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FACTOR PROPORTIONS, LINKAGES AND THE OPEN DEVELOPING ECONOMY

by

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James Riedel

July 1974

FACTOR PROPORTIONS, LINKAGES AND THE OPEN DEVELOPING ECONOMY[x]

The purpose of this paper is to examine the theoretical rationale underlying the growth of "footloose", import-dependent industry observed in many of the most successful developing countries (Hong Kong, Taiwan, S. Korea, for example). A second objective is to develop empirical formulations appropriate for analyzing the resource allocation consequences of a "footloose" industrial structure in a developing country. It is argued that previous applications of input-output techniques to factor-intensity measurement have in general ignored the implications of trade in intermediate inputs. The "Leontief test" of the Heckscher-Ohlin trade theory is perhaps the first and certainly the most widely adopted application of input-output techniques to the measurement of the factor intensity of production.[1] The first section of this paper will attempt to demonstrate that the procedure developed by Leontief is not strictly appropriate in an open economy which utilizes imported as well as domestically supplied inputs. An alternative formulation is developed in this paper, which when compared to the "Leontief" formulation yields a measure of the domestic resource cost or saving resulting from the use of imported rather than domestically produced inputs.

In section II, the formulations developed in section I are applied to the Taiwan economy in an effort to demonstrate the resource allocation consequences of an import-dependent, "footloose" industrial structure typical of the island economies in East Asia which dominate the exclusive group of superlative economic development performers. In concluding

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[1] W.W. Leontief, "Domestic Productions and Foreign Trade: The American Capital Position Re-examined", Proceedings of the American Philosophical Society, (1953) and "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis", Review of Economics and Statistics, Vol. XXXVIII (November 1956) p. 386-407.

(section III), the overall importance of linkages in the development process is discussed in light of the results derived in section II. It is argued that the role of linkages as "generators" of economic activity may be less important than the resource allocation consequences in terms of factor proportions or economies of scale.

I. FACTOR INTENSITY MEASUREMENT AND IMPORTED INPUTS

Perhaps the most important contribution of the "Leontief test" aside from its interesting revelations about neo-classical trade theory, was its recognition that the factor intensity of production of any given commodity is determined not only by the factor requirements at the last stage of production, but also by the factor requirements at each intermediate stage. Applying input-output techniques, Leontief measured the total (direct and indirect) labor required to produce one unit of commodity j by

$$L_j = \sum_i \ell_i \; r_{ij} \qquad (1)$$

where ℓ_i is the direct labor-output ratio at the i^{th} stage of production, and r_{ij} are elements of the inverted Leontief matrix $[I-A]^{-1}$. [1]

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[1] Standard input output notation is used.

$[A] = \{a_{ij}\}$

$a_{ij} = \frac{X_{ij}}{X_j}$ where X_{ij} is the total input of i in production of j, and X_j is the total value of production of j.

$[I-A]^{-1} = \{r_{ij}\}$.

Note, the element r_{ij} is the total (direct and indirect) output requirement of i per unit final demand of j. $\ell_i \; r_{ij}$ is thus the total labor required to produce that amount of commodity i used to produce one unit of commodity j for final demand, and $\sum_i \ell_i \; r_{ij}$ is the labor required at each and every stage in the production of commodity j.

Similarly,

$$K_j = \sum_i k_i r_{ij} \qquad (2)$$

is the total capital required to produce one unit of j for final demand, where k_i is the capital-output ratio at the i^{th} stage of production. If, e_j is the proportionate share of the j^{th} commodity in total exports, and n_j is the proportionate share of j^{th} commodity in total imports, then the Heckscher-Ohlin theory is confirmed by the Leontief test, if

$$\frac{\sum_j \left[\sum_i k_i r_{ij}\right] e_j}{\sum_j \left[\sum_i \ell_i r_{ij}\right] e_j} \text{ greater (less) than } \frac{\sum_j \left[\sum_i k_i r_{ij}\right] n_j}{\sum_j \left[\sum_i \ell_i r_{ij}\right] n_j}$$

in countries relatively well endowed with capital (labor).

The author is unaware of any application of the Leontief test which deviates from the above procedure. It will be argued, however, that the above procedure is appropriate only in the case in which a country imports strictly for final consumption.[1] Consider a country which imports intermediate goods; in such a case, elements of the $[I-A]^{-1}$ matrix $\{r_{ij}\}$ do not measure the amount of domestic output per unit of final demand. They measure instead the total "output" (or input) required, which may be supplied externally or domestically.[2]

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[1] The main interest of this paper is in deriving an appropriate measure of factor intensity in an economy utilizing imported inputs, not in providing an alternative test of Heckscher-Ohlin *per se*. Testing Heckscher-Ohlin is, however, one of the possible applications of the factor intensity measure formulated here.

[2] What is measured is the factor intensity of the goods which go into the production of commodity j. This is in itself interesting, but it does not reveal the factor intensity of the domestic structure of production, if imported inputs are utilized.

Consequently, the sum

$$L = \sum_i \ell_i r_{ij}$$

and

$$K = \sum_i k_i r_{ij}$$

do not measure the direct and indirect labor and capital required in the domestic economy to produce a given commodity (j). The domestic output required directly and indirectly per unit final demand is given by

$$[I-D]^{-1} = \{s_{ij}\}$$

where

$$[D] = \{d_{ij}\}$$

$$d_{ij} = \frac{X_{ij}}{X_j} - \frac{M_{ij}}{X_j} = a_{ij} - m_{ij}$$

and where M_{ij}/X_j (= m_{ij}) is the per unit import requirement of i in the production of j. Thus,

$$L_j^* = \sum_i \ell_i s_{ij}$$

and

$$K_j^* = \sum_i k_i s_{ij}$$

measure the labor and capital required in the production of commodity j at the last stage of production and in the production of domestically supplied intermediate inputs. Inter-industry transactions in imported inputs are omitted because the demand for imported inputs does not directly affect employment or capital investment in the domestic economy. Nevertheless, imported inputs are not freely available to the economy, much less the domestic producer; they can be acquired (in equilibrium) only through the exchange of domestically produced goods and services, which in turn involve a cost in terms of domestic resources -- capital and labor, to keep everything in neo-classical terms.[1] The total factor cost per unit of production is, therefore, the sum of (1) the labor and capital employed in producing domestic inputs and at the final stage of production, and (2) the labor and capital cost implicit in earning the foreign exchange (exporting) with which to purchase imported inputs required directly and indirectly in the production process.

The labor and capital cost of earning one unit of foreign exchange (in equilibrium) is the labor and capital required to produce one unit of exports, which in turn can be defined as the average labor and capital requirements per unit output in each sector of the economy weighted by the distribution of exports from each sector. The labor and capital required at the last stage of production and in the domestic production of inputs which go into exports is thus

$$L_f^* = \sum_j \left[\sum_i \ell_i s_{ij}\right] e_j = \sum_j L_j^* e_j$$

and

$$K_f^* = \sum_j \left[\sum_i k_i s_{ij}\right] e_j = \sum_j K_j^* e_j$$

respectively. Of course the production of exports itself requires

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[1] The analysis throughout abstracts from international capital flows. The assumption is that the balance on goods and services is in equilibrium; imports can be traded only for exports -- an assumption neither uncommon nor extremely restrictive.

imported inputs. If M_j^* , defined as

$$M_j^* = \sum_i M_i \, s_{ij} ,$$

is the total (direct and indirect) import requirement per unit output of commodity j, then

$$M_f^* = \sum_j \left[\sum_i M_i \cdot s_{ij}\right] e_j = \sum_j M_j^* \cdot e_j$$

is the direct and indirect import requirement per unit export. Thus to produce one unit of exports we need L_f^* units of labor and K_f^* units of capital at the last stage of production and for domestically produced inputs; and we need $L_f^* M_f^*$ and $K_f^* M_f^*$ of labor and capital, respectively, to produce additional exports to finance the imports which were employed in the original production of one unit of exports. In addition, we recognize that the additional exports (required to finance the imports used in the first round) also require imported inputs. In the first round M_f^* units of imports (foreign exchange = exports) are required; thus in the second round $M_f^* M_f^*$ units of imported inputs are required, which in turn will entail the employment of $L_f^*(M_f^{*2})$ labor and $K_f^*(M_f^{*2})$ capital in the production of exports with which to finance these additional imports. The second round of additional exports, likewise, requires imported inputs $(M_f^{*2} \cdot M_f^*)$ and consequently more exports and hence the employment of still more labor and capital, and so on. The sum of all labor and capital required in the production of one unit of exports (i.e., foreign exchange) is thus

$$L_f^* + L_f^* M_f^* + L_f^* M_f^{*2} + L_f^* M_f^{*3} + \ldots + L_f^* M_f^{*n}$$

and

$$K_f^* + K_f^* M_f^* + K_f^* M_f^{*2} + K_f^* M_f^{*3} + \ldots + K_f^* M_f^{*n}$$

respectively. Since $0 \leq M_f^* \lneq 1$, the above expression reduces to

$$\frac{L_f^*}{1 - M_f^*}$$

and

$$\frac{K_f^*}{1 - M_f^*}$$

For any given commodity j, therefore, the factor intensity of production as measured by total factor requirement per unit outputs is given by

$$L_j' = \sum_i \ell_i s_{ij} + M_j^* \left[\frac{L_f^*}{1 - M_f^*}\right] = L_j^* + M_j^* \left[\frac{L_f^*}{1 - M_j^*}\right]$$

and

$$K_j' = \sum_i \ell_i s_{ij} + M_j^* \left[\frac{K_f^*}{1 - M_f^*}\right] = K_j^* + M_j^* \left[\frac{K_f^*}{1 - M_j^*}\right]$$

which expresses the two components of total factor cost in an open economy: (1) employment and capital cost at the last stage of production and producing domestic inputs; and (2) employment and capital cost implicit in earning the foreign exchange (fraction of one unit of foreign exchange) with which to purchase imported inputs required directly and indirectly in the production of commodity j.[1]

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[1] Note that

$$\sum_j L_j' e_j = \frac{L_f^*}{1 - M_f^*} \qquad \text{and}$$

$$\sum_j K_j' e_j = \frac{K_f^*}{1 - M_f^*}$$

Recognizing the interrelatedness of the economy, not only explicit but also implicit relationships, points to the fact that the factor intensity of a given production activity is dependent upon the technology in the final stage of production, the technology in each and every sector of the economy from which it is supplied, and in an open economy, upon the technology which underlies the structure of foreign trade. In other words, when an economy, like Taiwan for example, imports steel, machinery, synthetic fibre and other relatively capital intensive intermediate goods with foreign exchange earned by exporting transistor radios, plastic toys, garments and the like, it is implicitly substituting the latter labor-intensive goods for the former capital-intensive goods in the production process. One can easily see that to evaluate the factor intensity of the structure of production on the assumption that all inputs are supplied domestically, can easily produce misleading conclusions in such an economy. It may very well be, for example, that automobile manufacturing is a relatively labor-intensive activity, if the steel for the body, the engine, the headlights and other relatively capital intensive inputs are imported, particularly if they are imported with foreign exchange earned by exporting relatively labor intensive goods.

The orthodox measure of total factor intensity, as developed by Leontief, indicates the factor intensity at the last stage of production and of the goods which go into the production process, only when all of the goods which go into the production process are supplied domestically does the Leontief measure indicate the total factor intensity of the prevailing structure of production. Comparing the Leontief measure of total factor intensity with the one developed above reveals the net factor cost or saving derived from the utilization of imported rather than domestically supplied intermediate goods. For example, $L_j < L_j^*$ and $K_j > K_j^*$ indicate that the importation of inputs (i.e. the implicit substitution of exports for otherwise domestically supplied inputs) reduces the overall capital requirement in the economy, but entails a greater demand for labor than would be the case if all intermediate inputs were supplied domestically. In a labor-abundant, capital-scarce LDC presumably such a trade-off indicates that the importation of intermediate inputs is in accordance with neo-classical principles of comparative advantage, though of course the resource allocation consequences of any such trade-off can be precisely weighed and evaluated only if one has knowledge of the shadow prices of labor and capital, from which the net resource cost (saving) can be derived.

It should be recognized that the total factor intensity of production in an open economy is highly sensitive to the structure of exports. In such cases where the export pattern is drastically out of line with comparative advantage considerations, the comparison of factor intensities under the existing structure of production with those under a hypothetical structure which assumes all intermediate inputs are supplied domestically will yield little in terms of "explaining" the existing structure, or as a guide for planning and policy. It may be, for example, that relatively capital-intensive intermediate inputs are imported in a given LDC with foreign exchange earned by exporting equally, or even relatively more capital-intensive commodities. In such a case, even though we may find $K < K'$ and $L > L'$, the optimal solution would not be the substitution of domestic inputs for imports (though it might be an improvement), but rather a restructuring of exports toward more labor-intensive commodities. If the relevant problem is one of deriving an *ex ante* measure of comparative advantage then certainly a more general concept of "domestic resource cost" than the one discussed above is required.[1]

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[1] Such as developed by M. Bruno, *Interdependence, Resource Use and Structural Change in Israel*, (Jerusalem: Bank of Israel, 1963); and elaborated in his recent article "Domestic Resource Costs and Effective Protection: Clarification and Synthesis", *Journal of Political Economy*, Vol. 80 (Jan/Feb. 1972) p. 16-33.

II. FACTOR INTENSITY IN THE TAIWAN ECONOMY

Among the countries struggling to industrialize none has been more successful than several east Asian island economies (Hong Kong, Singapore, Taiwan, S. Korea); among this exclusive group perhaps Taiwan has witnessed the most remarkable gains. The manufacturing sector in Taiwan has grown at a compound growth rate of 18 percent per annum over the last decade, 1961-1971, providing the engine of growth in real per capita income of 7.0 percent per annum over the same period.[1] The industrialization process of the East Asian island economies exhibits two outstanding characteristics: (1) strong orientation toward exports; (2) heavy reliance on imported inputs. In Taiwan, for example, 30 percent of manufactured output was exported in 1969, while 14 percent of the value of manufactured output was contributed by imported inputs.[2] Applying the formulations developed above we attempt to demonstrate the rationale of these key features of industrualization in Taiwan in terms of neo-classical, factor-proportions theory.

Table I presents measures of total labor and capital requirements per million NT$ in each of 52 sectors of the Taiwan economy given the existing structure of production and alternatively assuming all intermediate inputs were domesticaly supplied. In columns 11 and 12 the difference between factor requirements under the two alternative production structures has been calculated to reveal the capital and labor cost or saving attributable to the importation of intermediate inputs.

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[1] Taiwan Statistical Data Book, CIECD, ExecutiveYuan, Taipei, Republic of China, 1972.

[2] According to Input Output Table for Taiwan, 1969, CIECD, Executive Yuan, Taipei, Republic of China. The percent of value contributed by imported inputs is calculated by

$$\sum_j \left[\sum_i M_i \, s_{ij}\right] q_j$$

where q_j is the proportion of the j^{th} sector in total value of manufacturing output.

Table 1

TOTAL LABOR AND CAPITAL REQUIREMENT PER MILLION NT $ OUTPUT IN THE TAIWAN ECONOMY: 1969/70

Sector		Per Unit Imported Input Requirement M_j	Direct Labor Requirement Per Million NT $ Output ℓ_i (man-years)	Direct Capital Requirement Per Million NT $ Output k_i (NT $)	$M_j^* = \sum_{i=1}^{52} M_i s_{ij}$	$L_j^* = \sum_{i=1}^{52} \ell_i s_{ij}$ (man-years)	$K_j^* = \sum_{i=1}^{52} k_i s_{ij}$ (NT $)	Existing Production Structure: Total Labor Requirement Per Million NT $ Output L_j' (man-years)	Existing Production Structure: Total Capital Requirement Per Million NT $ Output K_j' (NT $)	Assumed Production Structure: Total Labor Requirement Per Million NT $ Output L_j (man-years)	Assumed Production Structure: Total Capital Requirement Per Million NT $ Output K_j (NT $)	Resource Cost (Saving) from Utilization of Imported Inputs Per Million NT $ Output: L_j-L_j' (man-years)	Resource Cost (Saving) from Utilization of Imported Inputs Per Million NT $ Output: K_j-K_j' (NT $)	Sectoral Share of Total Exports e_j	Sectoral Share of Total Output q_j
Agriculture	1	.0188	56.970	246000	.0895	77.187	513060	80.037	603896	80.813	601590	0.776	-2306	.053	.130
Forestry	2	.0029	50.000	184500	.0197	52.412	249760	53.039	269754	52.867	269570	-0.172	- 184	.006	.008
Fishing	3	.1245	36.256	585200	.1920	41.263	766570	47.377	961436	46.018	955390	-1.359	-6046	.043	.017
Mining	4	.0118	22.847	738100	.0589	27.650	904170	29.526	963949	28.149	924120	-1.377	-39829	.004	.016
Sugar	5	.0021	8.550	1298692	.0651	48.652	1757515	50.725	1823587	50.694	1840263	-0.031	16676	.034	.010
Canned Food	6	.0280	7.787	242365	.1554	46.356	698351	51.305	856071	47.867	854255	-3.438	-1816	.068	.011
Tobacco	7	.0627	3.081	321641	.0839	11.041	446853	13.713	532005	12.438	505772	-1.275	-26233	.002	.014
Alcoholic Beverage[1]	8	.0039	4.000	400000	.0395	12.324	551520	13.582	591609	13.655	591080	0.073	- 529	.001	.010
M.S.G. (Flavoring)	9	.0108	5.939	280677	.0844	18.410	873247	21.098	958907	20.522	959403	-0.576	496	.004	.002
Wheat Flour	10	.6964	3.111	533878	.7147	6.970	631021	29.730	1356392	60.212	1015072	30.482	-341320	.000	.006
Edible Veg. Oil	11	.6614	2.148	210167	.6805	13.258	339825	34.929	1030485	63.621	707109	28.692	-323376	.000	.008
Non-alcoholic Beverage	12	.0359	5.568	367042	.0982	16.624	802920	19.751	902586	18.874	903496	-0.877	910	.001	.002
Tea	13	.0024	7.508	448014	.0613	61.540	866457	63.492	928672	63.213	924052	-0.279	-4620	.009	.002
Miscellaneous Food	14	.1491	8.123	260209	.3066	31.226	712513	40.990	1023690	51.356	909457	10.366	-114233	.014	.024
Artificial Fibre	15	.3367	4.489	1280546	.4128	8.967	1596490	22.113	2015453	16.915	2351993	-5.198	336540	.017	.009
Artificial Fabric	16	.2320	5.764	597855	.4416	13.833	1323599	27.896	1771792	23.098	2209460	-4.798	437668	.088	.021
Cotton Fabrics	17	.2796	9.095	557415	.4866	19.095	1064935	34.591	1558800	50.735	1405319	16.144	-153481	.041	.021
Wool & Worst Fabric.	18	.3508	6.156	427474	.4685	11.786	689426	26.706	1164921	46.492	1131493	19.786	-33428	.010	.006
Apparel	19	.0490	16.623	404585	.2355	29.500	888655	37.000	1127671	42.058	1114892	5.058	-12779	.029	.016
Lumber	20	.0084	6.111	371877	.0463	40.412	642105	41.887	689096	41.830	687947	-0.057	- 1149	.014	.008
Plywood	21	.5505	5.518	370496	.6074	9.634	525323	28.977	1142292	40.513	753849	11.536	-388443	.044	.008
Bamboo, Rattan Prod.	22	.0276	15.856	115481	.0923	35.873	407299	38.812	500977	38.804	485407	-0.008	-15570	.014	.006
Paper/Pulp	23	.1309	7.614	520819	.2369	22.475	1047173	30.019	1287610	29.177	1339397	-0.842	51787	.000	.012
Printing/Publications	24	.0469	10.685	422377	.1418	19.518	806455	24.034	950372	23.435	976681	-0.599	26309	.004	.009
Leather & Products	25	.3169	8.689	354884	.4346	15.319	623773	29.159	1064862	41.405	1043152	12.246	-21710	.005	.002
Rubber & Products	26	.3247	8.147	241660	.4020	15.321	519430	28.123	927432	26.852	953379	-1.271	-25947	.012	.005
Chem. Fertilizer	27	.0703	3.390	1241972	.2437	14.217	2013051	21.978	2260389	20.334	2288390	-1.644	28001	.005	.008
Medicines	28	.1408	8.524	515814	.2036	15.228	804663	21.712	1011302	19.712	1026313	-2.000	15011	.002	.004
Plastic & Products	29	.1970	3.887	392530	.3353	10.768	788642	21.446	1128948	18.581	1176112	-2.865	47164	.051	.017
Petroleum	30	.3053	1.781	676605	.3432	3.451	792559	14.381	1140883	11.948	1112679	-2.433	-28204	.017	.023
Non-edible Veg. Oil	31	.1259	2.500	200000	.1724	39.462	516043	44.952	691017	47.147	644227	2.195	-46790	.002	.001
Misc. Industrial Chemicals	32	.1902	3.088	665978	.2922	13.205	1173168	22.510	1469730	20.451	1489438	-2.059	19708	.003	.014
Misc. Chemical Manufacturers	33	.3528	4.262	191486	.4089	10.634	423162	23.656	838167	21.566	929033	-2.090	90866	.004	.009
Cement	34	.0547	1.559	783263	.0965	8.038	1021118	11.111	1119058	10.549	1123138	-0.562	4080	.009	.011
Cement Products	35	.0414	15.377	588430	.1503	24.036	1192471	28.823	1345015	27.437	1365772	-1.386	20757	.000	.002
Glass Products	36	.0381	6.921	735390	.1224	16.532	1214539	20.430	1338766	19.273	1336531	-1.157	-2235	.006	.003
Misc. Non-Metal Mineral Products	37	.0451	14.249	392638	.1036	24.374	771557	27.673	876703	27.016	874754	-0.657	-1949	.004	.005
Steel & Iron	38	.3173	3.218	384765	.4704	8.699	690864	23.679	1168287	17.351	1264854	-6.328	96567	.011	.015
Steel & Iron Products	39	.3701	10.507	395387	.4970	14.919	630418	30.747	1134838	23.934	1239167	-6.813	104329	.016	.008
Aluminium	40	.1455	5.922	1545269	.2824	16.414	2779985	25.407	3066601	22.719	3224579	-2.688	157978	.002	.003
Aluminium Products	41	.0198	12.830	597857	.1922	25.067	2197543	31.188	2392612	29.267	2482649	-1.921	90037	.003	.001
Misc. Metal Products	42	.3010	7.026	297688	.3589	11.967	537631	23.397	901889	19.054	931106	-4.343	29217	.005	.003
Machinery	43	.2268	11.505	348764	.3889	17.412	659536	29.797	1054242	25.366	1115222	-4.431	60980	.024	.013
H.H. Electrical Appl.	44	.1699	5.291	356492	.2756	11.976	671212	20.753	950926	17.975	968512	-2.778	17586	.005	.007
Communication Equipment	45	.4184	5.366	219267	.5028	11.219	411352	27.231	921659	22.796	891637	-4.435	-30022	.076	.020
Other Elect. Appliances	46	.2975	10.901	343635	.3947	17.164	656117	29.734	1056710	25.746	1139976	-3.988	83266	.007	.011
Shipbuilding	47	.3320	9.722	584362	.3842	14.069	728968	26.304	1118904	22.358	1168932	-3.946	50028	.004	.003
Motor Vehicles	48	.2732	4.002	333663	.3725	9.412	600229	21.275	978290	16.276	990103	-4.999	11813	.002	.013
Other Transport Equip.	49	.1862	13.036	336504	.2828	17.383	539411	26.389	826433	23.512	826073	-2.877	- 360	.006	.003
Misc. Manufactures	50	.3031	12.876	445818	.3749	21.071	700187	33.010	1080684	30.475	1202021	-2.535	121337	.026	.005
Construction	51	.0375	20.392	125700	.1369	29.100	545980	33.460	684924	32.283	677890	-1.177	-7034	.003	.060
Services	52	.0243	9.787	293700	.0516	12.197	385320	13.840	437690	13.248	425780	-0.592	-11910	.188	.353

Notes: [1] estimated by author

$M_f^* = \sum_{j=1}^{52} M_j^* e_j = .2662$; $L_f^* = \sum_{j=1}^{52} L_j^* e_j = 23.368$ (man-years); $K_f^* = \sum_{j=1}^{52} K_j^* e_j = 744758$ (NT $) $\frac{L_f^*}{1-M_f^*} = 31.846$ (man-years) $\frac{K_f^*}{1-M_f^*} = 1,014,931$ (NT $)

Sources: Input-Output Tables Taiwan 1969, CIECO, Executive Yuan, Taipei, Taiwan, Republic of China

Report on Industrial and Commercial Surveys, No. 2 (1969), Ministry of Economic Affairs, Taipei, Taiwan, Republic of China

Taiwan Agricultural Yearbook 1972, Department of Agriculture, Provincial Government of Taiwan, Republic of China.

It is of course inappropriate to sum the factor requirements over all sectors since the factor requirements of any one sector are measured in terms of total requirements throughout the entire economy. However, taking the average factor cost (saving), weighted by the distribution of output over all sectors, reveals that the utilization of imported inputs in the Taiwan economy entailed a saving of .189 man-years of employment and an additional capital cost of NT$ 224 per million NT$ output. The apparent paradox (of the Leontief type) which this result poses is resolved upon closer inspection of Table I. Note, it is precisely in those sectors which rely heavily on imported natural raw material inputs that exhibit the paradoxical $L > L'$, $K < K'$: wheat for flour; cotton for textiles; timber for plywood; hides for leather products, etc. In sectors more dependent upon imports of processed intermediate inputs the expected result ($L < L'$, $K > K'$) is found. It is of course well known that neo-classical factor-proportions theory is unable to explain trade in natural resources, and this fact has been used to resolve the paradox which Leontief descovered in the United States trade as well.[1]

Total factor requirements per million NT$ output in each of 46 manufacturing sectors -- excluding the indirect requirements in the primary sector (1-4), construction (51) and services (52) -- under the two alternative production structures are presented in Table II. Column 1 of Table II indicates the direct and indirect import requirement of manufactured intermediate inputs.[2] Calcutation of the implicit factor

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1 Seija Naya, "Natural Resources, Factor Mix and Factor Reversals in International Trade", American Economic Review, Vol. 57 (May 1967) p. 561-570.

2

$$M_i^* = \sum_{i=5}^{50} m_{ij}$$

Table II

TOTAL LABOR AND CAPITAL REQUIREMENT IN THE MANUFACTURING SECTOR PER MILLION NT $ OUTPUT 1969/70

Sector		Per Unit Imported Manufactured Input Requirement	$M_j^* = \sum_{i=1}^{52} M_i' s_{ij}$	$L_j^* = \sum_{i=5}^{50} \ell_i s_{ij}$	$K_j^* = \sum_{i=5}^{50} k_i s_{ij}$	Existing Structure of Production: Total Labor Requirement Per Million NT $ Output	Existing Structure of Production: Total Capital Requirement Per Million NT $ Output	Assumed Structure of Production: Total Labor Requirement Per Million NT $ Output	Assumed Structure of Production: Total Capital Requirement Per Million NT $ Output	Resource Cost (Saving) from Utilization of Imported Manuf. Inputs Per Million NT $ Output		Sectoral Share of Total Manufactured Exports	Sectoral Share of Total Manufactured Output
		M_i'				L_j'	K_j'	L_j	K_j	$L_j - L_j'$	$K_j - K_j'$	e_j	q_j
				(man years)	(NT $)	(man-years)	(NT $)	(man-years)	(NT $)	(man-years)	(NT $)		
Sugar	5	.0013	.0400	10.807	1537698	11.340	1575431	11.272	1594894	-0.068	19463	.049	.025
Canned Food	6	.0135	.1181	11.034	472225	12.608	583634	12.292	592628	-0.316	8994	.096	.026
Tobacco	7	.0620	.0702	3.674	391453	4.610	457675	4.109	436934	-0.501	-20741	.003	.035
Alcoholic Beverage	8	.0020	.0195	5.203	492225	5.463	510620	5.429	515501	-0.034	4881	.002	.024
M.S.G. (Flavoring)	9	.0005	.0372	9.279	737664	9.775	772756	9.723	783896	-0.052	11140	.005	.006
Wheat Flour	10	.0000	.0087	3.961	571980	4.077	580187	4.858	696343	0.781	116156	.001	.013
Edible Veg. Oil	11	.0007	.0113	2.454	244488	2.605	255147	3.311	364316	0.706	109169	.000	.019
Non-alcoholic Beverage	12	.0344	.0733	8.547	693114	9.524	762261	9.286	716609	-0.238	-45652	.001	.006
Tea	13	.0001	.0336	8.444	569044	8.892	601640	8.739	605319	-0.153	3679	.013	.005
Miscellaneous Food	14	.0136	.0440	10.759	522551	11.345	564058	11.536	607916	0.191	43858	.020	.057
Artificial Fibre	15	.3293	.3893	5.969	1517223	11.158	1884467	9.433	2156745	-1.725	272278	.024	.022
Artificial Fabric	16	.2234	.4032	10.350	1228784	15.725	1609235	14.416	2011998	-1.309	402763	.125	.051
Cotton Fabric	17	.0263	.0642	16.268	989216	17.123	1049778	17.489	1164170	0.366	114392	.058	.050
Wool & Worst Fabric.	18	.1200	.1699	8.705	603424	10.969	763698	11.544	854601	0.575	90903	.014	.015
Apparel	19	.0347	.0952	22.712	792049	23.981	881855	24.135	941360	0.154	59505	.041	.039
Lumber	20	.0031	.0259	6.965	437014	7.310	461446	7.336	466571	0.026	5125	.020	.019
Plywood	21	.0105	.0261	6.779	474649	7.130	495025	7.716	552250	0.586	57225	.062	.019
Bamboo, Rattan Prod.	22	.0181	.0495	18.270	276744	18.929	314439	18.806	326774	-0.123	12335	.019	.016
Paper/Pulp	23	.1270	.1895	10.815	863966	13.341	1042730	13.378	1073105	0.037	30375	.008	.030
Printing/Publications	24	.0417	.1149	14.386	705751	15.917	814141	15.876	829807	-0.041	15666	.006	.022
Leather & Products	25	.1867	.2550	11.828	533791	15.227	774344	15.321	786539	0.094	12195	.007	.005
Rubber & Products	26	.3176	.3503	10.443	400416	15.113	730870	15.494	727172	0.381	-3698	.018	.012
Chem. Fertilizer	27	.0363	.1108	7.187	1824655	8.664	1929177	8.379	1960787	-0.285	31610	.007	.020
Medicines	28	.1384	.1759	10.724	694131	13.069	860065	12.771	861803	-0.298	1738	.003	.010
Plastic & Products	29	.0072	.0486	7.005	690078	7.653	735924	9.492	964896	1.839	228972	.072	.042
Petroleum	30	.0321	.0428	2.162	755939	2.732	796314	2.885	830662	0.153	34348	.024	.055
Non-edible Veg. Oil	31	.1143	.1402	3.202	286424	5.071	418681	3.922	360239	-1.149	-58442	.003	.002
Misc. Industrial Chemicals	32	.0643	.1089	5.098	952634	6.549	1055364	6.257	1088114	-0.292	32750	.004	.034
Misc. Chemical Manufacturers	33	.3468	.3785	5.679	316857	10.725	673913	8.290	671965	-2.435	-1948	.005	.021
Cement	34	.0138	.0437	2.746	876069	3.329	917293	3.408	926679	0.079	9386	.013	.026
Cement Products	35	.0396	.1147	17.656	1009551	19.185	1117752	19.127	1131574	-0.058	13822	.000	.004
Glass Products	36	.0199	.0582	9.899	1032102	10.675	1087004	10.597	1098810	-0.078	11806	.009	.007
Misc. Non-metal Mineral Products	37	.0083	.0395	15.868	531193	16.395	568455	16.432	577662	0.037	9207	.005	.012
Steel & Iron	38	.3106	.4469	4.901	580326	10.859	1001907	9.398	1036102	-1.461	34195	.015	.039
Steel & Iron Products	39	.3668	.4814	12.370	559412	18.788	1013539	17.289	1051502	-1.499	37963	.022	.020
Aluminium	40	.1053	.1931	10.723	2622598	13.297	2804758	12.561	2942837	-0.736	138079	.003	.007
Aluminium Products	41	.0180	.1336	20.110	2059128	21.891	2185159	21.378	2263730	-0.513	78571	.004	.003
Misc. Metal Products	42	.2902	.3326	8.607	456720	13.041	770477	12.427	764900	-0.614	-5577	.007	.008
Machinery	43	.2198	.3649	14.212	574148	19.076	918375	18.795	939369	-0.281	20994	.035	.032
H.H. Electrical Appl.	44	.1561	.2362	8.364	580600	11.512	803418	11.602	813154	0.090	9736	.007	.016
Communication Equipment	45	.4121	.4786	7.675	331536	14.055	783021	14.595	712088	0.540	-70933	.108	.047
Other Elect. Appliances	46	.2957	.3733	13.927	567567	18.903	919718	18.968	961866	0.065	42148	.009	.026
Shipbuilding	47	.3287	.3704	11.022	679663	15.959	1029078	16.458	1054337	0.499	25259	.005	.006
Motor Vehicles	48	.2710	.3539	6.157	517066	10.874	850916	9.961	834634	0.913	-16282	.003	.031
Other Transport Equip.	49	.1825	.2586	15.011	481313	18.458	725262	18.889	707567	0.431	-17695	.009	.006
Misc. Manufacturers	50	.2776	.3243	14.609	577589	18.932	883516	18.280	975565	-0.652	92049	.037	.011

Note: $M_f^* = \sum_{j=5}^{50} M_j^* e_j = .2156$; $L_f^* = \sum_{j=5}^{50} L_j^* e_j = 10.475$ (man-years); $K_f^* = \sum_{j=5}^{50} K_j^* e_j = 739{,}962$ (NT $); $\frac{L_f^*}{1-M_f^*} = 13.331$ (man-years); $\frac{K_f^*}{1-M_f^*} = 943{,}347$ (NT $)

Source: See Table I.

costs of imported inputs (i.e. the export equilivant) is based on average factor requirements of manufactured exports.[1] Comparisons of (L, K) and (L′, K′) in Table II reveal the resource (labor and capital) cost or saving resulting from the importation of manufactured intermediate inputs, assuming these inputs were imported with foreign exchange earned by exporting strictly manufactured commodities.

Abstracting from trade in non-manufactured goods clearly resolves the paradox we found in our previous results. On the average (weighted by the distribution of output in the manufacturing sector) the trade off manufactured exports for imports of manufactured intermediate inputs saved the economy NT$ 59,893 in capital and entailed an additional labor cost of .083 man-years per million NT$ output -- as compared the alternative of supplying all manufactured inputs domestically. Although we would need to know the shadow prices of capital and labor to precisely calculate the net resource cost of this trade off, it is quite apparent that resource savings in terms of capital well out weigh resource costs in terms of labor.[2] In other words, import-dependent, "footloose" industry in a developing country such as Taiwan is quite justifiable in terms of resource allocation as judged by strictly factor-proportions considerations.

1

$$\frac{L_f}{1-M_j^*} = \frac{\sum_{j=5}^{50}\left[\sum_{i=5}^{50} \ell_i\, s_{ij}\right] e_j}{1 - \sum_{j=5}^{50}\left[\sum_{i=1}^{52} M_i'\, s_{ij}\right] e_j}$$

where e_j is the proportion share of the j^{th} sector in total export of manufactures.

2 The yearly average wage in the manufacturing sector in Taiwan in 1969 was NT$ 16,000.

III. CONCLUSION: LINKAGES AND ECONOMIC DEVELOPMENT

The conclusion that the optimal allocation of resources in a developing country might well rule against industries with strong backward linkages goes against much of the conventional wisdom of development planning.[1] In particular it is the antithesis of the prominant Hirschman model of development.[2] The Hirschman model singles out the scarcity of decision-making as the primary constraint to development and argues that the most important and effective means of stimulating growth is to creat circumstances that make the advantage of a certain course of action so obvious that even weak decision-makers will act. The appropriate development strategy, so the argument goes, should emphasize investments which induce further investment decisions. The interrelatedness of the economy provides the mechanism (in fact, the deus ex machina) through wich decisions are induced. Hirschman described two directions in which the mechanism works -- one through backward linkages, the other through forward linkages, though the former is recognized to be by far the stronger of the two. In terms of input-output terminology, the appropriate strategy of development is one which gives preference to industries for which $\sum_i s_{ij}$ is relatively high. The sum $\sum_i s_{ij}$ can be thought of as the total domestic income (output) multiplier from the expansion of one unit of commodity j and is in effect a measure of the inducement to expand production throughout the economy resulting from the decision to expand the production of a given commodity j.

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[1] For example in discussing the pro's and con's of multinational corporate investment in developing countries it has been suggested that one of the most serious "con's" of this type of investment is that it typically entails few backward linkages to other sectors of the economy. D.K. Helleiner, "Manufactured Exports from Less Developed Countries and Multinational Firms", The Economic Journal, Vol. 83, No. 329 (March 1973) p. 21-47.

[2] Albert O. Hirschman, The Strategy of Economic Development, (New Haven: Yale University Press, 1958).

Having singled out decision-making ability as the binding constraint to development, Hirschman's model ignores other considerations which may in reality be equally important. As we have demonstrated, factor proportions considerations may rule against industries with strong backward linkages to other relatively capital intensive industries. Moreover, economies of scale considerations might also mitigate the appropriateness of the linkage hypothesis in a particular developing country. If, for example, a country is small either in terms of population or domestic resources, economies of scale considerations may recommend concentration on a relatively few, self-contained, "footloose" industries. If we examine the economies in which footloose industry has flourished, we find generally small, export oriented countries in which the structure of production conforms rather well to existing factor endowments. The fact that these countries dominate the exclusive group of superlative economic performers in post-war period provides some casual evidence that linkages are not particularly important.[1]

There is little doubt that the supply of entrepreneurship is a severe constraint to development. What is at question, however, is whether linkages provide an effecitve mechanism for generating entrepreneurship, and decision-making. According to the Hirschman hypothesis, the creation of bottlenecks induces entrepreneurs to come forward. At the same time, we know from the experience of many underdeveloped countries, particularly those of Latin America, that the creation of bottlenecks has other consequences which most profoundly inhibit the supply of entrepreneurship. Moreover, if one considers the intricate and innovative

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[1] A direct test of the linkage hypothesis à la Hirschman has recently been published. However the results (which rejected the extreme interpretation of the theory, but confirmed a modified interpretation) are highly suspect on methodological grounds. See, Pan A. Yotopoulos and Jeffrey B. Nugent, "A Balanced-Growth Version of the Linkage Hypothesis: A Test", The Quarterly Journal of Economics, Vol. LXXXVII, No. 2, (May 1973) pp. 157-71.

ways in which people of developing countries deal with adversity (black markets are a prime example) it is apparent that decision-making ability is not altogether lacking. What is lacking is the incentive to apply this ability to productive enterprise. Whether the lack of incentive is the result of not knowing what to do because perhaps the bottlenecks (opportunities) are not obvious enough, or the result of government policy and the consequences of government policy which inhibit the market mechanism from transmitting the appropriate incentives is an open question which demands more attention than it has yet received. Certainly the mere existence of linkages is insufficient to ensure that inducements will indeed be generated. To speak of a certain amount of decision-making (output or employment)being "generated" throughout the economy via backward linkages implicitly assumes that demand creates its own supply. Such an assumption for developing countries at this point in history is at least as naive as the reverse assumption was for industrial countries in earlier times (pre Keynes). To conclude, one can find little *a priori* reason to favor linkage considerations à la Hirschman over factor proportions or economies of scale considerations in designing the appropriate industrialization strategy for a developing country.

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