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PROBLEMS IN CREATING A  
REGIONAL ECONOMIC MODEL

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SIMPOSIO 1.989

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INPUT-OUTPUT AND THE PROBLEM OF GENERATING  
A REGIONAL MATRIX FROM NATIONAL TABLES

1. INPUT-OUTPUT FLOWS

An input-output Transactions table shows the expenditure and purchasing flows between sectors of an economy. In Fig. 1 (Richardson), the rows show an industry's sales either to another industry (intermediate demand) or to Final Demands eg. Households.

$$\begin{array}{c}
 X_i = \sum_j^n x_{ij} + [C_i + I_i + C_i + E_{xi}] \\
 \uparrow \qquad \qquad \qquad \uparrow \qquad \qquad \qquad \underbrace{\hspace{10em}} \\
 \text{Gross} \qquad \qquad \text{Intermediate} \qquad \qquad \text{Final} \\
 \text{Output} \qquad \qquad \text{Demand} \qquad \qquad \text{Demand}
 \end{array}$$

or 
$$X_i = \sum_j^n x_{ij} + D_i \qquad (1)$$

The columns show the purchases made by each industry/sector from other industries or sectors - the latter including wages, profits and imports. Each  $X_{ij}$  is an input to sector  $j$  and can be expressed as a proportion of that sectors' total inputs -

$$\begin{array}{l}
 x_{ij} = a_{ij} X_j \qquad (2) \\
 \text{or} \quad a_{ij} = \frac{x_{ij}}{X_j}
 \end{array}$$

The  $a_{ij}$ 's are the technical coefficients and form the 'A' matrix. The assumption that they are constant implies no economies of scale and no import substitution. Given the flows in Fig. 2, the resulting 'A' matrix is given in Fig. 3 (Grampian Study).

## INPUT-OUTPUT

In algebraic terms, substituting Eqn (2) into Eqn (1) gives -

$$x_i = \sum_{j=1}^n a_{ij} x_j + d_i$$

or in matrix form,

$$X = A.X + D \text{ where } X = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}; A = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{bmatrix}; D = \begin{bmatrix} d_1 \\ \vdots \\ d_n \end{bmatrix}$$

Also,  $X - AX = D$

and  $(I - A) X = D$ ,

$$\begin{matrix} I & & A & & X & & D \\ \begin{bmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & & \vdots \\ \vdots & & & 0 \\ 0 & \dots & 0 & 1 \end{bmatrix} & - & \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{bmatrix} & \cdot & \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} & = & \begin{bmatrix} d_1 \\ \vdots \\ d_n \end{bmatrix} \end{matrix}$$

hence

$$\begin{matrix} \begin{bmatrix} 1-a_{11} & -a_{12} & \dots & -a_{1n} \\ -a_{21} & 1-a_{22} & & \vdots \\ \vdots & & \ddots & \vdots \\ -a_{n1} & -a_{n2} & \dots & 1-a_{nn} \end{bmatrix} & \cdot & \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} & = & \begin{bmatrix} d_1 \\ \vdots \\ d_n \end{bmatrix} \\ \underbrace{\hspace{10em}}_{(I-A)} & & & & \end{matrix}$$

and  $X = (I - A)^{-1} D$  where  $(I - A)^{-1}$  is the LEONTIEF INVERSE

$$\text{so } (I - A)^{-1} = B = \begin{bmatrix} b_{11} & \dots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{n1} & \dots & b_{nn} \end{bmatrix}$$

then  $X = BD$

## 2. MULTIPLIERS

2.1 Type 1 Output Multiplier Each element  $b_{ij}$  of the inverse Leontief matrix shows the direct and indirect effects on the output of each

sector from an increase in sales of £1 (or in the UK 1984 table, £1,000) to final demand by sector  $j$ . So summing the  $b_i$ 's down a  $j$  column will show the effect on all sectors of an increase in sales of £1 by sector  $j$  to final Demand,  $D$ . Multiplier:

$$M_j^1 = \sum_{i=1}^n b_{ij}$$

2.2 Type 2 Output Multipliers show the total effect including induced effects on all sectors of a unit increase in sales by sector  $j$ . To do this, the model must be "closed", i.e. the Household Sector must be included in the Transactions Matrix:

$$M_j^2 = \sum_{i=1}^n b_{ij}^* \quad , \quad \text{where } b_{ij}^* \text{ are the elements of the Leontief inverse which includes the Household Sector.}$$

Note that the summing is still over the original  $n$  industries, not  $n + 1$ .

There are Type 1 and 2 Multipliers for Income and Employment.

### 2.3 Income Multiplier

The Direct Income Effect Coefficient  $DIC_j = H_j / X_j$ , where  $H_j$  is the income

from sector  $j$  and  $X_j$  is the output of sector  $j$ .

If the  $DIC_j = 0.25$  (i.e. if wages make up 25% of industry  $j$ 's inputs), then a rise in output of £100 by  $j$  will increase incomes by £25. The Direct and Indirect effects are calculated by,

$$DIIC_j = \sum_{i=1}^n b_{ij} DIC_i \quad \text{for each sector } i \text{ supplying } j,$$

for sector  $j$

multiply the  $b_{ij}$  by the  $DIC$  for  $i$  and sum for all sectors.

The Type 1 Income Multiplier for sector  $j = DIIC_j / DIC_j$

2.4 Employment Multipliers Similarly, the direct effect of a change in output on employment in sector  $j$  ( $DEC_j$ ) =  $E_j / X_j$ , where  $E_j$  is employment in

sector  $j$ . This gives the number of employers per unit of output.

The direct and indirect effects of increased output in sector  $j$  are,

$$DIEC_j = \sum_{i=1}^n b_{ij} DEC_i$$

The Type 1 Employment Multiplier for sector  $j$   
 $= DIEC_j / DEC_j$

Closing the model allows Type 2 Multipliers (i.e. direct, indirect and induced effects) for income and employment to be calculated.

### 3. The Import Problem

A region will normally be more dependent on imports than a national economy, and hence we would expect smaller  $a_{ij}$  coefficients. There is the problem that inter-sectoral trade at National level can become inter-regional trade at the regional level. We could set up a NET flows matrix by setting transactions between firms in the same industry as zero. It is sometimes argued that multiplier calculation is less subject to overestimation if a Net matrix is used.

As regards the general problem of converting National to Regional Coefficients, the following main methods are used:

- 3.1 Ad hoc adjustment based on sector survey data.
- 3.2 Developing regional weights based on surveys or expert local knowledge.
- 3.3 Using some kind of Location Quotient or commodity balance approach.

We will probably begin with using a simple LQ method (as does Portsmouth). A LQ measures the relative importance of an industry in a region compared with its national importance. Data availability suggests that we use employment data for this purpose.

#### (a) The Simple Location Quotient

$$SLQ_i = \frac{E_i^R / E^R}{E_i^N / E^N}, \text{ where } E_i^R \text{ is regional employment in industry } i, E^N \text{ is total national employment.}$$

a  $SLQ_i \geq 1$  indicates a regional industry is more important regionally than in the national economy. It is then assumed that no inter-regional imports are necessary, and the national  $A_{ij}$ 's are used.

If the  $SLQ_i < 1$ , it is assumed that imports are needed, and regional  $A_{ij}$ 's are estimated by multiplying the national coefficients by the location quotient,

$$r_{ij} = a_{ij} \cdot SLQ_i$$

Imports of product  $i$  are estimated as the quantities required to satisfy regional output requirements. The residual,  $M_{ij}$ , is added to the relevant import coefficient,

$$m_{ij} = a_{ij}(1 - SLQ_i)$$

To carry out this process we must have a match between the National I/O tables industrial sectors and the employment data [check SIC's].

#### (b) A more sophisticated method is to use

The Cross Industry Location Quotient (used in Grampian Model). An employment based CILQ compares the proportion of national employment

in selling industry i in the region to that of purchasing industry j. It therefore recognises that a region may have different patterns of inter industry interdependence than the notion

$$CILQ_{ij} = \frac{E_i^R / E_i^N}{E_j^R / E_j^N}$$

This then requires CILQs to be calculated for all pairs of industries in the table (need a MACRO!). If an industry does not exist at the regional level then the CILQ = 0 and all local requirements must be imported and the  $a_{ij}$  is transferred to the Import row. For CILQs < 1 the same process is used to adjust the  $a_{ij}$ 's as described above, ie. the adjusted  $a_{ij}$  goes into the 'A' matrix and the residual is added to the relevant national import coefficient.

#### 4. Financial Flows

We now have to go back to estimate regional gross output for each producing sector (check availability of aggregated estimates for the Region - "Regional Trends"). If this data is not published in a consistent form, we use regional employment ratios to adjust national gross output figures -

$$RGO = \frac{E_i^R}{E_i^N} \cdot NAO_i$$

The inter-industry expenditure flows (check price base) are calculated as follows:

$$\begin{pmatrix} X_{i1}^{RI} \\ \vdots \\ X_{in}^{RI} \\ \vdots \\ X_{i1}^{RN} \\ \vdots \\ X_{in}^{RN} \end{pmatrix} = \begin{pmatrix} v_{11} & \dots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{n1} & \dots & v_{nn} \end{pmatrix} \cdot \begin{pmatrix} X_i^R \\ \vdots \\ X_n^R \end{pmatrix}$$

↑ Intermediate flows                      ↑ Adjusted Regional Coefficients                      ↑ Regional Gross Output

The Final Demand Vector must also be estimated. To do this multiply the National Household Coefficient by

$$E_i^R / E_i^N$$

The other final demand vectors (eg. Investment, Govt. Consumption) are estimated in a similar way. REGIONAL EXPORTS are then the Residual,

$$E_{X_i}^R = X_i^R - X_i^{RI} - H_i^R - I_i^R - G_i^R$$

#### 5. Next Steps

We will have done well to get this far, and we will then have to check our results against other known data, regional comparisons etc. Are

there obvious distortions? Check with experts in key sectors and our own (and others) survey data. For published reports we will need to aggregate to fewer sectors, so how many? Match official sources?

6. Further Development

Development will require detailed analysis of simulations and forecasts; surveys and special sector studies; adaption of technique to other areas eg. Counties, TWA's.

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1984

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Table 2 : The use matrix - commodity analysis of purchases by industry from domestic production in 1984

Sales by commodity group	Purchases by industry group											
	1 Agric	2 For&fish	3 Coal	4 Oil&gas	5 Mln oil	6 Electric	7 Gas	8 Water	9 Met ores	10 Steel	11 Alumin	12 Oth met
1 Agriculture	2,296	-	-	-	-	-	-	-	-	-	-	-
2 Forestry and fishing	-	4	-	-	-	-	-	-	-	-	-	-
3 Coal extraction etc	2	-	87	-	0	1,147	1	1	0	346	6	15
4 Extraction of oil and gas	-	-	0	882	7,135	-	1,936	-	-	-	-	-
5 Mineral oil processing	293	22	15	-	1,072	3,233	10	3	3	14	5	3
6 Electricity etc	89	12	262	-	58	873	18	114	15	213	58	59
7 Gas	89	3	7	-	2	89	211	1	5	115	18	20
8 Water	82	5	-	-	27	78	-	48	0	34	6	5
9 Extraction of metal ores etc	-	-	-	-	-	-	-	-	4	85	38	33
10 Iron and steel etc	5	-	195	21	-	11	18	7	1	1,600	2	179
11 Aluminium etc	-	-	-	-	-	2	0	0	-	35	188	12
12 Other non-ferrous metals	12	-	-	-	-	3	0	0	-	54	7	69
13 Extraction of stone etc	4	-	-	-	-	-	0	0	3	5	1	-
14 Clay products	12	-	-	-	-	-	9	0	-	0	-	-
15 Cement etc	23	-	-	-	-	-	1	1	-	17	-	-
16 Concrete etc	17	-	-	-	-	9	8	10	0	8	-	0
17 Glass	8	2	-	-	0	2	1	-	0	1	-	1
18 Refractory and ceramic goods	5	-	-	-	-	6	-	-	-	36	3	1
19 Inorganic chemicals	-	-	0	-	73	6	2	0	11	30	9	21
20 Organic chemicals	-	-	17	3	28	1	1	0	1	3	8	1
21 Fertilisers	802	-	-	-	0	1	2	0	0	3	-	0
22 Synthetic resins etc	-	-	1	-	0	1	2	0	0	3	-	0
23 Paints, dyes etc	13	-	1	2	1	1	4	0	0	21	4	0
24 Special chemicals	412	-	6	6	28	8	8	14	2	37	0	3
25 Pharmaceuticals	9	-	-	-	0	-	-	0	0	0	-	-
26 Soap and toiletries	14	-	1	-	0	1	5	1	0	0	-	0
27 Chemical products nes	-	-	-	-	-	-	-	-	-	-	-	-
28 Man-made fibres	-	-	-	-	-	-	-	-	-	-	-	-
29 Metal castings etc	14	-	8	29	0	28	10	14	0	59	-	1
30 Metal doors, windows etc	-	-	-	-	-	-	1	0	-	0	0	-
31 Metal packaging products	-	-	0	-	27	17	-	-	0	5	-	3
32 Metal goods nes	38	-	2	14	1	13	28	8	1	33	5	5
33 Industrial plant & steelwork	-	-	18	71	29	34	15	-	0	55	-	5
34 Agricultural machinery etc	23	7	-	-	-	-	-	-	-	-	-	-
35 Machine tools	-	-	-	-	-	0	0	-	-	7	2	4
36 Engineers small tools	9	-	1	8	1	5	5	2	1	0	1	2
37 Textile etc machinery	-	-	-	-	-	-	-	-	0	-	-	-
38 Process machinery etc	-	-	1	-	10	9	10	10	-	28	8	6
39 Mining etc equipment	-	-	310	-	1	8	3	-	13	15	3	3
40 Mech power transmission equip	-	-	1	107	-	-	-	-	-	7	4	1
41 Other machinery etc	-	12	34	517	9	19	24	9	2	57	12	10
42 Ordnance etc	-	-	-	-	-	-	-	-	-	-	-	-
43 Office machinery, computers etc	-	-	8	-	1	4	2	4	-	8	-	-
44 Insulated wires and cables	4	-	18	-	-	50	1	-	-	-	0	0
45 Basic electrical equipment	-	-	9	-	0	44	15	1	-	7	-	-
46 Industrial electrical equipment	1	-	8	-	-	1	2	-	0	8	0	0
47 Telecommunication etc equipment	-	3	8	-	3	20	127	1	0	18	2	2
48 Electronic components	-	-	15	-	-	13	-	3	-	-	-	-
49 Electronic consumer goods etc	-	-	-	-	-	-	-	-	-	-	-	-
50 Domestic electric appliances	-	-	-	-	-	-	-	-	-	-	-	-
51 Electric lighting equipment	2	-	-	-	-	4	-	-	-	-	-	-
52 Motor vehicles and parts	18	15	3	-	1	5	7	4	1	4	1	1
53 Shipbuilding & repairing	-	19	-	238	-	-	-	-	-	-	-	-
54 Aerospace etc	-	-	-	-	-	-	-	-	-	-	-	-
55 Other vehicles	-	12	-	-	-	-	-	-	-	-	-	-
56 Instrument engineering	-	-	1	-	0	3	1	2	-	4	1	3
57 Oils and fats	4	-	-	-	4	-	-	-	-	-	-	-
58 Slaughtering & meat processing	-	-	-	-	-	-	-	-	-	-	-	-
59 Milk and milk products	241	-	-	-	-	-	-	-	-	-	-	-
60 Fruit, veg and fish processing	-	-	-	-	-	-	-	-	-	-	-	-
61 Grain milling and starch	-	-	-	-	-	-	-	-	-	-	-	-
62 Bread, biscuits etc	-	14	-	-	-	-	-	-	-	-	-	-
63 Sugar	-	-	-	-	-	-	-	-	-	-	-	-
64 Confectionery	-	-	-	-	-	-	-	-	-	-	-	-
65 Animal feeding stuffs	2,032	17	-	-	-	-	-	0	-	-	-	-
66 Miscellaneous foods	238	7	-	-	-	-	-	-	-	-	-	-
67 Alcoholic drink	1	1	0	5	6	5	-	-	-	1	-	1
68 Soft drinks	-	-	-	-	-	-	-	-	-	-	-	-
69 Tobacco	-	-	-	-	-	-	-	-	-	-	-	-
70 Woollen and worsted	-	-	-	-	-	-	-	-	-	-	-	-
71 Cotton etc spinning & weaving	-	-	-	-	-	-	-	-	-	-	-	-
72 Hosiery & other knitted goods	-	-	-	-	-	-	-	-	-	-	-	-
73 Textile finishing	-	-	-	-	-	-	-	-	-	-	-	-
74 Carpets etc	-	-	-	-	-	-	-	-	-	-	-	-
75 Jute etc	38	42	-	-	-	-	-	-	-	-	1	-
76 Leather and leather goods	-	-	-	-	-	-	-	-	-	-	-	-
77 Footwear	8	-	8	-	1	4	1	1	-	1	-	1
78 Clothing and furs	10	10	12	-	1	6	2	-	-	1	1	-
79 Household and other textiles	11	-	-	-	-	-	-	-	1	0	-	-
80 Timber and wood products	27	10	17	-	-	2	1	1	1	2	0	0
81 Wooden furniture etc	-	-	-	-	0	-	-	0	-	-	-	0
82 Pulp, paper and board	-	-	-	-	-	-	-	-	-	-	1	0
83 Paper and board products	52	-	3	-	1	18	10	3	3	18	8	7
84 Printing and publishing	8	-	5	-	10	30	20	7	1	14	4	7
85 Rubber products	48	1	33	-	0	1	2	1	1	5	1	0
86 Processing of plastics	48	-	1	-	13	4	39	11	1	7	4	4
87 Other manufacturing	5	2	-	-	-	-	-	-	-	-	-	-
88 Construction	108	13	0	-	-	18	8	10	0	17	5	3
89 Distribution etc	381	15	105	92	53	398	49	20	2	488	62	68
90 Hotels, catering etc	0	0	-	0	-	-	-	-	-	-	-	-
91 Railways	13	0	20	3	13	19	2	0	-	81	5	18
92 Road transport etc	73	24	27	18	2	21	11	1	31	184	13	22
93 Sea transport	29	0	34	103	7	32	12	0	1	102	1	103
94 Air transport	22	0	18	100	28	48	7	0	1	53	2	41
95 Transport services	47	17	8	446	98	18	12	5	1	9	2	4
96 Postal services	14	3	5	-	1	15	10	5	0	4	1	2
97 Telecommunications	47	8	11	-	3	33	21	10	0	9	2	4
98 Banking and finance	58	18	13	-	23	69	49	18	2	34	8	18
99 Insurance	84	12	5	5	4	33	3	5	2	24	3	20
100 Business services etc	243	13	69	9	108	201	105	53	5	128	22	48
101 Other services	413	47	0	-	1	2	1	1	0	1	0	0
102 Public administration etc	-	-	-	-	-	-	-	-	-	-	-	-
103 Total intermediate	8,374	391	1,417	2,858	8,881	6,691	2,848	414	121	4,131	535	839
104 Imports of goods & services	1,087	2	180	1,215	4,529	2,135	1,452	38	28	879	431	817
105 Sales by final demand	9	8	9	12	12	1	5	2	1	385	158	279
106 Taxes on expend, less subsidies	-854	15	-1,800	-10	30	344	188	107	12	141	25	27
107 Income from employment	1,385	231	1,333	486	292	2,215	1,214	524	71	1,354	202	335
108 Gross profits etc	4,507	99	985	18,095	1,154	1,339	1,356	813	68	296	81	90
109 Total inputs	14,709	744	2,105	23,455	14,898	12,725	7,041	1,697	298	7,285	1,412	2,387

Fig 4. SIMPLE LOCATION QUOTIENTS

LQSW1.XLS

	1	2	3	4	5	6	7	8
1	SLQ >1	1984:		SW	Devon	PlymTTW	Cornwall	1981
2								
3	Ag, For & Fish			1.88	2.12	0.7	Agric.	4.01
4	Min. Mining & Proces			3.78	4.25	2.12	Ch. Clay	6
5	Trans. Gds. non Motor			2.42	4	10.52	Tin Min.	16.7
6	Hotels & Catering			1.36	1.56	1.07	Hot&Cat	4.6
7							Fishing	7.83
8	:						Milk Prod	2.9
9	SLQ = or close to 1							
10								
11	Elect Gas, Water			1.08	0.94	0.89		
12	Elect Engineering			0.96	0.89	0.97		
13	Distribution			1.04	1.07	1.04		1.2
14	Communications			0.99	1.01	1.03		1.2
15	Public Administration			1.01	1.05	1.08		
16								
17	SLQ <1							
18								
19	Chemicals Mfg.			0.69	0.4	0.25		
20	Motor Vehcls & Parts			0.42	0.06	0.02		
21	Textiles			0.3	0.49	0.07		
22								
23	Cornwall Model 1984			TYPE I	Multipliers			
24	(Aberdeen)							
25	INDUSTRY			OUTPUT	INCOME	EMPLOY		
26								
27	Agriculture			1.54	1.64	1.39		
28	Fishing			1.3	1.33	2.31		
29	Tin Mining			1.19	1.15	1.19		
30	China Clay			1.17	1.18	1.21		
31	Ship Build. & Repair			1.33	1.13	1.3		
32	Slaughtering & Meat			2.22	4.36	6.1		
33	Milk & Milk Process.			2.12	5.55	7.13		
34	Distribution			1.29	1.29	1.22		
35	Hotels & Catering			1.2	1.2	1.12		

Rij 5. Type 1 Output Multipliers

MATTEST.XLS

	BA	BB	BC	BD	BE
1	COMPARATIVE	UK (CSO)	SWReg	Devon	Cornwall
2	MULTIPLIERS 1984		PBS	PBS	(Aberdeen)
3	Type 1 Output Mults				
4					
5	Aq. Fish For	ag=2.294	2.074	2.037	ag=1.54
6	Coal/Oil Extract	co=2.384	1.007	1	
7	MinOilProcess	1.856	1.211	1.306	
8	Utilities	ga=1.599	1.619	1.585	ga=1.15
9	Metals	om=1.691	1.264	1.083	1.77
10	Minerals	ci=1.733	1.75	1.718	1.17
11	Chemicals	orc=1.982	1.486	1.26	1.44
12	Metal Goods	mca=1.858	1.316	1.096	1.58
13	Mech. Eng	mto=1.848	1.869	1.591	1.27
14	Elect&Offic Equip.	off=1.631	1.585	1.504	1.39
15	Motors	1.855	1.292	1.038	
16	Transport Equip.	sh=1.855	1.564	1.524	sh=1.33
17	Food	ofo=2.071	2.265	2.208	mi=2.12
18	Drink/Tobacco	sdr=2.121	1.964	1.424	1.71
19	Textiles	wo=1.693	1.156	1.252	Of=1.43
20	Cloth/Footwear	ci=1.608	1.442	1.32	1.25
21	Timber/Furniture	ti=1.869	1.698	1.654	1.53
22	Paper&Pulp	pa=1.731	1.535	1.34	1.33
23	Rubber Prods	ru=1.672	1.604	1.166	1.39
24	Other Mfg.	1.7	1.398	1.421	1.3
25	Constructions	2.078	1.794	1.652	1.56
26	Distribution	1.756	1.575	1.553	1.29
27	Hotels&Catering	1.618	1.53	1.506	1.2
28	Transport Serv.	ro=1.7	1.439	1.396	ro=1.24
29	Posts&Comunic.	te=1.415	1.353	1.34	1.17
30	Fin. Services	fi=1.638	1.624	1.607	Fi+ot=1.44
31	Other Bus. Serv.	1.339	1.251	1.279	



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