6.79	-56.15	17.75	-28.19	-21.25

taken to be 66599×10^7 units with a world price of one dollar and a regional price (in world currency) of

$$80260 / 66599 = 1.21 \text{ dollars},$$

or to be 80260×10^7 units with a regional price of one dollar and a world price of

$$66599 / 80260 = 0.83 \text{ dollars}.$$

In other words, for commodities that are not traded between regions, private consumption in physical units can be determined equally well from Table 6 or Table 7.

In CGE models, commodities of the same type produced in different regions are generally treated as different commodities whether they are traded between regions or not; i.e., markets generally clear separately for all commodities produced in different regions. Hence there is no requirement that they be measured in common physical units. However, as the CGE approach assumes that agents can always tell the difference between varieties of a commodity such as *Textiles and apparel* produced in different regions, it imposes its own formidable reqirements for data in the form of bi-lateral trade flow matrices.

Finally, it should be noted that the GIOM employs the same commodity classification for all components of demand, whereas the ICP employs different classifications for private consumption, government consumption, investment and net exports, and does not consider intermediate usage at all. Hence the price assigned to a particular commodity in the ICP private consumption classification reflects the relative importance of its constituents in private consumption, whereas, for the GIOM, gross output weights are strictly required. This problem is limited to the extent that GIOM commodities are specialized in their use, i.e., to the extent that a commodity with significant sales to final consumption does not have significant sales to other uses.

5. Concluding Remarks

This paper has presented a method for obtaining various estimates of GDP and its components for 1980. The estimates conform as far as possible to the sectoral and regional classifications of the global input-output model (GIOM) of Duchin et al., and are based on three different sets of relative prices: domestic relative prices for 60 ICP countries (Table 5), a set of average world prices (Table 6) and 11 sets of average regional prices (Tables 7).

The original purpose of the exercise was to provide estimates of private consumption expenditure for the GIOM database. However the method also allowed an assessment of a common practice in preparing data for multisectoral global models, namely, that of collecting expenditure data evaluated in local (national) prices and converting to world prices using published exchange rates. The analysis suggests that, when commodities produced in different countries are treated as perfect substitutes in the model, the practice may seriously compromise the model's results.

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