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A MODIFIED THEORY OF INVESTMENT FOR ORANI

by

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ABSTRACT

This paper reviews both the theoretical treatment of investment in the ORANI model and the implementation of that theory in the linearised ORANI equations. The relationship between the coefficients in the linearised investment equations and various elements of the ORANI database is examined in detail. Anomalies in the current method of calculating these coefficients are portrayed as symptoms of a problem of calibration -- the process of ensuring (through appropriate selection of parameter values) that the database is indeed a solution of the model equation system. A slightly more flexible functional form is proposed for the investment equations, which allows the requirements of calibration to be satisfied, without unduly constraining the specification of investment behaviour.

A MODIFIED THEORY OF INVESTMENT FOR ORANI

by

Mark Horridge and Ian Bruce

1: INTRODUCTION

This paper reviews the treatment of investment in ORANI. The following three areas are examined in detail:

(a) the restrictiveness of the functional form chosen by Dixon, Parmenter, Sutton and Vincent (1982) (hereafter DPSV);

(b) the accuracy of the implementation of the DPSV theory in the computer package which solves the ORANI model; and

(c) the sensitivity of simulation results with respect to the settings of the investment parameters in the DPSV theory.

The discussion leads to the proposal of a slightly modified theory of investment. A method is then suggested, to implement the modified theory in a way which is consistent with the ORANI database.

The remainder of the paper is laid out as follows. Section 2 summarizes the current ORANI theory of investment. Section 3 presents a critique of this theory. Section 4 examines difficulties in implementing the existing theory. Two methods of implementation are compared, but each is found to be wanting. In Section 5 a modified theory is proposed, which is easier to implement satisfactorily. Conclusions, and suggestions for further research appear in Section 6.

2: SUMMARY OF THE CURRENT ORANI THEORY OF INVESTMENT

The current ORANI theory of investment may be examined from two angles: the theory itself, and its implementation in the model. It seems best to start with a summary of the theory, adapted from pages 118-122 of DPSV.

The theory does not attempt to explain aggregate private investment in fixed plant, machinery and buildings; only how this investment is directed amongst industries. The view is that aggregate investment is best explained in a macroeconomic model which captures the effects of monetary phenomena and government macroeconomic policy. Instead the DPSV theory explains how a given total of private investment is distributed between the 'private' industries. Provision is also made for investment in a selection of industries to be 'exogenous'. Real investment in these industries is simply tied to aggregate real investment - normally exogenous and constant in short-run closures. The 'exogenous' industries will not be considered further here.

The first step in the theory of the allocation of investment across industries is to note that the current net rate of return on fixed capital in industry j is:

$$R_j(0) = \frac{P^{(1)}_{(g+1,2)j}}{\Pi_j} - d_j , \qquad j = 1, \ldots, h \qquad 2.1$$

where d_j is the rate of depreciation (assumed fixed), $P^{(1)}_{(g+1,2)j}$ and Π_j are the rental value and the cost of a unit of capital in industry j, and there are h industries recognized in the model.

The second step is to assume that capital in industry j takes one period to install. For the present purpose it is not important whether a period is two or three years, or some other length of time. It would be important if the theory of investment were to be a vehicle for making the ORANI model dynamic. However, this is not the aim. (In fact the exposition in DPSV is slightly ambiguous in this respect; the 'period' is sometimes a year, sometimes the time taken for installation of new capital.)

The third step is to assume that investors are cautious in assessing the effects of expanding the capital stock in industry j. They behave as if they expect that industry j's rate-of-return schedule in one period's time

Table A5 (continued)

No.	Ind.Name	Z_j	Z^*_j	Ratio
58	CLAY PRODS	1.147	1.156	0.993
59	CEMENT....	1.144	1.213	0.943
60	RDYMIXCONC	1.132	1.338	0.846
61	CONC PRODS	1.119	1.310	0.854
62	NMETOREPRD	1.109	1.196	0.927
63	BASIRONSTL	1.142	1.126	1.015
64	OTHBASMETL	1.129	1.090	1.036
65	STRUCTMETL	1.114	1.134	0.982
66	SHEETMETAL	1.119	1.093	1.023
67	OTHMETALPR	1.102	1.151	0.957
68	M.V.,PARTS	1.095	1.056	1.037
69	SHIPS BOAT	1.101	1.162	0.948
70	LOCOMOTVES	1.085	1.085	1.000
71	AIRCRAFT..	1.091	1.006	1.085
72	SCIENTEQUP	1.091	1.111	0.982
73	ELEC EQUIP	1.087	1.014	1.072
74	HOUSE APPL	1.082	1.097	0.987
75	OTHELECGDS	1.073	1.049	1.023
76	AG MACHINE	1.105	1.032	1.072
77	CNSTR MACH	1.100	1.098	1.002
78	OTHMACHINE	1.110	1.082	1.026
79	LEATHERPRD	1.100	1.064	1.034
80	RUBBER PRD	1.124	1.045	1.076
81	PLASTICPRD	1.083	1.136	0.954
82	SIGNS,WRIT	1.132	1.110	1.020
83	OTH MANUFG	1.088	1.111	0.979
84a	ELCTRICITY	1.108	1.048	1.057
85a	GAS.......	1.104	1.072	1.030
86a	WATER.DRNS	1.142	1.088	1.049
87	RES BUILDG	1.088	1.055	1.032
88	OTH CONSTR	1.140	1.227	0.929
89	WHOLSL TRD	1.114	1.140	0.978
90	RETAIL TRD	1.116	1.069	1.044
91	MECH RPAIR	1.108	1.122	0.987
92	OTH REPAIR	1.108	1.034	1.072
93	ROAD TRANS	1.115	1.009	1.105
94a	RAIL TRANS	1.098	1.011	1.087
95	WATER TRNS	1.067	0.991	1.077
96	AIR TRANSP	1.101	1.006	1.094
97a	COMMUNICAT	1.101	1.046	1.053
98	BANKING...	1.079	1.115	0.968
99	NBNK FNANZ	1.062	1.031	1.031
100	INVEST SRV	1.071	1.047	1.023
101	INSURN SRV	1.096	1.029	1.065
102	OTHBUS SRV	1.086	1.054	1.031
103a	OWN DWELLS	1.019	0.961	1.060
104a	PUBLCADMIN	1.089	0.995	1.094
105a	DEFENCE...	1.948	1.787	1.090
106a	HEALTH....	1.090	1.016	1.073
107a	EDUC,LIBRI	1.090	0.997	1.094
108a	WELFRE,REL	1.093	1.002	1.091
109	ENTERTNMNT	1.086	1.047	1.037
110	RESTAURNTS	1.093	1.050	1.041
111	PRSNL SRVC	1.092	1.129	0.968
Geometric Means:		1.1069	1.1069	1.0000

Table A5: Capital Growth Factors Z and Z* Compared

No.	Ind.Name	Z_j	Z^*_j	Ratio
1	PASTORAL..	1.111	1.042	1.066
2	WHEATSHEEP	1.096	1.023	1.072
3	HIGHRAINFL	1.103	1.031	1.069
4	NORTHNBEEF	1.116	1.049	1.064
5	MILKATLPIG	1.101	1.029	1.070
6	OTHFARMEXP	1.095	1.021	1.072
7	OTHFARMIMP	1.096	1.022	1.072
8	POULTRY...	1.105	1.210	0.913
9	AG.SERVICE	1.173	1.126	1.042
10a	FORESTRY..	1.299	1.201	1.082
11	FISHING...	1.153	1.077	1.070
12	FERROUSORE	1.150	1.144	1.006
13	NONFERRORE	1.110	1.108	1.002
14	BLACK COAL	1.157	1.236	0.936
15	OIL,GAS,BR	1.156	1.234	0.936
16	OTHER MINS	1.146	1.132	1.013
17a	MIN.SERVCE	1.109	1.114	0.996
18	MEAT PRODS	1.117	1.075	1.039
19	MILK PRODS	1.092	1.097	0.996
20	FRUIT,VEGE	1.111	1.073	1.035
21	.OILS,FATS	1.111	1.099	1.011
22	FLOUR,CERL	1.112	1.147	0.970
23	BREAD,CAKE	1.106	1.113	0.994
24	CONFECTNRY	1.117	1.188	0.940
25	OTHER FOOD	1.114	1.140	0.977
26	SOFT DRINK	1.136	1.216	0.934
27	BEER MALT	1.119	1.146	0.976
28	OTHALCDRNK	1.132	1.283	0.882
29	TOBACCOPRD	1.087	1.048	1.037
30	COTTONGING	1.089	1.024	1.064
31	MMDEFIBRES	1.118	1.047	1.069
32	COTTONYARN	1.099	1.038	1.058
33	WOOLWORSTD	1.100	1.088	1.011
34	TEXTLFINSG	1.099	1.038	1.059
35	TEXTLFLOOR	1.106	1.081	1.024
36	OTHERTEXTL	1.106	1.178	0.938
37	KNIT MILLS	1.120	1.096	1.023
38	CLOTHING..	1.092	1.123	0.972
39	FOOTWEAR..	1.124	1.134	0.992
40	SAWMILLPRD	1.101	1.125	0.978
41	VENEERBRDS	1.117	1.103	1.013
42	JOINRYWOOD	1.085	1.069	1.015
43	FURNITURE.	1.115	1.234	0.903
44	PULP,PAPER	1.124	1.129	0.995
45	BAGS,BOXES	1.104	1.118	0.988
46	PAPER NEC.	1.097	1.163	0.943
47	NEWS,BOOKS	1.100	1.157	0.950
48	COMM PRINT	1.106	1.107	0.999
49	CHEM FERTL	1.109	1.175	0.944
50	OTHBASCHEM	1.089	1.067	1.021
51	PAINTS,VAR	1.083	1.089	0.994
52	PHARMACEUT	1.087	1.123	0.968
53	SOAP,DETER	1.085	1.200	0.904
54	COSMETOILT	1.081	1.372	0.788
55	OTHCHEMGDS	1.094	1.116	0.980
56	PETROL PRD	1.135	1.129	1.006
57	GLASS PROD	1.084	1.056	1.026

...continued

will have the form:

$$R_j(1) = R_j(0)\left[\frac{K_j(1)}{K_j(0)}\right]^{-\beta_j}, \qquad 2.2$$

where β_j is a positive parameter, $K_j(0)$ is the current level of capital stock in industry j and $K_j(1)$ is the level at the end of one period.

The fourth step is to assume that total private investment expenditure is allocated across industries so as to equate the expected rates of return. This means that there exists some anticipated rate of return Ω such that:

$$\left[\frac{K_j(1)}{K_j(0)}\right]^{-\beta_j} R_j(0) = \Omega. \qquad 2.3$$

The fifth step is to assume that:

$$K_j(1) = K_j(0)\ (1 - d_j) + Y_j, \qquad 2.4$$

establishing $K_j(1)$ as the capital stock in one year's time.

DPSV illustrate the theory by a diagram, reproduced as Figure 1. It graphs, for one industry, the relationship between the expected rate of return, $R_j(1)$, and the rate of growth of capital stock, $K_j(1)/K_j(0)$. Note that the position of the $R_j(1)$ schedule is dependent on the current rate of return $R_j(0)$. The diagram is normally interpreted as follows: to find an initial equilibrium, we imagine moving **along** the schedule. If the rate expected for next period, $R_j(1)$, were equal to the current rate $R_j(0)$, no growth would be planned, so that $K_j(1)/K_j(0)$ would equal 1. In actual fact, investors in the industry expect its rate of return to be equal to the economy-wide expected rate, Ω. Therefore, they invest enough to bring about growth rate (Z-1).

To move from one equilibrium to another, we imagine moving the schedules themselves. If $R_j(0)$ rises, the $R_j(1)$ schedule moves up and will cross the Ω line at a higher value of Z. If the Ω line rises, the appropriate Z will be smaller. If $R_j(0)$ and Ω rise by an equal proportion, Z will be unchanged.

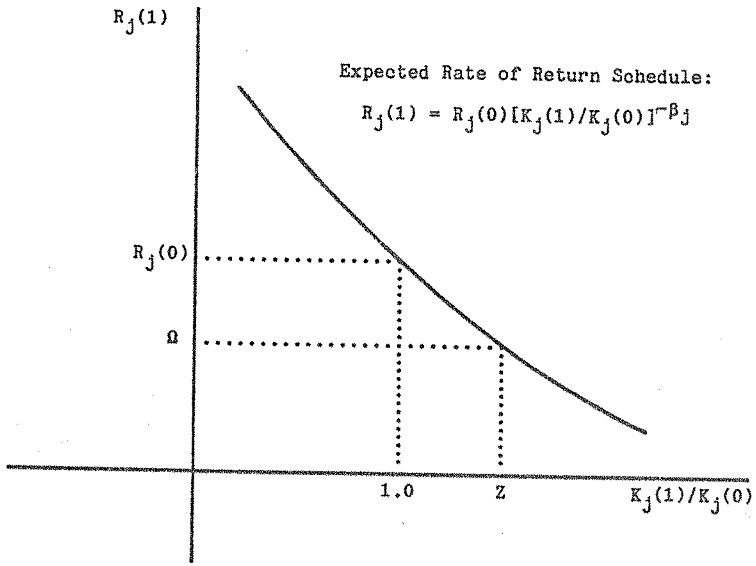


Figure 1: The DPSV Theory Represented for a Single Industry

Table A4 (continued)

No.	Ind.Name	β	G_j	Q_j^*	$100/\beta G_j$	$100Q_j^*/\beta G_j$
58	CLAY PRODS	267.2867	0.1751	0.2623	2.1367	0.5604
59	CEMENT....	267.2867	0.1906	0.4199	1.9626	0.8241
60	RDYMIXCONC	267.2867	0.1822	0.7092	2.0535	1.4564
61	CONC PRODS	267.2867	0.1723	0.6853	2.1718	1.4883
62	NMETOREPRD	267.2867	0.1648	0.4655	2.2700	1.0566
63	BASIRONSTL	267.2867	0.1870	0.2204	2.0010	0.4410
64	OTHBASMETL	267.2867	0.1773	0.1666	2.1096	0.3515
65	STRUCTMETL	267.2867	0.1662	0.3080	2.2513	0.6935
66	SHEETMETAL	267.2867	0.1697	0.1979	2.2043	0.4362
67	OTHMETALPR	267.2867	0.1570	0.3764	2.3834	0.8971
68	M.V.,PARTS	267.2867	0.1742	0.1885	2.1482	0.4049
69	SHIPS BOAT	267.2867	0.1539	0.3989	2.4314	0.9699
70	LOCOMOTVES	267.2867	0.1411	0.2579	2.6519	0.6838
71	AIRCRAFT..	267.2867	0.1460	0.0393	2.5624	0.1008
72	SCIENTEQUP	267.2867	0.1579	0.3183	2.3690	0.7541
73	ELEC EQUIP	267.2867	0.1702	0.0998	2.1985	0.2194
74	HOUSE APPL	267.2867	0.1665	0.3223	2.2464	0.7241
75	OTHELECGDS	267.2867	0.1594	0.2254	2.3466	0.5288
76	AG MACHINE	267.2867	0.1609	0.0763	2.3255	0.1774
77	CNSTR MACH	267.2867	0.1569	0.2544	2.3839	0.6064
78	OTHMACHINE	267.2867	0.1646	0.1919	2.2731	0.4362
79	LEATHERPRD	267.2867	0.1605	0.1760	2.3317	0.4103
80	RUBBER PRD	267.2867	0.1846	0.0768	2.0266	0.1557
81	PLASTICPRD	267.2867	0.1809	0.4285	2.0680	0.8861
82	SIGNS,WRIT	267.2867	0.1924	0.2214	1.9446	0.4306
83	OTH MANUFG	267.2867	0.1593	0.3302	2.3485	0.7755
84a	ELCTRICITY	267.2867	0.1473	0.0941	2.5402	0.2392
85a	GAS.......	267.2867	0.1570	0.1797	2.3831	0.4282
86a	WATER.DRNS	267.2867	0.1392	0.0778	2.6874	0.2090
87	RES BUILDG	267.2867	0.1663	0.1984	2.2501	0.4463
88	OTH CONSTR	267.2867	0.2040	0.4789	1.8337	0.8781
89	WHOLSL TRD	267.2867	0.1494	0.3014	2.5047	0.7550
90	RETAIL TRD	267.2867	0.1511	0.1264	2.4753	0.3128
91	MECH RPAIR	267.2867	0.1444	0.2747	2.5908	0.7116
92	OTH REPAIR	267.2867	0.1444	0.0560	2.5905	0.1452
93	ROAD TRANS	267.2867	0.2076	0.0389	1.8020	0.0701
94a	RAIL TRANS	267.2867	0.1198	0.0001	3.1222	0.0004
95	WATER TRNS	267.2867	0.1325	0.0641	2.8227	0.1810
96	AIR TRANSP	267.2867	0.2027	0.0702	1.8461	0.1297
97a	COMMUNICAT	267.2867	0.1428	0.1074	2.6201	0.2815
98	BANKING...	267.2867	0.1288	0.3365	2.9045	0.9775
99	NBNK FNANZ	267.2867	0.1257	0.1786	2.9766	0.5317
100	INVEST SRV	267.2867	0.1275	0.1937	2.9337	0.5681
101	INSURN SRV	267.2867	0.1229	0.0595	3.0431	0.1812
102	OTHBUS SRV	267.2867	0.1276	0.1589	2.9321	0.4659
103a	OWN DWELLS	267.2867	0.0701	0.0842	5.3376	0.4492
104a	PUBLCADMIN	267.2867	0.1296	0.0002	2.8859	0.0005
105a	DEFENCE...	267.2867	0.5134	0.0100	0.7287	0.0073
106a	HEALTH....	267.2867	0.1306	0.0522	2.8640	0.1496
107a	EDUC,LIBRI	267.2867	0.1308	0.0011	2.8609	0.0031
108a	WELFRE,REL	267.2867	0.1326	0.0081	2.8206	0.0229
109	ENTERTNMNT	267.2867	0.1272	0.1431	2.9401	0.4206
110	RESTAURNTS	267.2867	0.1327	0.1339	2.8191	0.3776
111	PRSNL SRVC	267.2867	0.1324	0.3289	2.8268	0.9297
Geometric Means:			0.1633	0.2158	2.2917	0.4946
Variance of logs:			0.0138	0.4598	0.0138	0.4506

Table A4: Investment Parameters and Coefficients for the Modified Theory

No.	Ind.Name	β	G_j	Q^*_j	$100/\beta G_j$	$100Q^*_j/\beta G_j$
1	PASTORAL..	267.2867	0.1508	0.0747	2.4813	0.1855
2	WHEATSHEEP	267.2867	0.1528	0.0747	2.4486	0.1830
3	HIGHRAINFL	267.2867	0.1519	0.0747	2.4623	0.1840
4	NORTHNBEEF	267.2867	0.1501	0.0747	2.4922	0.1863
5	MILKATLPIG	267.2867	0.1522	0.0747	2.4582	0.1837
6	OTHFARMEXP	267.2867	0.1530	0.0747	2.4458	0.1828
7	OTHFARMIMP	267.2867	0.1529	0.0747	2.4475	0.1829
8	POULTRY...	267.2867	0.1508	0.4941	2.4807	1.2257
9	AG.SERVICE	267.2867	0.1898	0.1299	1.9707	0.2560
10a	FORESTRY..	267.2867	0.2920	0.0581	1.2813	0.0744
11	FISHING...	267.2867	0.1819	0.0651	2.0573	0.1340
12	FERROUSORE	267.2867	0.2122	0.2670	1.7632	0.4708
13	NONFERRORE	267.2867	0.1832	0.2781	2.0417	0.5678
14	BLACK COAL	267.2867	0.2008	0.4404	1.8628	0.8203
15	OIL,GAS,BR	267.2867	0.2010	0.4404	1.8615	0.8198
16	OTHER MINS	267.2867	0.2017	0.2402	1.8545	0.4456
17a	MIN.SERVCE	267.2867	0.1745	0.2854	2.1438	0.6119
18	MEAT PRODS	267.2867	0.1631	0.1521	2.2939	0.3489
19	MILK PRODS	267.2867	0.1639	0.2867	2.2832	0.6547
20	FRUIT,VEGE	267.2867	0.1637	0.1677	2.2853	0.3832
21	.OILS,FATS	267.2867	0.1657	0.2337	2.2574	0.5275
22	FLOUR,CERL	267.2867	0.1632	0.3393	2.2922	0.7778
23	BREAD,CAKE	267.2867	0.1586	0.2731	2.3597	0.6444
24	CONFECTNRY	267.2867	0.1635	0.4190	2.2876	0.9586
25	OTHER FOOD	267.2867	0.1648	0.3207	2.2696	0.7277
26	SOFT DRINK	267.2867	0.1639	0.4219	2.2832	0.9633
27	BEER MALT	267.2867	0.1511	0.3050	2.4760	0.7551
28	OTHALCDRNK	267.2867	0.1609	0.5757	2.3250	1.3384
29	TOBACCOPRD	267.2867	0.1693	0.1888	2.2102	0.4173
30	COTTONGING	267.2867	0.1632	0.1129	2.2923	0.2588
31	MMDEFIBRES	267.2867	0.1854	0.1001	2.0176	0.2021
32	COTTONYARN	267.2867	0.1707	0.1259	2.1918	0.2760
33	WOOLWORSTD	267.2867	0.1719	0.2488	2.1770	0.5416
34	TEXTLFINSG	267.2867	0.1709	0.1252	2.1890	0.2740
35	TEXTLFLOOR	267.2867	0.1662	0.2037	2.2513	0.4587
36	OTHERTEXTL	267.2867	0.1658	0.4363	2.2572	0.9848
37	KNIT MILLS	267.2867	0.1826	0.2130	2.0490	0.4365
38	CLOTHING..	267.2867	0.1610	0.3473	2.3237	0.8072
39	FOOTWEAR..	267.2867	0.1910	0.3021	1.9591	0.5918
40	SAWMILLPRD	267.2867	0.1625	0.3260	2.3019	0.7505
41	VENEERBRDS	267.2867	0.1749	0.2328	2.1394	0.4981
42	JOINRYWOOD	267.2867	0.1543	0.2305	2.4253	0.5589
43	FURNITURE.	267.2867	0.1532	0.5174	2.4422	1.2636
44	PULP,PAPER	267.2867	0.1847	0.2848	2.0251	0.5767
45	BAGS,BOXES	267.2867	0.1705	0.3060	2.1941	0.6715
46	PAPER NEC.	267.2867	0.1650	0.4293	2.2681	0.9738
47	NEWS,BOOKS	267.2867	0.1685	0.4103	2.2203	0.9110
48	COMM PRINT	267.2867	0.1732	0.2763	2.1605	0.5970
49	CHEM FERTL	267.2867	0.1812	0.4340	2.0649	0.8961
50	OTHBASCHEM	267.2867	0.1665	0.2240	2.2472	0.5033
51	PAINTS,VAR	267.2867	0.1468	0.2806	2.5486	0.7150
52	PHARMACEUT	267.2867	0.1461	0.3472	2.5615	0.8892
53	SOAP,DETER	267.2867	0.1624	0.5488	2.3038	1.2643
54	COSMETOILT	267.2867	0.1456	0.9024	2.5690	2.3183
55	OTHCHEMGDS	267.2867	0.1476	0.3089	2.5351	0.7830
56	PETROL PRD	267.2867	0.1795	0.2427	2.0845	0.5059
57	GLASS PROD	267.2867	0.1617	0.2098	2.3132	0.4853

...continued

In percentage change form, Equations 2.1, 2.3 and 2.4 may be expressed as follows:

$$r_j(0) = Q_j(p^{(1)}_{(g+1,2)j} - \pi_j), \qquad 2.5$$

$$\beta_j[k_j(1) - k_j(0)] = r_j(0) - \omega, \qquad 2.6$$

$$k_j(1) = k_j(0)\ (1 - G_j)\ + y_jG_j, \qquad 2.7$$

where $Q_j = (R_j(0) + d_j)/R_j(0)$, i.e., Q_j is the ratio of the gross rate of return in industry j to the net rate of return. $G_j = Y_j/K_j(1)$, i.e., G_j is the ratio of gross investment in industry j to its future capital stock. β_j, the (negative of the) elasticity of the expected rate of return in industry j with respect to the size of its capital stock, will satisfy:

$$\beta_j = \frac{\log[R_j(0)] - \log[\Omega]}{\log[K_j(1)/K_j(0)]}\ . \qquad 2.8$$

Since the capital stocks, K_j, are held constant in short run simulations, Equations 2.6 and 2.7 can be reduced to:

$$y_j = \phi_j(r_j(0) - \omega), \qquad \text{where } \phi_j = 1/(\beta_jG_j). \qquad 2.9$$

In sum, the theory rests on the equalisation of the $R_j(1)$ to some rate Ω which will satisfy the aggregate investment constraint. In most simulations where the theory has been implemented, aggregate investment is exogenous, and the variable Ω endogenous. Thus a given aggregate investment is redistributed towards those industries with a rising rate of return. The severity of the redistribution depends on the values of the ϕ_j. Indeed, industries which have similar changes in their rates of return may experience quite different percentage changes in their investment. Alternatively, an exogenous increase in investment may be distributed unevenly between the industries. This discrimination between industries will be more marked as the values of ϕ_j are more dispersed. Also, the higher the average value of the ϕ_j, the more will a given differential in industry rates of return redistribute investment between the industries. Therefore, unless the theory were known to be an accurate representation of reality, we would hope that the ϕ_j had both low and uniform values. This would correspond to a more agnostic stance.

3: PROBLEMS IN THE CURRENT ORANI INVESTMENT THEORY

The DPSV theory of investment incorporates a positive relationship between the rate of return in an industry and the growth rate of its capital stock. Although this relationship is plausible, the theory is open to at least two objections.

The first centres on the particular choice of functional form, which is rather restrictive. To illustrate this point, Figure 2 graphs equations of the form:

$$\frac{R_j(0)}{\Omega} = \left[\frac{K_j(1)}{K_j(0)} \right]^{\beta_j}, \qquad 3.1$$

which is a recasting of Equation 2.3. Curves are shown for various positive values of β_j; according to the theory each industry must lie on one such curve. Thus, a large number of possible observations are excluded by the theory. Unexceptionably, negative $K_j(1)/K_j(0)$ are disallowed - they are located in Zone 1 on the graph. The negative $R_j(0)$ in Zone 2 are also ruled out, although there is nothing unusual in a negative rate of return. Zones 3 and 4 are illicit because they correspond to negative values of β_j - this would mean that a rising rate of return would bring about decreased investment. However, in the real world we would expect to observe industries in Zone 4, which although returning less than other industries, nevertheless are growing slowly. Nor are Zone 3 industries wildly improbable. In short, any collection of industry data will probably contain observations in Zones 2, 3 or 4. For example, Cox (1984), using data gathered independently of the ORANI database, found that data for 17 out of 111 industries could not plausibly be reconciled with Equation 3.1. Bruce (1986), using the 1978-79 ORANI database, found that 32 of the 111 industries were located in Zones 2, 3, or 4. In general, then, we would expect difficulties in reconciling industry data to Equation 3.1.

Second, there is only one parameter in the investment Equation 3.1. Thus the β_j corresponding to some set of observations reflect at least three different phenomena:

(i) Some industries consistently display abnormally high or low rates of return. Variance of profitability may be part of the explanation. The β_j reflect this dispersion, and serve to adjust the crude $R_j(0)$ for risk. This is one accepted interpretation of the β_j (see Powell (1977), p.71).

Table A3 (continued)

No.	Ind.Name	β_j	G_j	Q_j	$1/\beta_j G_j$	$Q_j/\beta_j G_j$
58	CLAY PRODS	7.7896	0.1751	1.2581	0.7332	0.9224
59	CEMENT....	11.7001	0.1906	1.2139	0.4484	0.5443
60	RDYMIXCONC	17.5692	0.1822	1.1165	0.3124	0.3488
61	CONC PRODS	19.1155	0.1723	1.1211	0.3037	0.3404
62	NMETOREPRD	16.4583	0.1648	1.1890	0.3687	0.4383
63	BASIRONSTL	5.5149	0.1870	1.4782	0.9698	1.4336
64	OTHBASMETL	2.3613	0.1773	1.7479	2.3879	4.1738
65	STRUCTMETL	11.0887	0.1662	1.3006	0.5427	0.7058
66	SHEETMETAL	5.0898	0.1697	1.5619	1.1576	1.8080
67	OTHMETALPR	14.9632	0.1570	1.2333	0.4257	0.5251
68	M.V.,PARTS	2.8408	0.1742	2.0356	2.0212	4.1143
69	SHIPS BOAT	15.8502	0.1539	1.2059	0.4100	0.4944
70	LOCOMOTVES	11.9523	0.1411	1.3589	0.5930	0.8059
71 b	AIRCRAFT..	8.4651	0.1460	-1.3668	0.8091	-1.1059
72	SCIENTEQUP	13.7575	0.1579	1.3435	0.4603	0.6184
73 c	ELEC EQUIP	8.4651	0.1702	50.5923	0.6942	35.1208
74	HOUSE APPL	14.4192	0.1665	1.4356	0.4164	0.5978
75	OTHELECGDS	8.1612	0.1594	1.7667	0.7685	1.3578
76 c	AG MACHINE	8.4651	0.1609	19.6259	0.7343	14.4109
77	CNSTR MACH	9.7603	0.1569	1.3979	0.6528	0.9126
78	OTHMACHINE	4.8937	0.1646	1.6058	1.2415	1.9937
79	LEATHERPRD	3.4685	0.1605	1.7638	1.7968	3.1692
80 b	RUBBER PRD	8.4651	0.1846	-12.2821	0.6399	-7.8595
81	PLASTICPRD	18.5937	0.1809	1.3578	0.2973	0.4036
82	SIGNS,WRIT	5.1577	0.1924	1.6279	1.0078	1.6405
83	OTH MANUFG	14.5911	0.1593	1.3488	0.4302	0.5803
84ac	ELCTRICITY	8.4651	0.1473	2.3928	0.8021	1.9192
85a	GAS.......	4.3833	0.1570	1.6248	1.4532	2.3612
86ac	WATER.DRNS	8.4651	0.1392	1.2839	0.8486	1.0895
87	RES BUILDG	4.5908	0.1663	1.8809	1.3100	2.4641
88	OTH CONSTR	12.8904	0.2040	1.2407	0.3802	0.4718
89	WHOLSL TRD	11.5315	0.1494	1.2094	0.5806	0.7022
90	RETAIL TRD	0.2464	0.1511	1.7178	26.8544	46.1300
91	MECH RPAIR	11.0767	0.1444	1.2346	0.6252	0.7719
92 c	OTH REPAIR	8.4651	0.1444	14.6115	0.8180	11.9515
93 b	ROAD TRANS	8.4651	0.2076	-0.5008	0.5690	-0.2850
94ab	RAIL TRANS	8.4651	0.1198	-0.0042	0.9858	-0.0042
95 b	WATER TRNS	8.4651	0.1325	-6.2503	0.8913	-5.5708
96 b	AIR TRANSP	8.4651	0.2027	-1.3546	0.5829	-0.7896
97ac	COMMUNICAT	8.4651	0.1428	2.0889	0.8273	1.7281
98	BANKING...	17.8355	0.1288	1.2183	0.4353	0.5303
99	NBNK FNANZ	6.7142	0.1257	1.6612	1.1850	1.9685
100	INVEST SRV	8.4803	0.1275	1.5134	0.9247	1.3994
101 c	INSURN SRV	8.4651	0.1229	2.8573	0.9609	2.7455
102	OTHBUS SRV	4.8111	0.1276	1.4893	1.6290	2.4260
103ac	OWN DWELLS	8.4651	0.0701	2.6336	1.6854	4.4385
104ab	PUBLCADMIN	8.4651	0.1296	-0.0031	0.9112	-0.0029
105ab	DEFENCE...	8.4651	0.5134	-0.2370	0.2301	-0.0545
106ac	HEALTH....	8.4651	0.1306	1503.7350	0.9043	1359.8326
107ab	EDUC,LIBRI	8.4651	0.1308	-0.0209	0.9033	-0.0189
108ab	WELFRE,REL	8.4651	0.1326	-0.1839	0.8906	-0.1638
109	ENTERTNMNT	2.8872	0.1272	1.5745	2.7219	4.2857
110	RESTAURNTS	1.4918	0.1327	1.6386	5.0509	8.2766
111	PRSNL SRVC	15.2989	0.1324	1.1887	0.4939	0.5871
Geometric Means:		8.4651	0.1639	1.4032	0.7207	1.0112
Variance of logs:		0.6095	0.0128	0.0232	0.6167	0.8192

Table A3: DPSV Investment Parameters and Coefficients Derived from the 1978-79 ORANI Database

No.	Ind.Name	β_j	G_j	Q_j	$1/\beta_jG_j$	Q_j/β_jG_j
1 c	PASTORAL..	8.4651	0.1508	4.0988	0.7835	3.2113
2 c	WHEATSHEEP	8.4651	0.1528	20.6697	0.7732	15.9810
3 c	HIGHRAINFL	8.4651	0.1519	7.6770	0.7775	5.9687
4 c	NORTHNBEEF	8.4651	0.1501	3.2320	0.7869	2.5433
5 c	MILKATLPIG	8.4651	0.1522	9.4780	0.7762	7.3566
6 c	OTHFARMEXP	8.4651	0.1530	31.5902	0.7723	24.3965
7 c	OTHFARMIMP	8.4651	0.1529	24.1366	0.7728	18.6526
8	POULTRY...	18.0704	0.1508	1.1435	0.3669	0.4196
9	AG.SERVICE	0.6883	0.1898	1.6258	7.6532	12.4428
10ab	FORESTRY..	8.4651	0.2920	-2.6447	0.4046	-1.0700
11 c	FISHING...	8.4651	0.1819	8.0084	0.6496	5.2022
12	FERROUSORE	6.3117	0.2122	1.5424	0.7467	1.1517
13	NONFERRORE	9.0977	0.1832	1.5090	0.5999	0.9052
14	BLACK COAL	11.1836	0.2008	1.2073	0.4452	0.5375
15	OIL,GAS,BR	11.2219	0.2010	1.2099	0.4434	0.5365
16	OTHER MINS	5.6706	0.2017	1.5465	0.8742	1.3519
17a	MIN.SERVCE	9.9921	0.1745	1.4234	0.5735	0.8163
18	MEAT PRODS	1.7585	0.1631	1.7483	3.4867	6.0959
19	MILK PRODS	11.6577	0.1639	1.4348	0.5235	0.7511
20	FRUIT,VEGE	2.8489	0.1637	1.7362	2.1441	3.7225
21	.OILS,FATS	7.6723	0.1657	1.4561	0.7864	1.1451
22	FLOUR,CERL	12.4599	0.1632	1.2557	0.4917	0.6174
23	BREAD,CAKE	10.3623	0.1586	1.3388	0.6087	0.8149
24	CONFECTNRY	14.4070	0.1635	1.1853	0.4244	0.5030
25	OTHER FOOD	11.6401	0.1648	1.2788	0.5212	0.6664
26	SOFT DRINK	12.9478	0.1639	1.1360	0.4713	0.5354
27	BEER MALT	11.3220	0.1511	1.1985	0.5845	0.7005
28	OTHALCDRNK	16.1179	0.1609	1.0962	0.3856	0.4226
29	TOBACCOPRD	2.9453	0.1693	2.0654	2.0058	4.1427
30 c	COTTONGING	8.4651	0.1632	4.7202	0.7238	3.4164
31 c	MMDEFIBRES	8.4651	0.1854	8.9838	0.6371	5.7233
32 c	COTTONYARN	8.4651	0.1707	3.4105	0.6921	2.3603
33	WOOLWORSTD	8.4171	0.1719	1.5571	0.6913	1.0764
34 c	TEXTLFINSG	8.4651	0.1709	3.4606	0.6912	2.3920
35	TEXTLFLOOR	5.6088	0.1662	1.6152	1.0728	1.7328
36	OTHERTEXTL	16.0423	0.1658	1.2163	0.3761	0.4574
37	KNIT MILLS	5.1688	0.1826	1.6524	1.0596	1.7508
38	CLOTHING..	14.8461	0.1610	1.3195	0.4184	0.5520
39	FOOTWEAR..	9.2644	0.1910	1.4291	0.5652	0.8077
40	SAWMILLPRD	12.9520	0.1625	1.3161	0.4750	0.6252
41	VENEERBRDS	6.9506	0.1749	1.5067	0.8227	1.2396
42	JOINRYWOOD	8.8943	0.1543	1.5523	0.7288	1.1314
43	FURNITURE.	17.1625	0.1532	1.1216	0.3803	0.4266
44	PULP,PAPER	8.8458	0.1847	1.4176	0.6119	0.8674
45	BAGS,BOXES	11.3985	0.1705	1.3777	0.5145	0.7088
46	PAPER NEC.	16.9879	0.1650	1.2429	0.3569	0.4435
47	NEWS,BOOKS	15.9062	0.1685	1.2636	0.3731	0.4715
48	COMM PRINT	9.7320	0.1732	1.4489	0.5934	0.8597
49	CHEM FERTL	15.1108	0.1812	1.2687	0.3652	0.4634
50	OTHBASCHEM	7.1426	0.1665	1.6959	0.8409	1.4261
51	PAINTS,VAR	13.2158	0.1468	1.3742	0.5154	0.7083
52	PHARMACEUT	16.1039	0.1461	1.2594	0.4251	0.5354
53	SOAP,DETER	22.7098	0.1624	1.1990	0.2712	0.3251
54	COSMETOILT	31.3430	0.1456	1.0924	0.2191	0.2393
55	OTHCHEMGDS	13.5224	0.1476	1.2791	0.5011	0.6410
56	PETROL PRD	7.0138	0.1795	1.3964	0.7944	1.1093
57	GLASS PROD	6.2509	0.1617	1.7660	0.9891	1.7467

...continued

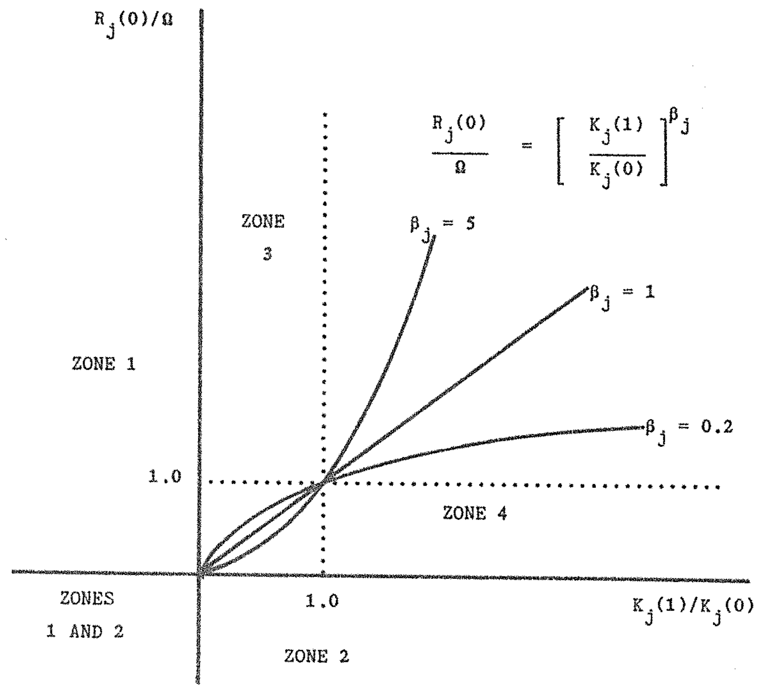


Figure 2: The Restrictive Nature of the DPSV Theory

(ii) The β_j also reflect the speed with which investors respond to a divergence of any one of the $R_j(0)$ from the rest. This is another accepted interpretation of the β_j (see DPSV) - a measure of investors' caution.

(iii) In an economy where all risk-adjusted rates of return are equal to the going rate of interest, investment in each industry will serve to maintain some customary or expected rate of growth in the capital stock. The β_j reflect these varying secular rates of growth.

These three roles for the β_j are not necessarily closely related. The last of them has to do with phenomena that are not addressed in ORANI. If (iii) finds expression in real world data, then such data will not be representable in terms of Figure 2 because we have no guidance about the variables omitted from the ORANI theory which would cause the β_j schedules to shift. In other words, (3.1), as an econometric equation, is misspecified. This point is taken up in Section 4.

Table A2 (continued)

No.	Ind.Name	$K_jP^{(1)}_{(g+1,2)j}$	$K_j\Pi_j$	$Y_j\Pi_j$	d_j	$R_j(0)$
58	CLAY PRODS	43.43	165.60	33.26	0.0538	20.8458
59	CEMENT....	35.27	84.00	18.32	0.0740	34.5881
60	RDYMIXCONC	31.56	44.50	9.18	0.0740	63.5213
61	CONC PRODS	42.35	61.80	11.91	0.0740	61.1275
62	NMETOREPRD	46.64	100.20	18.31	0.0740	39.1469
63	BASIRONSTL	265.57	1204.90	257.33	0.0713	14.9108
64	OTHBASMETL	268.20	1609.50	322.23	0.0713	9.5336
65	STRUCTMETL	52.15	169.30	31.34	0.0712	23.6833
66	SHEETMETAL	64.28	324.80	61.67	0.0712	12.6706
67	OTHMETALPR	105.47	280.20	48.46	0.0712	30.5210
68	M.V.,PARTS	105.41	559.20	106.62	0.0959	9.2601
69	SHIPS BOAT	18.03	45.20	7.66	0.0681	33.0794
70	LOCOMOTVES	9.67	37.50	5.74	0.0681	18.9767
71	AIRCRAFT..	21.63	550.00	87.63	0.0681	-2.8773
72	SCIENTEQUP	23.43	73.60	12.68	0.0814	23.6942
73	ELEC EQUIP	17.51	175.50	32.47	0.0978	0.1972
74	HOUSE APPL	24.69	76.60	13.81	0.0978	22.4524
75	OTHELECGDS	43.63	193.60	33.13	0.0978	12.7562
76	AG MACHINE	4.89	64.10	11.40	0.0724	0.3887
77	CNSTR MACH	8.75	34.40	5.94	0.0724	18.1960
78	OTHMACHINE	58.07	302.60	55.30	0.0724	11.9504
79	LEATHERPRD	5.93	33.70	5.95	0.0762	9.9764
80	RUBBER PRD	17.82	231.90	48.14	0.0831	-0.6257
81	PLASTICPRD	76.01	177.40	34.76	0.1129	31.5567
82	SIGNS,WRIT	10.65	48.10	10.48	0.0854	13.6014
83	OTH MANUFG	10.27	31.10	5.39	0.0854	24.4825
84a	ELCTRICITY	738.95	7849.00	1281.39	0.0548	3.9346
85a	GAS.......	87.76	488.40	84.67	0.0691	11.0589
86a	WATER.DRNS	451.06	5799.00	921.75	0.0172	6.0582
87	RES BUILDG	93.09	469.30	84.90	0.0929	10.5459
88	OTH CONSTR	402.38	840.30	195.38	0.0929	38.5953
89	WHOLSL TRD	1277.95	4239.50	705.59	0.0522	24.9239
90	RETAIL TRD	367.67	2909.70	490.74	0.0528	7.3560
91	MECH RPAIR	77.54	282.30	45.16	0.0522	22.2472
92	OTH REPAIR	28.18	502.90	80.46	0.0522	0.3835
93	ROAD TRANS	149.22	3835.00	887.68	0.1166	-7.7690
94a	RAIL TRANS	1.00	7079.30	931.52	0.0335	-3.3359
95	WATER TRNS	180.96	2821.40	399.02	0.0744	-1.0262
96	AIR TRANSP	160.83	2289.60	510.89	0.1221	-5.1856
97a	COMMUNICAT	799.86	7445.40	1170.81	0.0560	5.1430
98	BANKING...	567.79	1687.10	234.41	0.0603	27.6248
99	NBNK FNANZ	1030.29	5767.80	770.22	0.0711	10.7528
100	INVEST SRV	102.64	530.00	72.38	0.0657	12.7960
101	INSURN SRV	130.26	2187.90	294.83	0.0387	2.0837
102	OTHBUS SRV	840.43	5289.50	733.25	0.0522	10.6686
103a	OWN DWELLS	6548.15	77811.00	5559.02	0.0522	3.1955
104a	PUBLCADMIN	1.00	6143.00	867.23	0.0522	-5.2037
105a	DEFENCE...	1.00	100.00	100.00	0.0522	-4.2200
106a	HEALTH....	277.80	5318.30	757.43	0.0522	0.0035
107a	EDUC,LIBRI	12.27	11477.00	1636.58	0.0522	-5.1131
108a	WELFRE,REL	16.21	1999.00	289.74	0.0522	-4.4091
109	ENTERTNMNT	230.92	1614.20	223.07	0.0522	9.0855
110	RESTAURNTS	318.71	2379.50	345.10	0.0522	8.1739
111	PRSNL SRVC	143.31	435.75	63.00	0.0522	27.6672
Arithmetic means:					0.0752	18.8612

Table A2: Data from the 1978-79 ORANI Database

No.	Ind.Name	$K_jP^{(1)}_{(g+1,2)j}$	$K_j\Pi_j$	$Y_j\Pi_j$	d_j	$R_j(0)$
1	PASTORAL..	94.49	1264.12	211.76	0.0565	1.8236
2	WHEATSHEEP	349.24	4672.37	782.71	0.0711	0.3616
3	HIGHRAINFL	109.90	1470.25	246.29	0.0650	0.9736
4	NORTHNBEEF	30.16	403.48	67.59	0.0516	2.3127
5	MILKATLPIG	79.25	1060.24	177.61	0.0669	0.7886
6	OTHFARMEXP	101.50	1357.93	227.48	0.0724	0.2366
7	OTHFARMIMP	45.02	602.34	100.90	0.0717	0.3097
8	POULTRY...	45.45	91.99	15.32	0.0620	43.2119
9	AG.SERVICE	54.93	422.87	94.14	0.0500	7.9893
10a	FORESTRY..	27.63	475.88	180.55	0.0800	-2.1950
11	FISHING...	20.30	311.70	65.33	0.0570	0.8133
12	FERROUSORE	272.86	1021.83	249.38	0.0939	17.3130
13	NONFERRORE	459.07	1650.80	335.62	0.0938	18.4288
14	BLACK COAL	505.58	1148.08	266.72	0.0756	36.4772
15	OIL,GAS,BR	480.55	1091.23	253.51	0.0764	36.3970
16	OTHER MINS	113.79	473.62	109.53	0.0849	15.5347
17a	MIN.SERVCE	17.64	61.82	11.96	0.0849	20.0525
18	MEAT PRODS	112.40	739.00	134.64	0.0651	8.6992
19	MILK PRODS	56.00	195.31	34.95	0.0869	19.9844
20	FRUIT,VEGE	18.85	112.42	20.44	0.0711	9.6575
21	.OILS,FATS	16.53	70.73	13.02	0.0732	16.0477
22	FLOUR,CERL	32.83	96.75	17.57	0.0691	27.0218
23	BREAD,CAKE	58.43	213.97	37.53	0.0691	20.3971
24	CONFECTNRY	17.85	42.59	7.78	0.0655	35.3542
25	OTHER FOOD	85.99	268.16	49.23	0.0699	25.0752
26	SOFT DRINK	47.85	113.41	21.10	0.0505	37.1403
27	BEER MALT	78.19	256.40	43.34	0.0505	25.4465
28	OTHALCDRNK	33.73	58.59	10.67	0.0505	52.5178
29	TOBACCOPRD	11.62	61.55	11.32	0.0974	9.1422
30	COTTONGING	3.03	26.85	4.77	0.0890	2.3924
31	MMDEFIBRES	11.54	115.23	23.90	0.0890	1.1148
32	COTTONYARN	12.95	102.85	19.29	0.0890	3.6921
33	WOOLWORSTD	6.84	27.48	5.20	0.0890	15.9763
34	TEXTLFINSG	4.43	35.40	6.65	0.0890	3.6169
35	TEXTLFLOOR	8.93	43.82	8.06	0.0776	12.6143
36	OTHERTEXTL	16.27	37.29	6.83	0.0776	35.8710
37	KNIT MILLS	13.86	65.08	13.31	0.0841	12.8915
38	CLOTHING..	35.38	101.86	17.90	0.0841	26.3249
39	FOOTWEAR..	10.09	33.39	7.17	0.0907	21.1366
40	SAWMILLPRD	86.04	263.89	47.20	0.0783	24.7734
41	VENEERBRDS	14.59	62.68	12.24	0.0783	15.4533
42	JOINRYWOOD	40.57	176.03	29.48	0.0820	14.8461
43	FURNITURE.	45.39	87.72	14.98	0.0561	46.1308
44	PULP,PAPER	53.45	187.69	38.97	0.0839	20.0894
45	BAGS,BOXES	38.35	125.33	23.60	0.0839	22.2132
46	PAPER NEC.	28.04	65.30	11.82	0.0839	34.5442
47	NEWS,BOOKS	77.12	187.96	34.83	0.0856	32.4684
48	COMM PRINT	93.92	339.91	65.09	0.0856	19.0708
49	CHEM FERTL	40.55	93.44	18.78	0.0919	34.2068
50	OTHBASCHEM	116.54	520.37	94.39	0.0919	13.2064
51	PAINTS,VAR	8.73	31.13	4.95	0.0764	20.4165
52	PHARMACEUT	40.02	115.28	18.31	0.0715	27.5655
53	SOAP,DETER	25.94	47.26	8.33	0.0911	45.7694
54	COSMETOILT	10.35	11.47	1.81	0.0763	82.6141
55	OTHCHEMGDS	17.79	57.60	9.30	0.0674	24.1454
56	PETROL PRD	77.25	318.30	64.83	0.0689	17.3796
57	GLASS PROD	20.54	97.90	17.17	0.0910	11.8806

...continued

4: IMPLEMENTATION OF THE CURRENT INVESTMENT THEORY

The practical implementation of the DPSV theory of investment may be reduced to the task of finding values for the β_j, G_j and Q_j mentioned above. These parameters and coefficients might be calculated directly by using formulae derived from equations in Section 2:

$$\beta_j = \frac{\log[R_j(0)] - \log[\Omega]}{\log[K_j(1)/K_j(0)]}, \qquad 2.8$$

$$G_j = \frac{Y_j}{K_j(1)} = \frac{Y_j}{K_j(0)(1 - d_j) + Y_j} = \frac{Y_j\Pi_j}{K_j(0)\,\Pi_j\,(1-d_j) + Y_j\Pi_j} \qquad 4.1$$

$$Q_j = \frac{R_j(0) + d_j}{R_j(0)} = \frac{1}{1 - d_j \dfrac{K_j(0)\,\Pi_j}{K_j(0)\,P^{(1)}_{(g+1,2)j}}}. \qquad 4.2$$

Magnitudes $Y_j\Pi_j$, $K_j(0)\,\Pi_j$ and $K_j(0)P^{(1)}_{(g+1,2)j}$ may be identified as values from the ORANI database. They are, in order, the total expenditure on investment (at purchasers' prices) by industry j, the column sums of the capital stocks matrix, and the rentals to fixed capital. d_j is an estimate of the average rate of depreciation of fixed capital in industry j. This vector forms a subsidiary part of the ORANI database. Thus the only new information needed to calculate the coefficients is a value for Ω, the economy-wide anticipated rate of return. This direct method of calculating the β_j, G_j and Q_j has recently been provisionally attempted by Bruce (1986). Some of his numerical results are reported in the Appendix. Here we use a diagrammatic approach to explain how the values of β_j may be related to the ORANI database.

4.1 Direct Estimation of the Investment Parameters from the ORANI Database

The direct procedure may be illustrated by a diagram. In log form Equation 3.1 is linear:

$$\log[R_j(0)/\Omega] = \beta_j \log[K_j(1)/K_j(0)]. \qquad 4.3$$

The linear form is represented graphically in Figure 3, by a line passing through the origin. Figure 4 shows how data for a range of industries may be plotted on the same diagram. Each industry is represented by a dot, the position of which is derived from the ORANI database (given some value for Ω). Each dot in either of the northeast or southwest quadrants lies on a line given by Equation 4.3, passing through the origin. The arrows show the slopes of these lines - the β_j. Thus the diagram shows very clearly

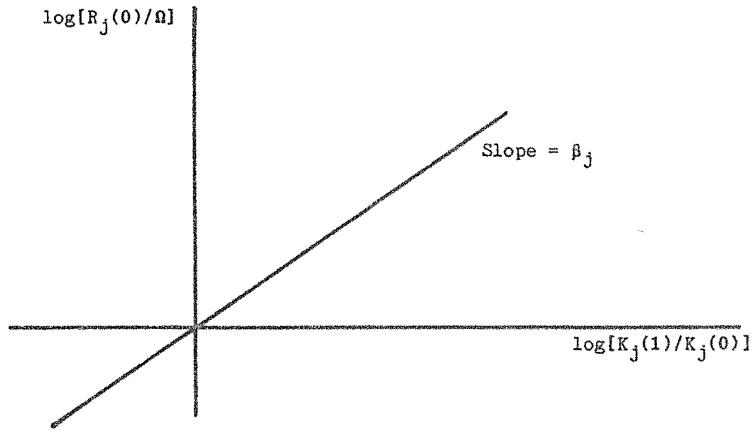


Figure 3: Transformed DPSV Theory Represented on Log Axes

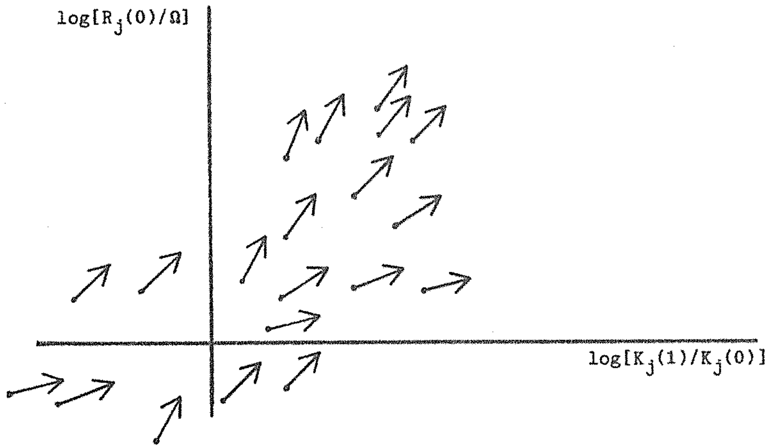


Figure 4: Arrows with Data from ORANI Database - Partial Consistency

Table A1 (continued)

No.	Ind.Name	β_j	G_j	Q_j	$1/\beta_jG_j$	Q_j/β_jG_j
58	CLAY PRODS	31.7000	0.0920	1.7300	0.3429	0.5932
59	CEMENT....	36.1000	0.1110	1.8380	0.2496	0.4587
60	RDYMIXCONC	36.1000	0.1110	1.8380	0.2496	0.4587
61	CONC PRODS	36.1000	0.1110	1.8380	0.2496	0.4587
62	NMETOREPRD	36.1000	0.1110	1.8380	0.2496	0.4587
63	BASIRONSTL	34.2000	0.1010	2.1740	0.2895	0.6294
64	OTHBASMETL	29.8000	0.1050	2.1740	0.3196	0.6948
65	STRUCTMETL	75.4000	0.0900	1.7440	0.1474	0.2570
66	SHEETMETAL	75.4000	0.0900	1.7440	0.1474	0.2570
67	OTHMETALPR	75.4000	0.0900	1.7440	0.1474	0.2570
68	M.V.,PARTS	87.4000	0.1070	2.6900	0.1069	0.2876
69 b	SHIPS BOAT	112.8000	0.0850	1.4380	0.1043	0.1500
70 b	LOCOMOTVES	112.8000	0.0850	1.4380	0.1043	0.1500
71 b	AIRCRAFT..	112.8000	0.0850	1.4380	0.1043	0.1500
72	SCIENTEQUP	37.8000	0.1180	1.8610	0.2242	0.4172
73	ELEC EQUIP	57.6000	0.1180	2.3190	0.1471	0.3412
74	HOUSE APPL	34.2000	0.1320	2.3190	0.2215	0.5137
75	OTHELECGDS	109.8000	0.1080	2.3190	0.0843	0.1956
76	AG MACHINE	73.7000	0.0900	1.9050	0.1508	0.2872
77 b	CNSTR MACH	112.8000	0.0840	1.9050	0.1055	0.2011
78	OTHMACHINE	99.8000	0.0850	1.9050	0.1179	0.2246
79 b	LEATHERPRD	28.2000	0.1080	2.4130	0.3283	0.7923
80	RUBBER PRD	43.5000	0.1040	2.5460	0.2210	0.5628
81	PLASTICPRD	29.7000	0.1610	2.0910	0.2091	0.4373
82	SIGNS,WRIT	37.0000	0.1230	1.8990	0.2197	0.4173
83	OTH MANUFG	37.0000	0.1230	1.8990	0.2197	0.4173
84a	ELCTRICITY	13.9000	0.1540	1.5920	0.4672	0.7437
85a	GAS.......	13.5000	0.1530	1.9610	0.4841	0.9494
86a	WATER.DRNS	9.3000	0.1150	1.3270	0.9350	1.2408
87	RES BUILDG	24.5000	0.1600	1.7030	0.2551	0.4344
88	OTH CONSTR	24.5000	0.1600	1.7030	0.2551	0.4344
89	WHOLSL TRD	19.6000	0.1590	1.2550	0.3209	0.4027
90	RETAIL TRD	17.5000	0.1560	1.3520	0.3663	0.4952
91	MECH RPAIR	11.9000	0.1950	1.3740	0.4309	0.5921
92	OTH REPAIR	11.9000	0.1950	1.3740	0.4309	0.5921
93	ROAD TRANS	11.9000	0.2600	1.7170	0.3232	0.5549
94ab	RAIL TRANS	30.7000	0.0650	1.6150	0.5011	0.8093
95	WATER TRNS	13.1000	0.1720	1.8610	0.4438	0.8259
96	AIR TRANSP	9.7000	0.2480	2.3700	0.4157	0.9852
97a	COMMUNICAT	17.8000	0.1180	1.8430	0.4761	0.8775
98	BANKING...	8.1000	0.1740	2.0620	0.7095	1.4630
99	NBNK FNANZ	10.4000	0.1980	1.7700	0.4856	0.8596
100	INVEST SRV	9.5000	0.1860	1.8810	0.5659	1.0645
101	INSURN SRV	11.7000	0.1680	1.3580	0.5088	0.6909
102	OTHBUS SRV	11.9000	0.1950	1.3740	0.4309	0.5921
103a	OWN DWELLS	11.9000	0.1950	1.3740	0.4309	0.5921
104a	PUBLCADMIN	11.9000	0.1950	1.3740	0.4309	0.5921
105a	DEFENCE...	11.9000	0.1950	1.3740	0.4309	0.5921
106a	HEALTH....	11.9000	0.1950	1.3740	0.4309	0.5921
107a	EDUC,LIBRI	11.9000	0.1950	1.3740	0.4309	0.5921
108a	WELFRE,REL	11.9000	0.1950	1.3740	0.4309	0.5921
109	ENTERTNMNT	11.9000	0.1950	1.3740	0.4309	0.5921
110	RESTAURNTS	11.9000	0.1950	1.3740	0.4309	0.5921
111	PRSNL SRVC	11.9000	0.1950	1.3740	0.4309	0.5921
Geometric means:		32.7932	0.1176	1.9080	0.2592	0.4946
Variance of logs:		0.5072	0.1111	0.0596	0.3743	0.5462

Source: Cox (1984).

Table A1: Investment Parameters and Coefficients Used in the Current Implementation of ORANI

No.	Ind.Name	β_j	G_j	Q_j	$1/\beta_j G_j$	$Q_j/\beta_j G_j$
1 b	PASTORAL..	39.2000	0.0920	1.6300	0.2773	0.4520
2 b	WHEATSHEEP	9.8000	0.1860	1.9760	0.5486	1.0840
3 b	HIGHRAINFL	9.8000	0.1000	3.2270	1.0204	3.2929
4	NORTHNBEEF	25.1000	0.0770	2.3090	0.5174	1.1947
5 b	MILKATLPIG	9.8000	0.0240	6.2070	4.2517	26.3903
6 b	OTHFARMEXP	9.8000	0.0600	5.1200	1.7007	8.7075
7 b	OTHFARMIMP	39.2000	0.0980	2.1600	0.2603	0.5623
8	POULTRY...	18.9000	0.1150	2.0330	0.4601	0.9354
9	AG.SERVICE	30.4000	0.0870	1.7580	0.3781	0.6647
10a	FORESTRY..	23.4000	0.1150	2.6000	0.3716	0.9662
11	FISHING...	15.2000	0.0820	2.9000	0.8023	2.3267
12	FERROUSORE	12.2000	0.2130	1.8390	0.3848	0.7077
13 b	NONFERRORE	30.7000	0.1510	1.5650	0.2157	0.3376
14	BLACK COAL	13.8000	0.2010	1.5000	0.3605	0.5408
15	OIL,GAS,BR	17.9000	0.1610	1.6790	0.3470	0.5826
16	OTHER MINS	17.3000	0.1810	1.6270	0.3194	0.5196
17a	MIN.SERVCE	17.3000	0.1810	1.6270	0.3194	0.5196
18 b	MEAT PRODS	28.2000	0.0960	2.2540	0.3694	0.8326
19	MILK PRODS	81.5000	0.1010	2.1910	0.1215	0.2662
20	FRUIT,VEGE	34.2000	0.0930	2.5820	0.3144	0.8118
21	.OILS,FATS	29.6000	0.1170	1.8910	0.2888	0.5460
22	FLOUR,CERL	49.1000	0.1010	1.6390	0.2016	0.3305
23	BREAD,CAKE	106.4000	0.0840	1.6390	0.1119	0.1834
24	CONFECTNRY	89.5000	0.0810	1.8040	0.1379	0.2488
25	OTHER FOOD	52.2000	0.0920	2.0130	0.2082	0.4192
26 b	SOFT DRINK	28.2000	0.0980	1.5990	0.3618	0.5786
27	BEER MALT	41.9000	0.0830	1.5990	0.2875	0.4598
28	OTHALCDRNK	41.9000	0.0830	1.5990	0.2875	0.4598
29	TOBACCOPRD	88.8000	0.1180	1.6470	0.0954	0.1572
30	COTTONGING	39.4000	0.1160	2.3390	0.2188	0.5118
31	MMDEFIBRES	31.4000	0.1230	2.3390	0.2589	0.6056
32	COTTONYARN	31.4000	0.1230	2.3390	0.2589	0.6056
33	WOOLWORSTD	31.4000	0.1230	2.3390	0.2589	0.6056
34	TEXTLFINSG	86.5000	0.1020	2.3390	0.1133	0.2651
35	TEXTLFLOOR	57.0000	0.0950	2.3270	0.1847	0.4297
36	OTHERTEXTL	51.6000	0.0970	2.3270	0.1998	0.4649
37	KNIT MILLS	104.9000	0.0980	1.8820	0.0973	0.1831
38	CLOTHING..	78.9000	0.1020	1.8820	0.1243	0.2339
39	FOOTWEAR..	95.8000	0.1080	1.7470	0.0967	0.1689
40	SAWMILLPRD	77.9000	0.0940	2.0530	0.1366	0.2804
41	VENEERBRDS	39.3000	0.1090	2.0530	0.2334	0.4793
42	JOINRYWOOD	29.1000	0.1380	1.6550	0.2490	0.4121
43 b	FURNITURE.	28.2000	0.1090	1.5450	0.3253	0.5026
44	PULP,PAPER	29.4000	0.1300	1.9190	0.2616	0.5021
45	BAGS,BOXES	29.4000	0.1300	1.9190	0.2616	0.5021
46	PAPER NEC.	29.4000	0.1300	1.9190	0.2616	0.5021
47	NEWS,BOOKS	45.5000	0.1220	1.6580	0.1801	0.2987
48	COMM PRINT	45.5000	0.1220	1.6580	0.1801	0.2987
49	CHEM FERTL	35.2000	0.1280	2.1190	0.2219	0.4703
50	OTHBASCHEM	35.2000	0.1280	2.1190	0.2219	0.4703
51	PAINTS,VAR	52.9000	0.1040	1.7590	0.1818	0.3197
52	PHARMACEUT	30.8000	0.1150	1.8180	0.2823	0.5133
53	SOAP,DETER	30.2000	0.1450	1.7210	0.2284	0.3930
54	COSMETOILT	44.3000	0.1140	1.6160	0.1980	0.3200
55	OTHCHEMGDS	45.6000	0.1080	1.4340	0.2031	0.2912
56	PETROL PRD	30.4000	0.1060	2.0160	0.3103	0.6256
57 b	GLASS PROD	28.2000	0.1260	2.5280	0.2814	0.7115

...continued

how the original data values are related to the calculated β_j. It also shows how the capital growth rate of each industry is affected by a change in its rate of return (relative to Ω). This corresponds to a movement along the appropriate arrow.

The direct method of parameter estimation gives rise to several problems:

(a) The β_j vary greatly and many are small numbers. This leads to dispersed and high ϕ_j. As noted in Section 2, this causes either a uniform change, or a small relative disturbance, in industry rates of return to bring about a major redistribution of investment.

(b) Observations with negative $R_j(0)$ cannot be plotted on the diagram. They are inconsistent with the theory and have to be discarded. The β_j for the corresponding industries must be assigned a default value. In our example of the direct procedure, detailed in the Appendix, we chose an average value of β for the default value, so that the arrows for these industries do not point through the origin. Therefore, these default values of β are inconsistent with the DPSV theory.

(c) Some of the calculated β_j will be negative. These are inconsistent with the theory and have to be discarded and replaced. Thus, observations in the northwest or south east quadrants must be assigned a default value of β. Again, these default values are inconsistent with the DPSV theory.

(d) Results are highly dependent on the value chosen for Ω - this governs the vertical position of the origin.

(e) Values for the Q_j, given by Equation 4.2, also tend to be highly dispersed - some are even negative! The possibility of negative values for the Q_j is unsettling, for reasons similar to those which motivate the elimination of negative Gross Operating Surplus from the ORANI database (see Bruce (1985), pp. 11-12). It would mean that a positive value of $r_j(0)$ in a printout of simulation results could represent either an increase in a positive rate of return or a decrease in a negative rate. In either case, the industry in question would receive an increased share of total investment, according to the DPSV theory. Dispersion of the positive Q_j has a similar effect to dispersion of the ϕ_j. It means that a uniform change in industry rentals to capital leads to varying changes in rates of return, and to varying effects on industry investment.

The dispersion of parameter values found by the direct method means that the treatment of investment in ORANI can have marked effects on model results. At the same time, the data from which the parameters and coefficients are derived are some of the less reliable parts of the ORANI database. No data on industry capital stocks, or on investment by industry, are contained in the Australian Bureau of Statistics (ABS) input-output tables which are the main source of the ORANI database. Instead the capital stocks data have been constructed from a variety of sources, in a manner which is too complicated to describe here (see Lawson, 1985). Comparing the results with preliminary ABS estimates covering about half the ORANI industries (Walters and Dipplesman, 1985), the majority of the ORANI estimates fall within the range from one half to double the ABS estimate. Comparison may also be made with the Bureau of Industry Economics study by Karpouzis and Offner (1983), with similar results. Paucity of data is one reason for the poor consistency of these estimates, coupled with problems of method. For example, if capital is measured by summing investment series, equally plausible assumptions about depreciation may yield quite different estimates of capital stocks.

Turning to the investment data, we encounter different problems. The Y_j, by convention equal to $Y_j\Pi_j$, are not drawn directly from any empirical study. The ABS input-output tables provide a breakdown of Private Gross Fixed Capital Expenditure by commodity used, but not by industry of destination. The two may be related via a matrix Υ, where Y_{ij} is the amount of commodity i destined for inclusion in freshly created capital in industry j. The row sums, Y_i, are the amounts of commodity i used in aggregate investment, while the column sums, Y_j, are the amounts of capital created for industry j. In the ORANI database, the matrix Υ is disaggregated into a number of matrices representing both imported and domestic inputs to capital creation at basic values, and the margins thereon. For the present purpose, the simplification of aggregating goods regardless of source is suitable to show the main features.

Investment by industry, Y_j, is deduced from investment by commodity, Y_i, by the formula:

$$Y_j = \frac{\sum_i K_{ij} Y_i}{\sum_j K_{ij}} . \qquad 4.4$$

In words, the Y_i are expanded into a matrix Y_{ij} by distributing them along the rows in proportion to the amount of that commodity embodied in the existing capital stocks of the various industries according to the ORANI capital stocks matrix, K_{ij}. The Y_{ij} may be summed down the columns to produce the Y_j.

are clustered tightly around unity, lending some plausibility to the modified theory. Three points are worth noting. First, the ratio of Z_j to Z_j^* is strongly related to the assumed value of β. If a lower value of β had been chosen, the redistributive effect of the investment equations would be increased, and the ratios would be further from unity. Second, the actual values of the Z_j^* have no effect on the percentage change coefficients of the modified theory. Indeed, their dispersion illustrates one rationale for the functional form chosen for the modified theory: to attribute inexplicable dispersion in the database to a parameter which will not affect percentage change coefficients. Third, a consequence of our chosen value for Ω is that the Z_j^* and the Z_j have the same mean value, and that their mean ratio is unity.

β was chosen such that the mean value of the $Q_j/(\beta_j G_j)$ in Table A1 (identified above as the key coefficient in the reduced form investment equations) was the same as the mean value of the $100Q_j^*/(\beta G_j)$ in Table A4. This means that, on average, the relationship between real rental rates, and investment levels is the same for the modified theory as in the current treatment of investment. Thus our attention is focused on the dispersion of the coefficients in each case. The dispersion of the modified $100Q_j^*/(\beta G_j)$ is only slightly less than that for the current parameter set (.45 as against .54) but the source of the dispersion is different in Table A4: it stems from dispersion of the Q_j^*, rather than from the β_j. If the same data were used to calculate coefficients according to both DPSV and modified theories, it is likely that the modified theory would yield a much less dispersed set of coefficients. The dispersion of the modified $100/(\beta G_j)$ is very low, implying that an increase in aggregate investment will be distributed impartially amongst the industries.

Table A5 Capital Growth Factors Z and Z* Compared

Table A5 shows the Z_j, or the growth factors of capital, $K_j(1)/K_j(0)$, implicit in the current ORANI database. These were calculated from Table A2 as:

$$Z_j = \frac{K_j(0)\Pi_j(1-d_j) + Y_j\Pi_j}{K_j(0)\Pi_j} .$$

The table also shows the Z_j^*, or 'underlying' growth factors which appear in the modified theory of investment. These are really the component of growth in each industry which the modified theory cannot relate to the rate of return in that industry. Bearing in mind our caveats (at the the end of Section 5) against a too-literal interpretation of the Z_j^*, we found it interesting to calculate their values. This gives some idea of the overall plausibilty of the modified theory. To do this, we require not only the data listed in Table A2, but also values for β and Ω. We combined our assumed value of β with a proxy for Ω, the mean value of the $R_j(0)$ listed in Table A2. The Z_j^* were then calculated by rewriting Equation 5.3:

$$R_j(0) - \Omega = \beta \log[Z_j/Z_j^*]$$

as:

$$Z_j^* = Z_j \exp\left[\frac{R_j(0) - \Omega}{\beta}\right].$$

In addition, this table also shows the ratios of the Z_j^* to the Z_j. They

This procedure does not ensure that the commodity composition of investment, Y_{ij}/Y_j, is equal to the commodity composition of an industry's capital stock, K_{ij}/K_j. Rather it seems to be a compromise between two conflicting hypotheses: first, that the commodity composition of investment is that of the existing stock; second, that the gross (non-depreciation-adjusted) growth rate of the capital stock is the same in all industries. To appreciate the second point, note that there is no other reason why each column of the K_{ij} matrix should receive the same weighting in the redistribution of the Y_i. Whatever the merits of the procedure, it does lead to fairly uniform values of the G_j! At the same time, little reliance should be placed on these calculated values of the Y_j.

In summary, ORANI's investment and capital stock data are of poor quality, although they may be the best available at present. A salient theme of this paper is that where the data are poor, only bland or neutral conclusions should be drawn from them. Because it leads to high, dispersed values of the ϕ_j, the direct method of estimating the investment parameters does not meet this criterion.

The Industries Assistance Commission (IAC) is currently examining methods to improve the quality of ORANI's investment and capital stock data. However, the arguments advanced in Section 3 suggest that more accurate data may still be incompatible with the DPSV theory of investment.

4.2 Estimation of the Investment Parameters Using 'Outside' Data

In contrast, the method by which the investment parameters and coefficients were derived for the first (1968-69) ORANI database produced lower and more uniform values of the ϕ_j, so that the ORANI investment distribution mechanism tended to be more neutral between the industries. This is still the standard method of recalculating the β_j, G_j, and Q_j when a new database is produced (see Dixon et al. (1977), pp. 164-71, DPSV, p. 197, Brooks and Stevenson (1981) and Cox (1984)); it uses 'outside' data, which are quite independent of the ORANI database. The β_j were estimated from observations of net rates of return averaged over time, $Av[R_j(0)]$, average growth factors, $Av[K_j(1)/K_j(0)]$, and the average safe rate of interest, $Av[\Omega]$, which was set at 2 per cent:

$$\beta_j = \frac{\log Av[R_j(0)] - \log Av[\Omega]}{\log Av[K_j(1)/K_j(0)]} . \qquad 4.5$$

The G_j and Q_j were computed according to the formulae:

$$G_j = 1 - Av\left[\frac{K_j(0)}{K_j(1)}\right](1 - d_j), \qquad 4.6$$

and

$$Q_j = \frac{Av[R_j(0)] + d_j}{Av[R_j(0)]}, \qquad 4.7$$

where d_j is an estimate of the average rate of depreciation of fixed capital in industry j. Apart from the d_j, all of the information used for the estimates of the β_j, Q_j, and G_j was taken from sources independent of the ORANI database.

Several of the technical details of the original method of estimating the investment parameters contributed towards low, uniform, ϕ_j. The use of averaging led to fairly small variation in the 'outside' data, leading in turn to fairly uniform parameter values. Figure 5, which is analogous to Figure 4, illustrates the estimation of the β_j. A hat is placed over the axes labels, to show that it is 'outside' data being used. The 'ratio of averages' technique of estimating the β_j (which is criticized below) means that the points graphed in Figure 5 are clustered more closely than those in Figure 4, leading to smaller variation in the β_j. Estimates of the $R_j(0)$ which incorporated the effects of inflation ('nominal' rates) were combined with a rather low choice of Ω (2% - a 'real' interpretation), meaning that the cluster of observations subtends a smaller angle at the origin, than it would using a higher choice of Ω or lower $R_j(0)$. Again, observations were restricted not just to the northeast/southwest quadrants (as in the direct method) but to a sector of these quadrants. β_{max} and β_{min} are the upper and lower bounds, within which the values of β were constrained to lie. They can be thought of as lines with, respectively, double and half the slope of the mean β line. All these techniques helped to ensure high and fairly uniform β_j - a useful result.

The β_j derived from outside data were then applied to the ORANI database. Figure 6 shows the observations from the ORANI database, with slope arrows to indicate the values of β derived from the 'outside' data. Note that there are no hats on axes labels. Although the β_j are fairly uniform and tend to be large, few arrows point through the origin, indicating that the model is <u>not</u> calibrated correctly to the ORANI database and that Equation 2.8 is not satisfied.

There are two main objections to the above method of calculating the coefficients for the percentage change forms of the investment equations from 'outside' data. The first is that the resultant investment parameters are inconsistent with the ORANI database. Thus the linearised ORANI equation system cannot represent an implementation of the theory proffered in DPSV. We argue here that there is a strong case for ensuring

Two features of Table A2 may be noted. First, the great variation in rates of return, $R_j(0)$, perhaps reflects features of the real world, but it is also conditioned by the sequence of adjustments and assumptions required to produce the first four vectors of numbers from rather limited raw data. Second, the low dispersion of the Z_j (see Table A5) is mainly due to the method used to construct the vector $Y_j \Pi_j$ — described in Section 4. These two features explain the failure of the regression method (described in Section 5) to induce from the ORANI database any systematic relation between industry rates of return and capital growth factors.

<u>Table A3</u> <u>DPSV Investment Parameters and Coefficients Derived from the 1978-79 ORANI Database</u>

Table A3 lists the DPSV investment parameters and coefficients derived from the data presented in Table A2, using Equations 2.8, 4.1 and 4.2 above. For industries marked with 'b', a negative $R_j(0)$ prevented any direct evaluation of β_j. The marking 'c' shows that a negative β_j was implied by the ORANI database. In both these cases, β_j was set to the geometric mean of the remaining β_j. Apart from the choice of default β_j, this table contains material presented by Bruce (1986). In particular, the same value of Ω, 7.16%, was assumed for both sets of calculations.

Main features of this table are the high variances of the β_j and Q_j, also affecting the two rightmost reduced form coefficients. The dispersion derives from the highly dispersed $R_j(0)$ implied by the ORANI database. The listed variances exclude from the sample all of the outliers marked with 'b' or 'c', and so underestimate the true coefficient dispersion. Note the negative values of Q_j, causing negative values for $Q_j/(\beta_j G_j)$. Increasing rentals in these industries would be associated with decreasing investment levels in an ORANI result, were this set of coefficients to be used.

<u>Table A4</u> <u>Investment Parameters and Coefficients for the Modified Theory</u>

Table A4 presents coefficients for the modified theory of investment, using the data from tha ORANI database shown in Table A2. The G_j are the same as those presented in Table A3. The Q_j^* are calculated using Equation 5.10: they are gross rates of return. The value of β is the same for all industries, as suggested in Section 5. However, since the ORANI database displayed no relation between rates of return, and capital growth rates, it would not support the regression technique for estimating β that was described in Section 5. Instead we assigned a value for β <u>a priori</u>. This was chosen purely as a means of comparing coefficients for the modified theory of investment with those currently in use. Accordingly, a value of

For some of the columns of figures, measures of the mean and of dispersion around it are included. Because the investment coefficients are used multiplicatively, geometric means are most often chosen. Similarly, the measure of dispersion is the variance of the logs. In computing these aggregate measures, 'exceptional' industries whose number is annotated by 'a', 'b', 'c', etc., are sometimes excluded from the sample.

COMMENTARIES ON TABLES A1 TO A5

Table A1 Investment Parameters and Coefficients Used in the Current Implementation of ORANI

Table A1 shows the values of β_j, G_j and Q_j used in the current (1978-79) ORANI database. Their derivation is described by Cox (1984). The reduced form coefficients $1/(\beta_j G_j)$ and $Q_j/(\beta_j G_j)$, are also shown. The salient feature in this table is the rather high dispersion of the β_j, which is responsible for most of the variance of the coefficients $1/(\beta_j G_j)$ and $Q_j/(\beta_j G_j)$. Industries for which investment is normally modelled exogenously (marked 'a' in the table) were excluded from the calculation of the means and variances. For industries marked with 'b', Cox (1984) used a boundary rule to determine β_j, since his 'outside' data were inconsistent with the DPSV theory.

Table A2 Data from the 1978-79 ORANI Database

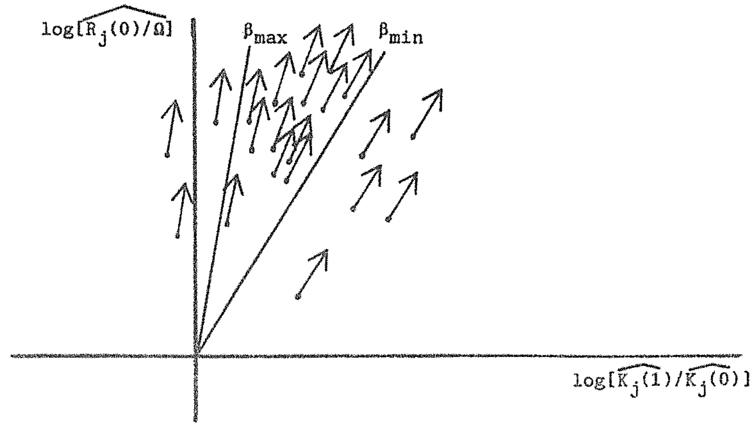
This table shows excerpts from the 1978-79 ORANI database which are relevant to the treatment of investment. From left to right the columns show:

$K_j(0)P^{(1)}_{(g+1,2)j}$	the rentals to capital in each industry,
$K_j(0)\Pi_j$	the replacement value of industry capital stocks or column sums of the capital stocks matrix,
d_j	the depreciation rate in each industry, expressed as a fraction,(percentage rate divided by one hundred), and
$Y_j\Pi_j$	the total value of investment in each industry, including margins and taxes.

The table also shows the derived figures for:

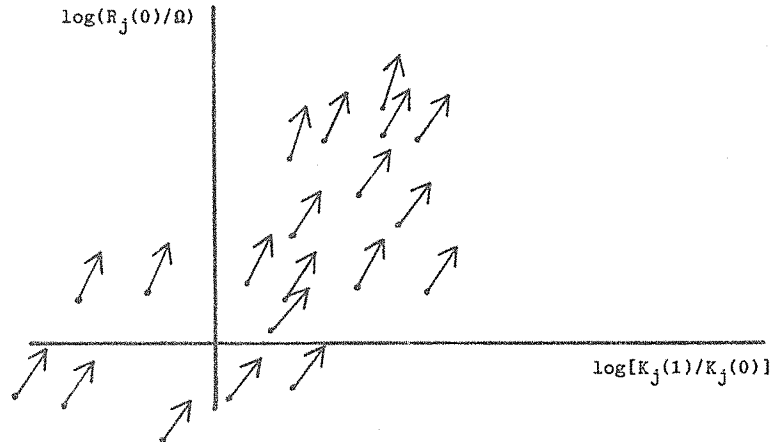
$R_j(0)$	the industry rate of return, in percentage points, calculated using Equation 5.4:

$$R_j(0) = 100 \left[\frac{K_j(0)\, P^{(1)}_{(g+1,2)j}}{K_j(0)\, \Pi_j} - d_j \right] .$$



The slope of the arrows shows the values of the estimated β_j. Points outside the sector bounded by β_{max} and β_{min} have arrows parallel to the β_{max} and β_{min} lines, which have the slopes given respectively by twice and one half the mean β value.

Figure 5: Current Method with Axes Showing Outside Data: the Constraints



The slope of the arrows shows the values of the β_j estimated from outside data, as implemented in ORANI.

Figure 6: Current Method with Axes Showing ORANI Data, and Arrows Slope of which Shows 'Outside' β_j

that the parameters <u>are</u> consistent. Otherwise, the theory as described is not the theory which is implemented. In a model as complex as ORANI, formal consistency is a great help both in checking and understanding results.

Second, we may question various details of the way in which the parameters were derived from the 'outside' data. For example, it is arguable that the β_j have been estimated wrongly. As mentioned above, this single set of parameters is made to reflect a variety of industry characteristics. However, if we interpret them as showing the speed with which investors respond to a change in an industry's rate of return, it is clear that the β_j's should have been computed, not as a ratio of averages, but as an average of ratios. That is, instead of estimating β_j as in Equation 4.5:

$$\beta_j = \frac{\log Av[R_j(0)] - \log Av[\Omega]}{\log Av[K_j(1)/K_j(0)]} ,$$

the following estimate should have been used:

$$\beta_j = Av \left[\frac{\log R_j(0) - \log \Omega}{\log[K_j(1)/K_j(0)]} \right] . \qquad 4.8$$

Again, it may be argued that the definition of the $R_j(0)$ should be consistent with the interpretation of Ω. That is, either both rates should be 'nominal' rates (including the effects of inflation), or both should be 'real' rates.

However, if either of these suggestions were followed up, a more dispersed set of β_j would result. This illustrates a more general problem of parameter estimation using 'outside' data. There will always be choices to be made, whether between alternative data sources or amongst methods of data treatment. Where the parameters are re-estimated for each new dataset, it is difficult to maintain consistency between successive estimation exercises. The difficulty is especially pronounced where the parameter estimates are chosen, not only to fit the 'outside' data, but also to satisfy unarticulated criteria of suitability, based on the plausibility of simulation results.

APPENDIX NUMERICAL DATA AND DERIVED INVESTMENT COEFFICIENTS

This Appendix contains the numerical data and results which are needed to compare the current implementation of the DPSV investment theory, the direct method of calculating the DPSV investment coefficients from the ORANI database, and the modified theory of investment proposed in Section 5 above. Data is drawn from the latest (1978-79) ORANI database.

In order to compare the modified theory of investment with the original DPSV theory (whether implemented from 'outside' data, or from the ORANI database) it is helpful to present both the DPSV and the modified theories in a reduced percentage change form, which brings out the similarity between the two. The basic percentage change forms are:

<u>DPSV</u>

$$r_j(0) = Q_j(p^{(1)}_{(g+1,2)j} - \pi_j), \qquad 2.5$$

$$\beta_j[k_j(1)-k_j(0)] = r_j(0)-\omega, \qquad 2.6$$

<u>Modified</u>

$$\Delta R_j(0) = Q^*_j(p^{(1)}_{(g+1,2)j} - \pi_j), \qquad 5.7$$

$$\beta_j[k_j(1)-k_j(0)]/100 = \Delta R_j(0) - \Delta\Omega, \qquad 5.8$$

and common to both:

$$k_j(1) = k_j(0)(1-G_j) + y_jG_j . \qquad 2.7$$

By assuming that capital stocks are fixed, we can reduce these to:

<u>DPSV</u>

$$y_j = \frac{1}{\beta_jG_j}(r_j(0) - \omega)$$

$$y_j = \frac{Q_j}{\beta_jG_j}(p^{(1)}_{(g+1,2)j} - \pi_j) - \frac{\omega}{\beta_jG_j}$$

<u>Modified</u>

$$y_j = \frac{100}{\beta_jG_j}(\Delta R_j(0) - \Delta\Omega)$$

$$y_j = \frac{100Q^*_j}{\beta_jG_j}(p^{(1)}_{(g+1,2)j} - \pi_j) - \frac{100\Delta\Omega}{\beta_jG_j} .$$

In terms of the effect on other model variables, the DPSV and the modified theories are numerically equivalent if the coefficients of the last pair of equations are the same. Thus Tables A1 to A5 show not only the basic parameters Q_j, G_j and β_j, but also the reduced form coefficients $1/(\beta_jG_j)$ and $Q_j/(\beta_jG_j)$.

Certain features are common to all of the tables. The lefthand column shows the ORANI industry number ranging from 1 to 111. Descriptive names for each industry are listed in Bruce (1985); here we show only abbreviated names, to save space. The industry numbers are annotated by letters 'a', 'b', 'c', and so on. 'a' indicates that the industry normally enjoys 'exogenous' investment status, and so is unaffected by the investment theory discussed here. The remaining letters denote various exceptional conditions - explained in the commentaries to the individual tables.

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Thus we find that although the original estimates of the ϕ_j displayed the desirable properties of smallness and uniformity, subsequent attempts (by different people) to repeat the estimation procedure gave rise to larger and more dispersed ϕ_j. By contrast, the majority of ORANI's equation coefficients are computed from input-output data by 'direct' methods. The method of calculation is well defined and repeatable - it is implemented by the same computer programs for each new dataset. Alternatively, those parameters (mainly elasticities) which do require 'outside' estimation are interpretable as unchanging constants. They do not necessarily need to be re-estimated each time a new dataset is prepared.

5: A MODIFIED THEORY OF INVESTMENT

The problem of implementing the DPSV investment theory has been recognized as a problem of model calibration - the process of finding a set of parameters which allow the chosen equation system to be consistent with a given dataset (Bruce (1986),p. 27). To perform this task, the modeller divides the system's parameters into two groups. Parameters in the first group are assigned values using information drawn from outside the equilibrium dataset; perhaps from literature search, from econometric work using additional data, or even from intuition. Values for the second group of parameters are left free, to be determined jointly by the equation system, the equilibrium dataset, and by the values of 'assigned' parameters.

This division of the parameter set between assigned and free status is partially determined by logical considerations. For example, the number of assigned parameters will be related to the number of system equations and variables, and to the amount of information in the dataset. However, the choice of which parameters shall constitute the assigned set is left to the judgement of the modeller, who will be guided by the purposes to which the model is to be put.

Comparative static models, such as ORANI, are constructed for the purpose of comparing two equilibria 'before' and 'after' some external shock. Such models do not purport to explain characteristics of the initial, unshocked state - it is taken as given. Only the change between the two equilibria is of interest. Traditionally, the choice of 'assigned' and 'free' variables reflects this emphasis. Those parameters which most strongly influence the transition between equilibria are assigned their values. This means that both a wide range of empirical studies and prior theoretical restrictions can influence their values. Where the precise values are uncertain, it is customary to assign 'neutral' values. Neutrality takes two forms: first, in reducing the dispersion of parameters (for example, we may restrict the elasticity of substitution between capital and labour to be the same for all industries, as in the standard ORANI databases (Bruce (1985), p. 31), and second, in the choice of central tendency (unknown substitution elasticities may be set to unity).

The free parameters, on the other hand, are calculated as residuals, once the assigned parameters are chosen. Thus their values will reflect any peculiarities of the particular dataset chosen to represent initial equilibrium, and the extent to which the model equations oversimplify or misrepresent reality. In this sense the free parameters are much less reliable than the assigned parameters. However, as far as possible the set of free parameters is chosen to minimize their influence on model results, which show the transition from one equilibrium to

6: CONCLUSION

This paper has identified several flaws in the current treatment of investment in ORANI, most of which may be traced to the functional form of the DPSV investment equations. Because this was too restrictive, the β_j had to fill two conflicting roles: (i) to fit the original distribution of investment in the database to the DPSV theory; and (ii) to determine the redistribution of investment following a shock. The two roles should be distinguished, as they are in other parts of ORANI.

A modified theory of investment has been proposed which, whilst very similar to the DPSV theory, separates the parameters describing the characteristics of the original benchmark from those parameters which describe the process of adjustment to a new equilibrium. This enables us to impose strong assumptions of uniformity upon the latter, whilst allowing the former to explain the diversity of industry characteristics observed in the ORANI database.

The modified theory allows the average response of investment in each industry to a change in its rate of return (given via its β parameter) to be independent of constraints imposed by the ORANI database. The value of β (whether subscripted by industry or not) must be determined via econometric means, or by a literature search. This paper has not addressed that task. It is important to note that the model and data used for econometric estimation of β need not be identical to the model and data used in the ORANI model, although the imposition of a β derived from the former into the context of the latter presupposes a certain similarity between the two. For example, an econometric model might well incorporate a system of lags - not readily transplanted into ORANI's comparative static framework.

Throughout, we have concentrated upon aspects of technique. The kernel of the DPSV theory - that investment is governed by rates of return - has never been questioned. We have also taken the ORANI database as given. Further research could examine alternative ways of modelling investment, or seek new sources of data. Indeed the IAC is already reviewing means to improve ORANI's investment and capital stocks data. ORANI's notion of the rate of return could be refined to take better account of the influence of property taxes, or of risk premiums.

However, our method of calibrating the investment equations to the ORANI database may easily be adapted, either to a more reliable database, or to a different specification of investment behaviour.

have higher Z_j^*. Last, different industries adjust at different speeds to variations in their rate of return - giving varying β_j. These three complete vectors of parameters - Z_j^*, Ω_j and β_j - separate out the three different roles of the β_j mentioned in Section 3.

In the suggested treatment, we constrain all the β_j to be equal, and ignore the Ω_j. This enables parameters to be drawn from a single cross-sectional observation. Much more data would be required to estimate a full set of β_j, Ω_j, and Z_j^*. The Z_j^* from our simplified model, which may be calculated as residuals, reflect several different mechanisms, and so may perhaps bear no simple economic interpretation. However, unexplained dispersion in the Z_j^* will not affect simulation results.

another. Instead, they merely account for characteristics of the initial equilibrium.

For example, consider the CES functional form used in many general equilibrium models:

$$Y = \left[\sum_{i=1}^{n} \delta_i X_i^{-\rho} \right]^{-A/\rho}, \qquad 5.1$$

which contains three sets of parameters, A, $\{\delta_i\}$ and ρ. Adopting the convention that base year prices are unity, values of Y and X may be drawn from the equilibrium dataset. The calibration problem is to choose values for parameters A, δ_i and ρ which satisfy 5.1. Prior theoretical conviction guides the assignment of A to unity, enforcing constant returns to scale. The value of ρ is also assigned, by identifying $1/(1+\rho)$ as the common elasticity of substitution, probably drawn from a literature search. Through applying optimality conditions we can expand 5.1 into a group of n individual demand equations, which must also be satisfied by the database values of Y and X. This will determine values for the remaining, free, δ_i parameters. In the CES case the proper choice of free and assigned parameters seems so obvious that it may escape notice that a choice has in fact been made - especially since few model-builders highlight this aspect of their work. Consider, however, the logical possibility of assigning values to two of the δ_i, and allowing the remaining A, δ_i and ρ parameters to be determined by the demand equations and the database. To reject such a procedure as absurd, we must appeal to criteria of sensible calibration - criteria which, although not explicit, are nevertheless widely recognised.

Calibration is still an art rather than a science; its rules are only beginning to be codified (see Adams and Higgs (1986), and Mansur and Whalley (1984)). It certainly allows scope for individual variation! Notoriously, the settings of key assigned parameters may be disputed. Even the choice of 'neutral' parameter values is open to question. Again, there is often a tension between attempts to reduce the sensitivity of model results to circumstantial features of the database, and the need for the model to represent an actual economy. The possibility of a neat division of roles between free and assigned parameters also depends on the number of parameters in the model equations, and the way in which they appear. Indeed, the model should be specified with the calibration process in mind. Previous sections of this paper indicate the problems which may arise from the failure to take this into account.

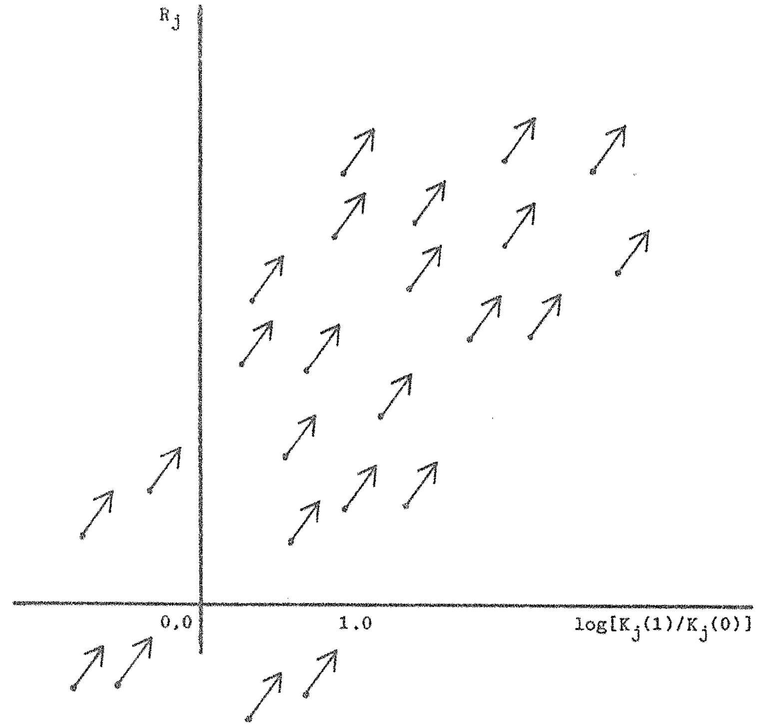
The difficulty of calibrating the DPSV theory of investment lies in the need for the β_j parameters to perform two distinct roles. On the one hand, the β_j are supposed to account for the variety of industry characteristics in the initial, unshocked, equilibrium, so that they will be determined by the initial ratios between rates of return and capital growth rates in the ORANI database. That is, they are free parameters. On the other hand, the β_j determine the redistribution of investment as adjustment takes place to a new, shocked, equilibrium. This is a role which we would normally associate with assigned parameters. By conflating these two roles, DPSV ensured that the set of β_j consistent with the diverse industry characteristics of the original database would be associated with an equally diverse response to shock-induced changes in system variables. This unpalatable consequence may explain some of the anomalies in the implementation of the DPSV theory, such as the recourse to 'outside' data for the estimation of the investment coefficients.

An improved model of investment would separate these two roles. This requires an additional vector of free parameters to be included in the investment equations, which identically fit the observed relationships between rates of return and capital growth rates in the ORANI database. The β_j may then be assigned values reflecting the speed with which investors respond to change in each industry's rate of return. It is obvious that a reasonably long time series of investment and rate of return data, disaggregated to industry level, would be required to obtain a robust estimate of a full set of β_j. As explained above, it has proved difficult to obtain even one reliable cross-section for the ORANI database. We may therefore invoke the maxim of neutrality, setting each β_j to a common value, β.

We can easily construct a theory in this way, without departing from the spirit of the DPSV theory. For example, we may postulate that investors expect the rate of return in an industry to be affected by growth of the capital stock in the following manner:

$$R_j(1) = R_j(0) - \beta \log[Z_j/Z_j^*]. \qquad 5.2$$

Here $R_j(1)$ and $R_j(0)$ are, as before, the anticipated and current rates of return. Z_j is simply a shorthand for the familiar $K_j(1)/K_j(0)$, the current growth factor of capital. Z_j^* is also a capital growth factor, which we might interpret as the long run, normal or secular growth rate for that industry. It is not a directly observable quantity. More generally, Z_j^* will be considered as an industry-specific parameter encapsulating influences on capital growth which are not explained by our investment theory. β is a positive parameter, the same for all industries. Equation 5.2 is illustrated by Figure 7, which, like Figure 1, graphs the relationship between the expected rate of return, $R_j(1)$, and the rate of growth of capital stock, $K_j(1)/K_j(0)$. Note that the position of the $R_j(1)$-schedule is dependent on the current rate of return $R_j(0)$. If the expected rate for the next period, $R_j(1)$, were equal to the current rate $R_j(0)$, the planned growth rate would be the 'normal' or secular growth rate, so that $K_j(1)/K_j(0) = Z_j^*$. Actually, investors in this industry



All arrows have the same slope, as β is the same for all industries.

Figure 8: Arrows and Data for the Proposed Method

where the square bracketed term is constant across the sample, and ε is a normal error term. The estimated value for β is then merely the reciprocal of the OLS coefficient on $R_j(0)$.

Unfortunately, the results of such a regression, using the 1978-79 database referred to above, are unsatisfactory. The reason is that the Z_j derived from the ORANI database tend to be tightly clustered about one common value - the economy-wide growth rate of capital. This follows from the procedure used to construct the $Y_j\pi_j$ vector, described in Section 4. On the other hand, the database $R_j(0)$ are very widely dispersed, as shown in the Appendix. In effect, we are regressing a constant against noise. The regression has little explanatory power ($R^2 = 0.04$) and leads to a very high β value (about 3000). For illustrative purposes, the Appendix shows instead the implications of assigning to β a value derived from 'outside' the ORANI database. The value chosen is that which leads to an average value for the new ϕ_j which is the same as the average value given by the current (Cox,1984) method of parameter estimation from 'outside' data.

The result of reducing β to a scalar value is seen in Figure 8, which is analogous to Figures 3, 4 and 5. Instead of specifying the model so that each industry schedule has its own slope and a common intercept (the origin), we have revised the DPSV theory so that the industry schedules have a common slope but different intercepts. This is implied by a uniform value for all the β_j. Thus, Figure 8 is similar to Figure 4, which depicts the original, inconsistent parameter settings, except that in Figure 8 the arrows point in exactly the same direction. However, in this case the free parameters Z_j^* allow the arrows to have different intercepts, so that the model can be calibrated. Specimen values of the Z_j^* are shown in the Appendix.

Not too much weight should be placed on the interpretation of the Z_j^* as the industry secular growth rates, because of the simplicity of the proposed model. A more completely specified relation would link Z_j, the industry's actual growth rate, to the following variables:

- Z_j^*, the industry's secular growth rate,
- β_j, the industry-specific adjustment rate,
- $R_j(0)$, the industry rate of return,
- Ω, the economy-wide expected rate of return, and
- Ω_j, the industry risk premium.

To see this, we may note that, in a long run equilibrium, not all industries have the same rate of return - the risk premiums Ω_j will cause some dispersion. Also, even with equal (risk-adjusted) rates of return, some industries (e.g., the service sector) grow faster than others - they

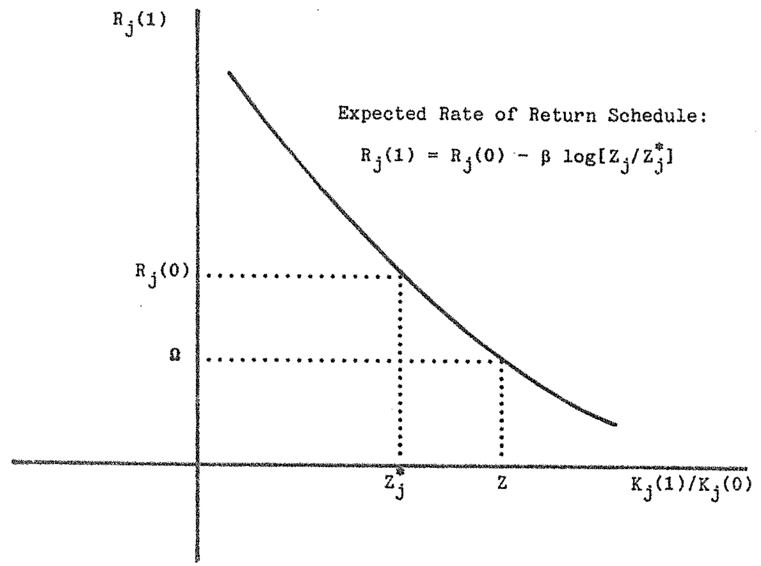


Figure 7: Graphical Representation of Modified Theory of Investment

expect its rate of return to be equal to the economy-wide expected rate, Ω. Therefore, they invest enough to bring about growth rate (Z-1).

As in the original DPSV theory, investment is distributed between industries so that all the $R_j(1)$ are equal to the same anticipated rate Ω. Hence:

$$R_j(0) - \Omega = \beta \log[Z_j/Z_j^*] \qquad 5.3$$

It is interesting to compare this equation to Equation 3.1 above. In contrast, no plausible combinations of observed $R_j(0)$ and Z_j are ruled out by Equation 5.3. We only require that both Z_j and Z_j^* are positive, i.e., that capital stocks cannot disappear in a single year.

To go into change form, required by ORANI's solution method, we take account of the fact that rates of return may well have a zero or negative value. Thus ordinary change form is preferred to percentage change form for the $R_j(0)$ and Ω terms. We choose the units of $R_j(0)$ and Ω to be percentage points per annum, so that if the change in $R_j(0)$ were 3, $R_j(0)$ could have increased from 1% to 4%, or from -1% to 2%. Thus, replacing Equation 2.1, we define the current rate of return by:

$$R_j(0) = 100 \left[\frac{P^{(1)}_{(g+1,2)j}}{\Pi_j} - d_j \right] . \qquad 5.4$$

On the other hand, we retain the percentage change form for the Z_j, which are certainly positive, and mostly greater than unity. The Z_j^* are treated as parameters and disappear. This gives:

$$\Delta R_j(0) - \Delta\Omega = \beta z_j/100 . \qquad 5.5$$

Compare this with Equation 2.6, the corresponding part of the DPSV theory, which may be written:

$$r_j(0) - \omega = \beta_j z_j . \qquad 5.6$$

Apart from the more convenient change form on the left hand side, the only difference is that the industry-subscripted parameter β_j in Equation 5.6 is reduced to a single value in Equation 5.5. This will go a long way towards reducing variation in the ϕ_j $(=1/(\beta_j G_j))$ and so towards implementing a neutral, non-discriminatory, treatment of industry investment.

Note that we do not need to be concerned with the original values of Ω and the Z_j^*, since they do not affect the coefficients of Equation 5.5. However, whatever value is chosen for β, there will exist values of Ω and the Z_j^* which reconcile Equation 5.3 with the database. That is, in the

proposed procedure the free parameters are chosen to be magnitudes which have no operational significance for simulation results, but which ensure that the benchmark dataset satisfies all of the model's equations.

The following change forms of the modified investment equations replace Equations 2.5 and 2.6:

$$\Delta R_j(0) = Q_j^*(p^{(1)}_{(g+1,2)j} - \pi_j), \qquad 5.7$$

$$\Delta R_j(0) - \Delta\Omega = \beta[k_j(1) - k_j(0)]/100, \qquad 5.8$$

while the original form of Equation 2.7 is retained:

$$k_j(1) = k_j(0)\ (1-G_j) + y_j G_j .$$

The share coefficients Q_j^* and G_j may be calculated from the ORANI database. Q_j^* must be reinterpreted as the gross rate of return, given by:

$$Q_j^* = \frac{K_j(0) P^{(1)}_{(g+1,2)j}}{K_j(0)\ \Pi_j} , \qquad 5.9$$

i.e., as the ratio of capital rentals to the value of the stock in each industry. The definition of G_j is unchanged from that given in Equation 4.1 above. Values of Q_j^* and G_j, computed from the 1978-79 (with Typicalised Agriculture) ORANI database (Kenderes (1986)), are shown in the Appendix, which also lists a number of other relevant quantities. The consistent calibration of the G_j and Q_j^* means that they need no longer be stored in ORANI's parameter files. Instead of being 'outside' or 'assigned' parameters, they can be derived from the database. On the other hand, the vector of depreciation rates, d_j, should be added to the ORANI parameter files together with the value of β, which replaces the current β_j.

The value of β may be found in a variety of ways. It may be drawn from a literature survey, or estimated using 'outside' data. The essential point is that the important parameter - β - is either estimated robustly by using a number of observations or assigned a neutral value, whilst the less important Z_j^* are deduced by the calibration method - derived as residuals. If sufficient data were available, it might even be possible to estimate a distinct β for each industry. Here, however, we describe a simple method of estimating a scalar β from the existing ORANI database. First, we rewrite Equation 5.3 as:

$$\log Z_j = \frac{1}{\beta} R_j(0) - \frac{1}{\beta} \Omega + \log Z_j^* . \qquad 5.10$$

The ORANI database tells us only $R_j(0)$ and Z_j. We assume that the unknown $\log Z_j^*$ are normally distributed around a mean value of α. This enables us to write Equation 5.10 in a suitable format for an OLS regression:

$$\log Z_j = [\alpha - \frac{1}{\beta} \Omega] + \frac{1}{\beta} R_j(0) + \varepsilon, \qquad 5.11$$