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The Information Sector in Singapore: Measuring Its Size and Economic Effects

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ABSTRACT

Economic planners in Singapore have recognised the importance and vitality of information technology and have mounted a holistic approach in encouraging it. Institutional and manpower support initiated by the public sector has shown favorable results but the field remains very competitive among newly-industrialising countries. From a conceptual framework based on incipient theories on information technology, this paper makes an attempt to measure the size of the information sector in Singapore using an input-output methodology. The results are found to be favourable although a number of caveats may be raised regarding its apparent import dependency and foreign exchange earning capability which has turned from positive to negative over the ten-year period, 1973 – 1983. Other issues concerning the institutional framework both domestically and internationally to support the sector efficiently and flexibly are also raised. Policy implications from the results of the input-output analysis are made to consolidate and reinforce current policies to promote information technology in Singapore.

ABSTRAK

Para perancang ekonomi di Singapura telah memperakui betapa pentingnya teknologi maklumat dan telah pun mengambil pendekatan yang menyeluruh untuk menggalakkannya. Sokongan institusi dan tenaga manusia yang diberi oleh sektor awam telah menunjukkan keputusan yang memuaskan, tetapi persaingan dalam bidang ini masih amat sengit antara negara-negara perindustrian baru. Daripada kerangka konsep berasaskan teori-teori awal tentang teknologi maklumat, kertas ini cuba mengukur saiz sektor maklumat di Singapura dengan menggunakan kaedah input-output. Keputusan yang diperolehi adalah menggalakkan walaupun beberapa persoalan boleh ditimbulkan tentang

penggantungan terhadap import dan kemampuan perolehan tukaran asing yang telah beralih daripada positif kepada negatif sepanjang tempoh 1973 – 1983. Isu-isu lain berkait dengan kerangka institusi, sama ada di dalam negeri atau pun luar negeri, untuk menyokong sektor ini secara cekap dan fleksibel juga ditimbulkan. Implikasi dasar daripada keputusan analisis input-output telah dikemukakan untuk memperkukuhkan dasar-dasar semasa bagi mengembangkan teknologi maklumat di Singapura.

INTRODUCTION

Information technology (IT) involving the management of information and knowledge by organisations and enterprises is as much associated with the post-industrial society as machine technology is to the industrial society (Bell 1974, 1980). The information revolution, has spawned new terminologies like technetronic era, telematic society, quinary sector (comprising knowledge activities) or compunications (involving the merging of telecommunications and teleprocessing using computers and other electronic means (Oettinger & Berman 1975), and induced a major wave of structural changes in all economies.

Information technology basically uses telecommunication networks to transmit and receive data flows. These are inputs used in the production and distribution of goods and services as well as information that results from such economic activities. When such data flows electronically via computers across nations, they become transborder data flows (Jussawalla & Cheah 1987). Diagram 1 typifies the development of the information industry which is ultimately linked with information systems across industries and even borders. In offices, there is a wide use of information equipment while in factories, computer-aided design and computer-aided machines (CAD/CAM) develop. For the society, medical, environmental, transportation and physical distribution information systems come into use. Homes use information systems based on the telephone and personal computers. The development will be on all fronts of software, hardware and systems, including communications and broadcast satellites.

While attempts to theorise information economics and surveys of such work can be found in the literature (like Lamberton 1980), empirical testing of hypotheses is hampered by the state of the art in quantification and measurement of the sector. Attempts include those of Machlup (1962), Oettinger and Berman (1975), Porat (1976, 1977), Lamberton

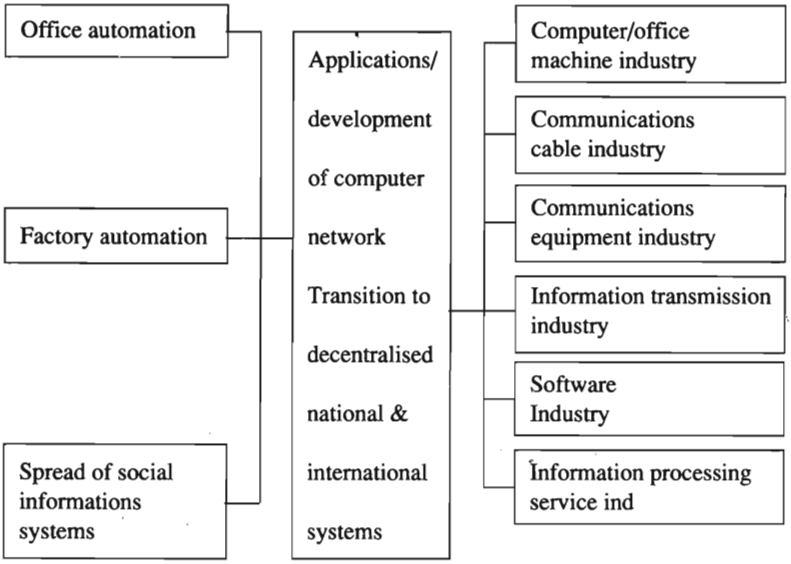

DIAGRAM 1. Development of the Information Industry
Source: Adapted from Long-Term Credit Bank of Japan, Industrial Research Division. Japan's High Technology Industries, May 1983.

(1982), Jussawalla and Cheah (1983) and Karunaratne (1983, 1986a, 1986b), among others. Porat's pioneering approach includes a primary information sector which produces information machines or markets information services as a commodity, and a secondary information sector.[1] The latter following Galbraith's notion of "technostructure", (Channon 1978: 9) has two segments, the public bureaucracy and private bureaucracies which have planning, programming, scheduling and marketing activities not directly counted in the national accounts as information services and whose values have to be imputed.

Singapore has latched on to IT with the launching of its National IT Plan jointly developed by the National Computer Board (NCB), Economic Development Board (EDB), Telecoms and Institute of Systems Science (ISS) of the National University of Singapore (NUS) in 1986. Its twin objectives are to develop a strong export-led IT sector and to improve competitiveness and productivity in the domestic economy through full exploitation of IT. However, measurements of both the primary or marketed and secondary or non-marketed information sectors are not easily made from published national income data bases. This paper

attempts to meet this challenge by using an input-output (I-O) approach which also highlights the interdependence of both these sectors with non-information ones like agriculture and manufacturing. Thus, besides estimating the scope and magnitude of IT, its economic impact and interindustry linkages can be assessed to offer policy directions for the development of the information sector.

CONCEPTUAL ISSUES OF IT

Though the scope of IT is yet to be demarcated, two policy issues have been raised (Bell 1980: 195). The first is a structural issue concerning the technical-economical organisation which must be both efficient and flexible to nurture the IT sector. The public sector and the political and institutional framework must also respond timely and accordingly (Blumenthal 1988: 538). Where adaptation is slow or obsolete institutions and outmoded rules create uncertainty and tensions, either by individual countries or by governments severally and jointly, the quality of IT development and dissemination will be affected.

The second is more intellectual, requiring a national information policy particularly for information dissemination. Such a policy has to deal with the problems of centralisation versus privacy, moral responsibility, intellectual property rights, regulation versus free access and others. Information being power, both these structural and intellectual issues must be resolved so that this power is not abused but consolidated. Related issues include decentralisation versus increased centralised decision-making, economic dualism versus a more participatory economy, whether IT growth would upgrade or deskill work, result in increased computer literacy or alienation, or intensify or debilitate personal relationship, (Miles & Gershuny 1986: 20).

Another issue is on the misplaced concern over productivity and employment in the service sector in general, and in IT in particular, relative to the manufacturing sector (Gershuny & Miles 1983: 6). In the United States and Japan, the information sector began to absorb the largest share of labour in 1960 and 1980 respectively (Ken-ichi Imai 1988). Another econometric study of the American information industry found information worker productivity rising continually from the late 1970s while that of production worker declines (Jonscher 1983, 1984).

Newly industrialised countries (NICs) have less of an employment problem anyway. A clear link between information intensity, such as research and development intensity, and economic performance (Rada

1987: 132) should be exploited. Service industries are no more labour-intensive than manufacturing ones as they equalled or exceeded manufacturing in capital intensity and in concentration (Quinn et al. 1987: 52). As IT grows, the demand for professional, technical and other specialised workers may change occupational structure of employment.[2]

Issues transcends border as transborder data flows grow. They may be issues on comparative advantage, trade, legal or sovereign rights as locational and time zone advantages and national boundaries eclipse. In the area of trade for instance, the ability of a country to use new IT effectively may alter or improve its comparative advantage, cost structure or trade flows. Electronics transmission via TDBF further complicates trade rulers like those relating to country of origin (Leeson 1984).

Industrial restructuring, induced by innovation, creating new economies of scale may blur or cause the disappearance of traditional industry boundaries (Quinn et al. 1987: 54 and Rada 1987: 157). Regulation or deregulation, as the case may be, as in financial services aided by electronic technologies, come into play. Bilateral government-to-government negotiations or under the aegis of international organisations to resolve issues, may become necessary.

Beyond earthly borders, rights into extra-terrestrial space and communication bands are presently exploited by only the superpowers (Cheah 1988). In time to come, other nations wishing to join the network may be "crowded-out". On another futuristic dimension, the development and use of artificial intelligences or the combination of science and technology with the power of information, have huge portends for both economic and political configurations. A change in information is a change in the probablity distribution of states of the world (Arrow 1980: 307). With technology, the world is no longer composed of individual national economic entities. Yet, both the nation-state and sovereignty continue to exist and are zealously guarded. No existing international institutional arrangement is yet equipped to sort out the commercial and regulatory issues in a manner consistent with a liberal international economic order for information services (Feketekuty & Aronson 1984: 64).

INPUT-OUTPUT APPROACH: MEASUREMENT AND RESULTS

In the Neo-Classical paradigm of economic analysis, perfect competition is the rule rather than the exception. It follows that information is

ubiquitous and freely accessible. However, in the real world, information is certainly neither perfectly available nor free. In any modern economic transaction, the exchange of goods and services is accompanied by a reverse flow of money payments. It is seldom discerned that another flow, namely, of information is present. When goods and services are exchanged, information is also exchanged. As economic transactions and structures become more complex, with multiplicity in the range of goods and services, the information component in any transaction is no longer "silent" and has acquired a higher profile. It has itself become an important input as well as providing a vital leverage in enhancing competitive edge. Its importance has fostered the development of an information industry which goes beyond advertising, to include data collection and processing, information dissemination and storage and the production of other products such as computer hardware and software to support it.

The emergence of the information sector is based on the diffusion of IT into other sectors of the economy rather than on the growth of an independent information industry. The traditional sectors such as agriculture and manufacturing are increasingly becoming "informatised". Economic activities generate both non-information and information commodities. While the information sector comprises an integral subset of all economic activities, a sectoral identity to the information component in an economic system is necessary. This would also allow an assessment of how information activities absorb scarce resources, claim on current production, impose transaction costs or act as intermediaries to further production. The familiar Leontief I-O framework is thus suited to unravel the hidden parameters of a country's information economy in a consistent manner.

In the measurement exercise, we have to first identity the activities that belong to information sector. These comprise activities associated with the production and distribution of information goods and services (Jussawalla & Cheah (1983)). Information goods are defined as those which are used primarily in the processing or conveyance of information related to economic transactions. On the other hand, information services are defined as that bundle of activities associated with the production, processing, storage and dissemination of this information. Given these definitions, the information sector can be measured in terms of the value-added or total output originating with the production and distribution of information goods and services.

Using a modified version of a methodology used by Kurunaratne (1986a), each industry in the *I-O* table is partitioned into two parts: the information and the non-information part by means of the information intensity coefficient.[3] Thus, for an *I-O* table which originally has n industries, it is now disaggregated into one with 2n industries consisting of n non-information industries and n information industries as depicted in Diagram 2.

	Non-Info industries	Information industries	Final Demand	Total Output
Non-Information industries	$(Xij)_{NN}$	$(Xij)_{NI}$	F_N	X_N
Information industries	$(Xij)_{IN}$	$(Xij)_{II}$	F_I	X_I
Value-Added	$(V.A)_N$	$(V.A)_I$		

DIAGRAM 2. Matrix of information and non-information sectors

II = Information to information matrix
NI = Non-information to information matrix
= the matrix of intermediate purchase of non-information commodities by information industries
NN = Non-information to non-information matrix
= the matrix of intermediate transactions between non-information industries
IN = Information to non-information matrix
= the matrix of intermediate information commodity sales to non-information industries

The n information industries are aggregated to form a single entity, which is known as the primary information sector[4] (Karunaratne 1983). An estimation of the information sector thus defined, and its contributions to various economic variables, are estimated using the latest I-O 175-sector tables for Singapore in 1983, compiled by the Department of Statistics, Ministry of Trade and Industry. For intertemporal comparison, similar estimations of the information sector in the I-O tables for the years 1973 and 1978 are also made. The 1973 tables contain only 75 sectors which expanded to 150 by 1978. As such, certain assumption about the grouping of industries which make up the information sector are made, for comparability and consistency (Appendix 2).

Table 1 gives the percentage contributions of the information sector compared with other sectors in 1983. It contributes 5.7% to national income in 1983, pays out 5.8% of the national wage bill and contributes 5.7% to national gross operating surplus. Products of the information sector constitute 2.8% of total domestic exports of the economy or about 14.3% of the nation's service exports. The information sector also accounts for 4.7% of gross domestic capital formation that year. The sector has become one of the fastest growing one, in terms of sales, revenue and outlay, investment or manpower (DBS 1987).

COST AND SALE STRUCTURE

The cost and sale structure of the information sector is shown in Table 2. In 1983, the production of a dollar of information product requires directly 30.5 cents of intermediate inputs form the non-information sectors, 23.5 cents of imports, 22.0 cents of labour input and 21.9 cents of non-labour inputs and 2.0 cents of indirect taxes. On the other hand, we note that the information sector sells 71.0% of its product as final demand, of which 14.6% are for private consumption, 18.6% for gross fixed capital formation and 31.8% are exported.

Comparing 1983 with 1973 in Table 2, the information sector has increased its intermediate inputs per unit of output (30.5% in 1983 versus 21.6% in 1973) without any reduction in its imports (23.5% versus 20.3%). This has resulted in the reduction of the value-added components in the unit output (55.9% versus 43.9%). However, it is observed that the reduction in unit labour cost is very much less than that for the reduction in gross operating surplus. There is an apparent squeeze on the profit of the information sector which may be attributed to the gradual "maturisation" of the industry as experienced in the product cycle of manufactures.

Over the decade, the sale structure has changed especially for private consumption and gross domestic capital formation. Between 1973 and 1983, the sale of information products for private consumption has decreased by one-half, from 29.0% to 14.6% while that to gross domestic capital formation has more than doubled, from 7.5% to 18.6%. The latter is reflected in the growing importance of information capital products such as computer hardware and telecommunication equipments in the composition of the national capital stock. Sale of information products for intermediate goods has increased moderately from 23.2% to 29.0%. Exports sale of the information sector has fluctuated from 29.8% in 1973 to 36.8% in 1978 and 31.8% in 1983.

TABLE 1. Percentage Contribution of Information Sector, 1983

	Imports	Wages	GOS	PteC	Govt	GDCF	Stock	Export	Tot outp
Agr	0.32	0.50	1.35	2.91	0.00	0.00	-0.20	0.21	0.38
Quarry	0.05	0.17	0.80	0.00	0.00	0.00	0.00	0.04	0.17
Mfr	67.33	22.31	26.50	15.19	0.00	5.02	72.37	77.04	26.01
Utility	0.41	0.83	3.10	2.02	0.00	0.04	-0.12	0.13	0.86
Constr	3.65	12.63	9.75	0.00	0.00	49.66	0.00	0.02	4.69
Service	11.31	57.72	52.81	55.18	97.28	10.52	0.46	19.73	20.14
Others+	14.88	0.00	0.00	20.74	0.00	30.04	27.13	0.00	45.43
Info	2.06	5.84	5.69	3.96	2.72	4.72	0.35	2.82	2.31
Total	100	100	100	100	100	100	100	100	100

Source: Computed from Singapore Input-Output Tables, 1983

GOS = Gross operating surplus
PteC = Private consumption
GDCF = Gross domestic capital formation
+ For imports, this figure of 14.8% refers to imports for final demand, while for the rest, the figures refer to imports and indirect components.

TABLE 2. Cost & Sale Structure of Information Sector, 1973, 1978 & 1983

	Cost Structure ($m)				Sale Structure ($m)		
	1973	1978	1983		1973	1978	1983
Interm	171.56	418.23	1342.37	Interm	184.41	433.29	1275.09
Imports	161.05	350.26	1035.46	IBSC	16.96	90.48	162.97
Imp Dut	2.05	2.54	4.00	Consum	230.11	388.68	641.43
Excise	2.18	1.89	3.97	Govt	59.72	43.17	108.76
OIT	12.91	23.79	87.02	GDCF	59.32	65.29	816.43
Wages	184.63	340.57	967.01	Stock	6.12	8.72	-1.19
GOS	259.02	492.12	962.46	Export	236.76	599.78	1398.79
Tot Out	793.40	1629.41	4402.28	Tot Out	793.40	1629.41	4402.28
	Cost Structure (percent)				Sale Structure (percent)		
Interm	21.62	25.67	30.49	Interm	23.24	26.59	28.96
Imports	20.30	21.50	23.52	IBSC	2.14	5.55	3.70
Imp Dut	0.26	0.16	0.09	Consump	29.00	23.85	14.57
Excise	0.28	0.12	0.09	Govt	7.53	2.65	2.47
OIT	1.63	1.46	1.98	GDCF	7.48	4.01	18.55
Wages	23.27	20.90	21.97	Stock	0.77	0.54	-0.03
GOS	32.65	30.20	21.86	Exports	29.84	36.81	31.77
Tot Out	100.00	100.00	100.00	Tot Out	100.00	100.00	100.00

Source: As in Table 1 and *I-O* Tables for 1973 and 1978.

Interm = Intermediate goods
Excise = Excise duties
GOS = Gross operating surplus
IBSC = Imputed bank service charges
OIT = Other indirect taxes

In terms of the foreign exchange earning capability of the information sector, it appears to enjoy a surplus for the three years shown in Table 2. For instance, in 1983, the information sector exported $1399 million and imported $1035 million, giving a surplus of $364 million. However, this import figure only represents direct imports for the sector, and the import content of the intermediate goods used by the information sector ($1342 million) has not been included. To consider both the direct and indirect requirements in the production of information output, I-O techniques are required and will be discussed in the next section.

MULTIPLIER ANALYSIS

Making the usual assumptions for I-O relations, we can formulate a model in the traditional Leontief inter-industry approach. The elements of the familar Leontief inverse matrix will provide the Leontief multipliers for analysing the economic impact. However the model above does not take into consideration the consumer demand feedback mechanism. An increase in the final demand for sector i will generate income directly in sector i and indirectly through production requirements of other sectors. Such an increase in income will induce more consumption, which will in turn increase output and income. To incorporate this familiar Keynesian multiplier effect in the standard Leontief I-O model, consumption is treated as an endogenous variable. The multipliers thus derived from the extended inverse matrix are known as Leontief-Keynes multipliers.

An increase of one dollar's final expenditure on the domestic output of sector i will directly change the output of sector i and indirectly change the output of the other sectos. The output multiplier of sector i is the total output of all n sectors required to satisfy one dollar's worth of final demand for the domestic output of sector i. It is obtained by the sum of the ith column of the Leontief or Leontief-Keynes' inverse matrix, depending whether the feedback effects of consumption are included.

The total (direct, indirect and induced) impact of the n sectors on employment and income are easily computed by pre-multiplying the inverse matrices by the respective vectors of value-added and labour coefficients. The feedback effects of the information sector on the non-information sector are also obtained by studying the partition inverse Leontief matrix.[5]

The upper and lower portions of Table 3 show the intertemporal measures of Leontief and Leontief-Keynes multipliers in the information sector, with respect to output income, imports and others. The leontief output multiplier is computed to be 1.43 in 1983, which has increased compared to the figure of 1.28 in 1973 and 1.34 in 1978. The income multiplier is relatively high compared to other sectors (Tables 5 and 6 give more details for 1983) though its values of 0.71, 0.67 and 0.63 respectively for the years 1973, 1978 and 1983, have fallen. The total import content of every dollar of output from the information sector is 33 cents in 1983. Comparing the figures for 1973 and 1978, import requirements per unit output has risen.

TABLE 3. Leontief and Leontief-Keynes Multipliers, for information sector, 1973, 1978 & 1983.

Leontief						
	Output	Income	Wages	GOS	Ind Tax	Imports
1973	1.2822	0.7081	0.2868	0.4213	0.0299	0.2620
1978	1.3432	0.6732	0.2712	0.4020	0.0273	0.2973
1983	1.4344	0.6331	0.3025	0.3306	0.0345	0.3304
Leontief-Keynes						
	Output	Income	Wages	GOS	Ind Tax	Imports
1973	2.0693	1.1290	0.4266	0.7023	0.0612	0.4151
1978	1.9521	0.9772	0.3760	0.6011	0.0482	0.4252
1983	1.8612	0.8376	0.3885	0.4491	0.0511	0.4093

Source: As in Table 2.

A more appropriate measure of the foreign exchange earning capability of the information sector is to compute the difference between the export per unit of output and the import multiplier. These computed figures are 0.0364 in 1973, 0.0708 in 1978 and 0.0127 in 1983. Its positive earning capability experienced in 1973 and 1978 has turned negative in 1983. The figure in 1983 implies that for every dollar of output of the information sector, it imports 1.27 cents more than it exports.

We have also computed the Leontief-Keynes multipliers which take into consideration the feedback (induced) effects of consumption in the generation of income and output. As shown in the lower portion of Table 3, all the Leontief-Keynes multipliers are larger in magnitude than the Leontief multipliers. However, when the feedback effects of consumption is taken into account, the multipliers with respect to output, imports, and wages record a declining trend in contrast to that observed in Leontief multipliers. Moreover, the decline in gross operating surplus generation is more marked for Leontief-Keynes, which reaffirms the profit squeeze phenomenon noted earlier.

The importance of the feedback effects of the information sector on the non-information sector is shown in Table 4 with respect to income and output multipliers. For all the sectors, the inclusion of the information sector has increased their output multipliers by 2 - 3% with the exception of utilities (0.9%). Similarly, for income multipliers, the feedback effect of the information sector has raised them by 2 - 4%, again with the exception of utilities (0.9%). Although these are not very large effects, they have job-creating potential which increase the overall impact.

The output, income and labour Leontief and Leontief-Keynes multipliers by sector for 1983 are given in Tables 5 and 6 respectively. Both the Leontief and Leontief-Keynes multipliers for the information sector for output and income are only slightly lower than for the service sector, but larger than for utilities, manufacturing and agriculture.

In terms of employment generation, the information sector provides 18 jobs (Table 5) or 25 jobs (Table 6) when the feedback effects of consumption on output is taken into consideration, for every million dollar worth of information products. In both cases, the information sector generates more jobs than the manufacturing sector but less than the service sector.[6] Disaggregated into various types of skill requirement, the information sector employs 3 professional and administrative staff, 9 clerical, sales and service workers, and 6 production and other workers (Table 5). The corresponding figures when consumption feedback effects are included are 4, 13 and 8 respectively (Table 6). Again, for the category of professional and administrative skills, the information sector lags behind the service sector, but ahead of manufacturing.

TABLE 4. Feedback Effects of the Information Sector on Output and Income of Non-information Sectors, 1983

Feedback on Output Industries	1 Output + info	2 Output - info	3 Feedback (1) - (2)	4 (3) as % of (2)
Agriculture	1.3916	1.3638	0.0278	2.04
Quarrying & mining	1.6534	1.6095	0.0439	2.73
Manufacturing	1.3898	1.3612	0.0286	2.10
Utilities	1.3243	1.3126	0.0117	0.89
Construction	1.6761	1.6312	0.0449	2.75
Services	1.4457	1.4089	0.0367	2.61
Feedback on Income **Industries**	**1** **Income** **+ info**	**2** **Income** **- info**	**3** **Feedback** **(1) - (2)**	**4** **(3) as %** **of (2)**
Agriculture	0.6045	0.5922	0.0123	2.08
Quarrying & mining	0.7945	0.7751	0.0194	2.50
Manufacturing	0.4393	0.4266	0.0126	2.96
Utilities	0.5786	0.5734	0.0052	0.90
Construction	0.6068	0.5869	0.0198	3.38
Services	0.7437	0.7275	0.0162	2.23

Source: As in Table 2.

TABLE 5. Leontief Multipliers for Output, Income and Labour,1983

Industries	Output	Income	All Workers	Prof & &Admin	Cler, Sale & Service	Prod & Others
Agriculture	1.3916	0.6045	21.30	1.67	3.30	16.33
Quarry	1.6534	0.7945	14.25	3.40	4.68	6.18
Manufacture	1.3898	0.4393	10.53	1.28	2.84	6.41
Utilities	1.3243	0.5786	7.88	1.42	2.28	4.19
Construction	1.6761	0.6068	14.84	1.71	3.24	9.89
Services	1.4457	0.7437	25.15	5.57	1.76	7.83
Information	1.4344	0.6331	17.68	2.55	9.14	6.00

Source: As in Table 1.

TABLE 6. Leontied-Keynes Multipliers for Output, Income and Labour, 1983

Industries	Output	Income	All Workers	Prof & &Admin	Cler, Sale & Service	Prod & Others
Agriculture	1.7992	0.7998	28.15	2.72	7.09	18.34
Quarry	2.1891	1.0511	23.26	4.78	9.66	8.82
Manufacture	1.6860	0.5812	15.50	2.04	5.59	7.87
Utilities	1.7144	0.7655	14.44	2.42	5.90	6.11
Construction	2.0852	0.8027	21.71	2.76	7.05	11.91
Services	1.9472	0.9840	33.58	6.86	16.42	10.30
Information	1.8612	0.8376	24.86	3.65	13.11	8.10

Source: As in Table 1.

INSTITUTIONAL SUPPORT AND ISSUES

The above measurement exercise indicates the importance of the information sector which is likely to become another growth pole of the economy. Its income and employment generation potential is certainly not less than that of the manufacturing sector. The transition from a manufacturing export-led economic growth path to one where the service sector, in particular, the information sector, is not without difficulties.

The economic planners have recognised the importance of the information sector. This is reflected by the establishment of various institutions such as the NCB and the ISS as part of the basic infrastructure. This is further evidenced by the implementation of the National IT Plan. There is also continuous upgrading in the telecommunication sector initiated by the Telecoms, a statutory board, incorporating the latest in the state of the arts. The gains from such externalities are disseminated to other private sector producers and users.

A limitation to the expansion of the information sector could be the dearth of qualified manpower in the information field. The institutional support from the government at the tertiary institutions and technological institutes as well in less formal training programmes, appears ample. At the apex of the manpower training is the National University of Singapore (NUS) under which the ISS provides technical state-of-the-art and postgraduate diploma courses while the Department of Information Systems and Computer Science (DICS) has both graduate and undergraduate courses in computer studies. The Singapore Polytechnic and Ngee Ann Polytechnic, and the Japan-Singapore Institute of Software

Technoloy (JSIST) bridge the gap for diploma, middle-level skills. Another joint government institute with AT & T, the Information Communication Institute of Singapore (ICIS) set up in 1988, is to train telecommunications software experts (*Sunday Times,* 23 October 1988). Its first intake for its one-year programme will comprise mainly electrical and electronics engineers or computer graduates because of its very technical nature. At the less formal level, the IT Training Centre has been set up by the International Business Machines (IBM) in 1988 for ordinary office workers in basic computer knowledge and skills.

However, training for the service sector as a whole has to be stepped up, with the National Productivity Board (NPB) and the Vocational and Industrial Training Board (VITB) jointly drawing up standards for such training programmes. Compared with the manufacturing sector, the utilisation of Skills Development Fund (SDF) for training in the service sector as a proportion of contribution was only 40% versus 65% in the former. Between 1980 and 1987, jobs in the service sector grew from 670,000 to 760,000 with half of them created in the small and medium enterprises (SMEs) (*Business Times,* 8 April 1988). The IT growth is very widespread as evidenced by the proliferation of private commercial schools offering courses on computer and informatics.

Both the number and qualifications of IT manpower has improved. For instance, while more than one-half of computer manpower did not have any IT degree or diploma according to the NCB manpower survey in the computer industry for 1982, this figure improved to 41% by the 1987 survey. The impact on productivity has also been encouraging as the 1987 survey reported high favourable responses of IT users in various areas of application such as in accounting finance, sales and purchasing/ inventory.

Singapore's expenditure on computers reported at 27% of GDP, is higher than that of the United States at 20% (Mitsubishi Research Institute, in *Straits Times*, 4 December 1986). Despite the higher expenditure, the number of computers installed per capita is only 39% if the US base is taken as 100%. In the Asia-Pacific region, this source found Singapore with a ratio of 0.3 in terms of the number of mainframe and minicomputer per 1,000 population, a rather distant second to Japan's ratio of 1.5, but ahead of Taiwan at 0.1, South Korea, 0.05 and Malaysia, 0.04. Singapore's IT expenditure per 1000 population is US$96.00 compared with US72.40 in Japan, US$11.00 in Malaysia, US$10.30 in South Korea and US$6.60 in Taiwan. Its IT expenditure per US$1,000 GDP at 13.3 is also ahead of Japan, 6.9, South Korea, 5.6,

Malaysia, 5.2, and Taiwan, 2.4. The potential for further upgrading in computer skills and productivity is good. The current stock of about 5,500 computer professionals is estimated by the NCB to almost double to 10,000 by 1992. More will also be in research and development in areas ranging from semiconductor electronics and communications systems to artificial intellegience.

Another area of concern is the recognition and utilisation of IT in every sector of the economy. A reference to Diagram 1 shown earlier will be useful. With regards to office automation, the public sector has spearheaded the efforts. In stages, each ministry and statutory board has drawn up plans to computerise and automate administrative operations. This has greatly increased productivity, upgraded manpower skills and enabled more efficient labour utilisation.[7] Adjustment problems are however not altogether absent. There may be difficulties confronted especially among older workers, who have to be retrained for the new technology age. Concurrently, a computer literacy drive to instill the IT culture has to be mounted.

The commercial and business firms in the private sector have been responsive to the new information age. The government has given SMEs the extra push in the computerisation and automation drive.[8] In the area of trade documentation, the Trade Development Board has implemented a Tradenet system which enables electronic documentation to expedite both information processing and conveyancing (*Straits Times*, 22 April 1988 an 27 June 1988). In the stock market, a scripless system has already been installed in the Stock Exchange of Singapore Dealing and Automated Quotation (SESDAQ).[9]

However, in the manufacturing sector, the pace of automation is perceived to be less pervasive. Though the use of CAD/CAM is found in designing and manufacturing, at the production level, the intensity in the use of robotics and automation is less satisfactory.[10] This may be due to either the operations being inherently difficult to automate, or that foreign workers are still a cheaper and possible alternative. With respect to the latter, the government has to increase the foreign worker levy to accelerate the pace of national automation.[11]

The widespread use of IT must however be accompanied by a proper legal framework which will assign the property right and guard against abuse (US Office of Technology Assessment 1988). The externalities associated with information flow may infringe on both corporate and personal privacies. The access to various databases pertaining to households particulars, such as names and addresses for commercial

use, has in some cases overloaded the consumers with unsolicited information. Such an exercise may be wasteful of resources and time for both parties and prove counter effective. Perhaps, some regulatory measures may be desirable to protect consumer sovereignty. Personal particulars given for one legitmate purpose, without proper permisson, may be utilised for other functions. While the IT age is a boon to productivity and efficiency, it must be cautioned that an over reliance without an alternative support and back-up system which can be manually operated, can be very disruptive.

Liberalisation in trade in services also has a direct impact on the information sector (Abu-Ghazeleh 1988). Issues such as intellectual protection of property rights, sovereignty and right of establishment as in the case of broadcasting and telecommunication facilities, becomes relevant. In this respect, national safeguards as provided by government-run or regulated authorities, may be preferred.

CONCLUSION AND POLICY IMPLICATIONS

The information sector has a decisive role in the upgrading of the serive sector as a leading growth sector in the 1990s[12]. Over the decade between 1973 and 1983, analysis from three I-0 tables show the increase in economic contribution of the information sector. In 1983, its output and income multipliers are almost as large as for the service sector. It is only second to the service sector in terms of creating professional and administrative jobs, excluding quarrying. It is also a net foreign exchange earner, ignoring the import content of intermediate inputs required by the information sector, which has itself declined between 1973 and 1983. This implies growing linkages with other sectors in the economy.

That the foreign exchange capability of the information sector has turned from positive in 1973 to negative in 1983 after considering both the direct and indirect import requirements, deserves further discussion on two scores. One is that it is unwise to ignore the information sector purely on grounds of its negative foreign exchange earning capability since 1983 in preference for some other growth sectors which has higher foreign exchange earning power. Tourism may be one such lucrative foreign exchange earner but its economic gain must be weighed against its social cost of dilution of indigenous cultural and other values in meeting foreign tourists' tastes.

There is much more to lose in the science and technological horizon for Singapore if the IT sector is neglected or ignored. This is in the

belief that information is the power house of future post-industrial growth and this is one area that Singapore just simply cannot opt out of, especially with other NICs competing so closely in it. While the retrogression from positive to negative foreign exchange earning capability of the information appears to imply increased import dependency, it may be simply due to higher sophistication of equipment and technologies as in satellite communication, compunication and computer application in the 1980s.

Second, taking the argument a step further, the negative foreign exchange earning capability may imply that the industrial structure is not sufficiently developed to provide the intermediate products to support the post-industrial society. As such, more rather than less must be done to lessen the import dependency. Like the manufacturing sector which has to nurture certain primary industrial sectors like basic iron and steel to support further industrial development, the information sector may similarly need to promote certain primary information industries. There appears a case for basic information software and hardware industries like in computers and telecommunication networking to be promoted before new heights in the information industry can be scaled. Other NICs like Taiwan and South Korea have a stronger primary information industries as in computer-related activities. There is much to catch up with other NICs in the development of the computer industry in Singapore.

The I-O approach has also shown quite favourable labour multipliers for the information sector. However, one limitation of such results is to be noted. There is no further breakdown on skills and categories like professional and administractive workers, clerical and others, are too broad. The impact at a more disaggregated level would require occupational structure of IT employment in greater detail and the NCB surveys may be useful. This would in turn allow more accurate projections of IT manpower to support the industry's expansion.

While the overall economic impact is favourable, the issues raised concerning the technical-economic structure and the national information policy to handle the development of the information sector are as relevant in the Singapore context. The government has been rather responsive in this respect with strong infrastructural, institutional and manpower support. Much remains to be done however, where interactions with other public sector agencies controlling information in other countries, are involved. In particular, the problems concerning TBDF, intellectual property rights, sovereignty and regulation among others, require international agencies to act as intermediaries.

Singapore is well-placed both in terms of its proximity and level of IT sophistication to derive some spillover effects from the industrial restructuring induced by IT innovations in Japan. The dominance of Japanese investment in Singapore especially in the electronics sector, may help it to tap growing new domestic demands in Japan, but not before outstanding issues in trade and property rights are resolved. Among the Association of Southeast Asian Nations (ASEAN) members, IT has the potential to narrow economic gaps and promote successful industrial development. Again, Singapore may have a useful role to bridge this gap, with its infrastructure in manpower and research and development facilities.

Appendix 1

Information Industries in Input-Output Tables 1983

Code	Industries
45	Newspapers
46	Books & magazine
47	Commercial & job printing
48	Other printing
56	Inks & carbon black
91	Computers
92	Other office machinery & equipment
101	Microphones, loudspeakers & amplifiers
102	Radios & sound recorders
103	Television sets
104	Electronics tubes & semi-conductors
105	Capacitors & resistors
106	Printed circuit boards
107	Other communication equipment
108	Records & magnetic tapes
122	Scientific & precision equipment
123	Photographic & optical goods
128	Signs & displays
135	Wholesale & retail trade
147	Communications
150	Banking
151	Finance companies
152	Other financial services
154	Legal services
155	Accounting & data processing

156 Architectural & engineering services
157 Petroleum & mining consultants
158 Employment & labour contracting
159 Advertising services
161 Management consultants
165 Education
169 Broadcasting & entertainment services

Appendix 2

Comparisons of Codes of Information industries in Input-Output Tables, 1973, 1978 and 1983

Industries	1973	1978	1983
Printing & publishing	27	53-54	45-48
Inks & carbon black	32*	62	56
Computers & office equipment	45*	91	91-92
Electronics	47-48	97-99	101-108
Scientific & photographic	53	111-112	122-123
Signs & displays	Nil	117	128
Wholesale & retail	60*	123	135
Communications	64	131	147
Banking & finance	65*	132-134	150-152
Other business services	68*	136-138	154-159
Management consultants	68*	139	161
Education	70* & 73*	142	165
Broadcasting & entertainment	70* & 73*	145	169

* Part of the industries based on contribution by turnover reported in the Census of Services, is included

NOTES

[1] There are altogether six sectors in Porat's model, being information sector, secondary information comprising the public bureaucracy and private bureaucracy, private productive sector, public productive sector and household sector (Bell 1980: 181).

[2] Gershuny and Miles (1983: 62) has used the technique of shift-share analysis to examine what change in occupational distribution of employment can be accounted for by within-industry change and across-industry change. They found that rather than being entirely propelled by the shifting of work across the economic sectors, the growth of service-type occupations is very much related to changes in organisational structure within these sectors.

[3] Following Jussawalla and Cheah (1983), the information sector in the 1983 *I-O* Tables is presented in Appendix 1.

[4] It is also possible to construct a secondary information sector which includes "the planning, controlling and decision making activities which are undertaken within the private and public bureaucracies and which do not reach the market" (Karunaratne and Cameron 1981: 113). For further details on the estimation of the information intensity coefficient, see Toh and Low (1988).

[5] For further details See Toh and Low (1988).

[6] The IT sector has spawned new key jobs in Singapore as reported in *Straits Times,* 18 August 1987. See also *ibid,* 14 April 1988 and 28 May 1988 on the government's focus on training more IT specialists and the increase in computer workers respectively.

[7] It is noted that for IT to be really useful, it should also be known and practised by older pre-industrial top management personnel. See *Economist,* 23-29 April 1988. The civil service gains about $125 million a year due to computerisation, as reported in *Straits Times,* 26 August 1988.

[8] A national automation drive with five key strategies has been initiated; see *Business Times,* 19 August 1988.

[9] The scripless system has run into some problems on the main board, the Singapore Stock Exchange; see *Business Times,* 9 July 1988.

[10] See *Business Times,* 3 May 1988, on a National Automation Survey on the use of robotics and the National Automation Committee Master Plan.

[11] See *Straits Times,* 17 November when the intention to raise the foreign worker levy from $170 to $250 in two stages was announced. Also in *ibid,* 23 November 1988, the government gave details of a $60 million plan to further accelerate the national automation drive, including more liberal training grants for up to 70% of training costs, more low-interest loans, free consultancy services on feasibility of automation for firms and an investment allowance of up to half the cost of equipment.

[12] The Minister for Trade and Industry Brigadier-General Lee Hsien Loong has affirmed this; see *Straits Times,* 13 February 1988. The Prime Minister has spoken of the potential in the service sector when he opened the EDB Conference on Global Strategies, in *ibid* 25 October 1988.

REFERENCES

Abu-Ghazaleh, T. 1988. The GATT and intellectual property. *Economic Impact,* No. 64.

Arrow, k. 1980. Economics of information. In *The Computer Age: A Twenty-Year View,* Dertouzos M.L. and Moses, Joel, eds. Cambridge: Masschussetts Institute of Technology Press.

Bell, D. 1974. *The Coming of Post-Industrial Society: A Venture in Social Accounting.* London: Heinemann.

Bell, D. 1980. The social framework of the information society. In *Dertouzos M.L. and Moses, Joel, eds. The Computer Age: A Twenty-Year View,* Cambridge: Massachussetts Institute of Technology Press.

Blumenthal, W.M. 1988. The world economy and technological change. *Foreign Affairs* 66 (3).

Butler, J.R.G. 1988 ed. *Current Economic Issues 1987.* Brisbane: Brisbane College of Advanced Studies.

Channon, D.F. 1978. *The Service Industries: Strategy , Structure and Financial Performance*. London: Macmillan.

Cheah Chee Wah 1988. The economics of satellite communications: Supply and demand in outer space. In *Current Economic Issues 1987,* Butler, J.R.G. ed. Brisbane: Brisbane College of Advanced Studies.

Dertouzos, M.L. & Moses, Joel, eds. 1980. *The Computer Age: A Twenty-Year View*. Cambridge: Masschussetts Institute of Technology Press.

Ferguson, M. ed. 1986. *New Communication Technologies and the Public Interest: Comparative Perspectives on Policy and Research*. London: Sage Publications.

Feketekuty, G. & Aronson, J.D. 1984. Meeting the challenges of the world information economy. *The World Economy* 1 (1).

Gershuny, J.I. & Miles, I.D. 1983. *The New Service Economy: The Transformation of Employment in Industrial Societies*. London: Frances Pinter Publishers.

Giarini, Orio, ed. 1987. *The Emergency Service Economy*. Oxford: Pergamon Press.

Imai, Ken-ichi. 1988. The breakthrough of the information industry in Japan as an engine for creating new demands. Paper presented to the 17th Pacific Trade and Development Conference on The Challenge of Technological Change to Pacific Trade and Development, Indonesia, 20-23 July.

Jonscher, C. 1983. Information resources and economic productivity. *Information Economics and Policy*. 1.

Jonscher, C. 1984. Productivity and growth of the information economy. In *Communication and Information Economics,* Jussawalla, Meheroo and Ebenfield H, eds. Amsterdam: North-Holland.

Jussawalla, Meheroo & Lamberton D.M. eds. 1982. *Communication Economics and Development*. Honolulu: East-West Centre.

Jussawalla, Meheroo & Ebenfield H, eds. 1984. *Communication and Information Economics*. Amsterdam: North-Holland.

Jussawalla, Meheroo & Cheah Chee Wah. 1983. Towards an information economy: The case of Singapore. *Information Economics and Policy* 1.

Jussawalla, Meheroo & Cheah Chee Wah. 1987. *The Calculus of International Communications: A Study in the Political Economy of Transborder Data Flows*. Littledon, Colorado: Libraries Unlimited Inc.

Karunaratne, N.D. & Cameron, A. 1981. A comparative analysis of the 'information economy' in developed and developing countries. *Journal of Information Science Principles and Practice* 3 (3).

Karunaratne, N.D. 1983. The information economy and a methodology for its identification. Paper based on East-West Center, University of Queensland Project, June.

Karunaratne, N.D. 1986a. An input-output approach to the measurement of the information economy. *Economics of Planning* 20 (2).

Karunaratne, N.D. 1986b. Analytics of information and empirics of the information economy. *The Information Society* 4 (4).

Leeson, K. W. 1984. *International Communications: Blueprint for Policy.* Amsterdam: North-Holland.

Machlup, 1962. *The Production and Distribution of Knowledge in the United States.* Princeton: Princeton University Press.

Miles, I.D. & Gershuny, J.I. 1986. The social economics of information technology. In *New Communication Technologies and the Public Interest: Comparative Perspectives on Policy and Research,* Ferguson, Marjorie, ed, London: Sage Publications.

Oettinger, A.G. & Berman, P.J. 1975. The medium and the telephone: The politics of information resources. Working Paper 75-8, December 15, Harvard Program on Information Technologies and Public Policy, Cambridge, Massachusett.

Porat. M. 1976. *The Information Economy.* PhD. thesis, Stanford University.

Porat. M. 1977. *The Information Economy* Vol. 1. Washington DC: United States Department of Commerce, Office of Telecommunications.

Quinn, J.B., Baruch, J.J. & Paquette, P.C. 1987. Technology in services. *Scientific America* 257 (6).

Rada, J. F. 1987. Information technology and services. In *The Emerging Service Economy,* Giarini, Orio, ed. Oxford: Pergamon Press.

Singapore, Development Bank of Singapore. 1987. Information technology in Singapore. Singapore Briefing, No 4 (November).

Singapore, Department of Statistics. 1978. *Singapore Input-Output Tables 1973.* Singapore: Singapore National Printers.

Singapore, Department of Statistics. 1983. *Singapore INput-Output Tables 1978.* Singapore: Singapore National Printers.

Singapore, Department of Statistics. 1987. *Singapore Input-Output Tables 1983.* Singapore: Singapore National Printers.

Stanback, T.M. et al. 1981. *Services: The New Economy.* New Jersey: Allanheld, Osmun & Co Publishers.

Toh Mun Heng & Linda Low. 1988. The economic impact of the information sector in Singapore. *Economics of Planning,* forthcoming.

United States Office of Technology Assessment. 1988. Disseminating information: Evolution of a concept. *Economic Impact,* No 64.

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