MEASURING KNOWLEDGE DEVELOPMENT IN THE INFORMATION ERA

R.Ramachandran
National Information Technology Council (NITC) Scretariat
MIMOS Berhad, Technology Park Malaysia , Bukit Jalil
57000 Kuala Lumpur,

Abstract:
Being abstract item, knowledge is difficult to quantify. However, manifestations of knowledge development including information, and communication can be measured using statistical criteria. Today, knowledge explosion activities are increasingly manifested in Internet inception which premises upon people and technology integration phenomena. Thus, the paper attempts to identify and integrate appropriate knowledge development variables under people and technology domain. Logarithmic concept is used to develop composite measures by aggregating variables of differing meaning, magnitude and units of measurement. For illustration purposes, secondary data were used to depict the knowledge development in the present information era. The paper also identifies a way forward to expand the scope and coverage of developing full-fledged knowledge development variables.

1. INTRODUCTION

As history acknowledges since the beginning of human civilization information, communication and knowledge as well as entertainment have been inherent attributes of societal progress besides land, labour, capital and technology. But, the parameters and imperatives that operated in the past agrarian and industrial societal development are different from those operating in the present information society. In particular, the inception of Internet technology worldwide gives rise to information and knowledge explosion besides global communication and networking. The contemporary parameters include on-line connectivity and real time interactivity modes irrespective of geography and time, convergence of computing, broadcasting and content technologies, integration of technology and people, ubiquity, phenomenal and pervasiveness. Indeed, the new imperatives are becoming explicit factors of production in economic domain and emerging cohesion factor in social spheres. As such, Internet affects the way individuals; societies and organizations communicate, interact, do business transactions, network and learn. Thus, it has become imperative for policy formulators and statistical communities to develop new indicators for monitoring and evaluating the information and knowledge society as well as Information Communication Technology (ICT) developments.

2. WORKING DEFINITIONS[1]

3. MEASURABILITY ASPECT OF KNOWLEDGE DEVELOPMENT

Knowledge is an abstract item and it cannot be measured using any instruments or gadgets or formulae, unlike abstract physical quantities like heat measurable using thermometer or radius of earth using scientific concepts. Any attempt to measure Knowledge Classifications such as meta, milieu, tacit, contingent, formal and instrumentality will be futile due to overlapping meaning. In

[1] *The paper titled "Emerging Statistical Concepts and Definitions In the Information Era" (Asha & Ramachandran, 2001) provides definitions pertaining to knowledge hierarchy, information and knowledge society, ICT, knowledge and information worker as well as networked worker, ICT literacy, information literacy et cetera. These working definitions are essential for developing statistical criteria for measurements.*

particular, tacit knowledge is difficult to distinguish, codify and measure (Lundvall and Johnson, 1994, OECD 1966). Similarly, information and knowledge assemblage in its generic form constituting contents, process, procedures, infrastructure, network, institutions, modus operandi, linkages and evolutionary processes et cetera is also difficult to quantify. Like in any other statistical systems **manifestations of attributes or variates of knowledge development phenomena become measurable quantities**. e.g medical knowledge development can be determined by number of doctors, specialists, medical discoveries, hospitals, telemedicine practices et cetera.

4. KEY ASSUMPTIONS

The key assumptions of measuring contemporary knowledge development are as follows:-

- Internet based ICT is the driver of achieving information and knowledge society;
- Information age developments give rise to new societal hierarchy, divides and differentials - data, information, knowledge and wisdom hierarchy; entertainment, information, research and value creation ICT usage prevalence; data workers, information workers, knowledge workers and value creators as emerging work force classification;
- People including institutions have inextricably inter-wined with ICT or an integral component of information; communication and knowledge development system, thus giving rise to sociotechnology phenomena.
- Individuals, societies and organizations willing to **adopt and adapt** new information and communication technology, is essential for knowledge development, perhaps even for pleasure and entertainment.
- Information, knowledge, communication and networking becoming explicit factors of production in economy and factor of cohesion in social domain.

5. SCOPE & COVERAGE

Statistically, the study covers all ICT products and services that are driven by electrical or microelectronic technology. Being obsolete, irrelevant and insignificant to the mainstream developments, all rudimentary ICT technologies are excluded from the study scope and coverage, despite its prevalence in remote areas. All non-electronic information and communication modes especially those are currently being used are regarded as enabling factor in the development of knowledge system In terms of people involvement, the study includes all from technologically savvy to a novice user. The ICT usage pattern vary greatly from simple things like listening to radio, watching television, conversing using telephones, surfing Internet for information and pleasure to complex activities like developing programming languages and sophisticated systems.

6. MEASUREMENT STRUCTURE: SOCIOTECHNOLOGY MODEL

After examining the assemblages, imperatives and correlates as well as evolutionary process, the information age knowledge development system is conceptualized as a sociotechnology model, comprising technology and people dimensions. The technology dimension constitutes computing, telecommunication and content development. While, the people dimension characterized by Information Access - ICT Diffusion, ICT Literacy and Information Literacy; and Knowledge Acculturation - Capability Building, Capacity Building and Knowledge Utilization.

7. MEASUREMENT METHODOLOGY

Besides providing basic variable statistics on knowledge development, the paper also provides two types of index measures – Level Measure Index (LMI) and Index of Disparity (IoD) computed using the following formulae respectively:-

LMI : ***Additive Approach:*** ***Multiplicative Approach***

$$\mathbf{I_d} = \left[\frac{1}{k}\left\{\sum\left[\log(V_t)/\log(V_0)\right]\right\}\right]*100 \quad \text{or} \quad \mathbf{I_d} = \left[\sqrt[k]{\prod\{\log(vt)/\log(V_0)\}}\right]*100$$

where, I_d is index value at a domain level; V_t is the current variable value at time t,; V_0 is the base variable value; Log(V_t) is the measure of level at period (t); Log(V_0) is the measure of level a variable referring to base period (o)

IoD[2] *:*

$$\mathbf{I_d} = \frac{\{(Actual(X) - Benchmark(Z)\}}{\{Maximum(Y) - Minimum(Y)\}}*100$$

Where, I_d is the index of disparity; Z refers to either national average or minimum value as a benchmark value ; Y refers to a data set values

8. PROTOTYPE RESULTS

Table 1 provides composite measures on both technology[3] and people[4] parameters of knowledge development. The **technology** aspect covers production, export and import of computing, telecommunication and content product and services. On people aspect, the **information access** is characterized by ICT products and services penetration, ICT and information literacy skills. The **capability** measures cover academics, working professionals, student population and undergraduates who are deemed to endowed with or have potency for knowledge development activities. While, the **capacity building** include learning institutions, regulatory, technology flows and enabling factors. The Table 2 provides a snapshot of Malaysian population dynamics by labour force and education status. In particular, demography parameters such as currently schooling, working, unemployed, aged, female participation et cetera are essential for formulating ICT access and equity policies and programmes. Table 3 shows access and equity distribution for telephone connectivity, Internet access, content development and affordability[5] as well as disparity at sub-national state level. These are essential parameters for bridging the widening digital gap. In the absence of direct measure, Table 6 provides a proxy measure on rise of knowledge and information workers in time series. The assumption is that the traditional professional, administrative and managerial are engaged in creating or adding values to an organization. Such workforce usually engaged in strategic work that demands thinking, creativity and innovation capabilities. Despite increasing trend, the challenge remains for Malaysia to produce quality work force in moving from current production based economy to knowledge driven economy (k-economy).

---

[2] *Modified from Human Development Index measure methodology, HDR*

[3] *Product items covers electronic data processing, office equipment, control & instrumentation, telecommunication, consumer, active and passive components. Of these, the content disseminating products include radio, television, video cameras, tape recorders, photocopiers et cetera.*

[5] *Household expenditure pattern (1994) revealed that on 17 percent of household income disposable optionally for entertainment and communication needs and RM250 for telephone, Internet and PC installment Average urban and rural income is RM3,406 and RM2,607 respectively. . A brief analysis showed that only 17 percent of total households in rural and 40% in urban considered can afford a purchase of personal computer with basic Internet installation, costing RM3,000*

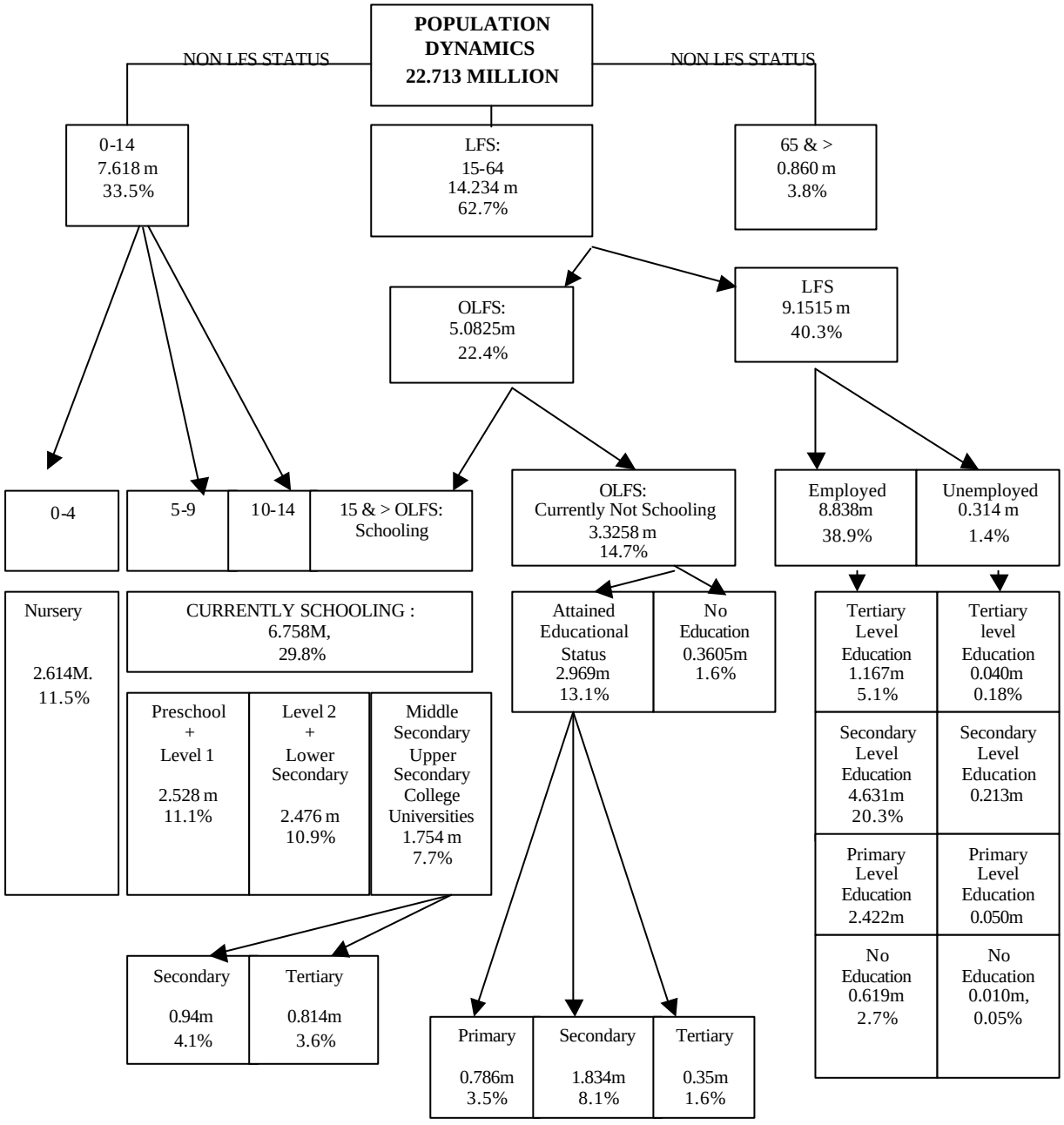
Table 1: Knowledge Imperative Index By Technology Parameters, 1990-1999

(Base level for year 1990 = 100)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
TECHNOLOGY PARAMETERS										
Production	100.0	106.3	111.2	118.8	125.8	128.2	131.2	132.6	136.5	138.4
Export	100.0	105.1	108.8	114.4	119.0	123.7	125.1	126.2	124.1	-
Import	100.0	104.9	107.8	111.5	116.4	120.9	119.7	119.5	111.7	-
Products	100.0	106.3	117.6	119.8	126.6	128.6	130.3	130.0	130.5	131.8
Services	100.0	100.3	102.3	104.4	105.3	113.8	116.5	*n.a*	*n.a*	*n.a*
Content	100.0	103.4	110.1	112.6	115.5	121.0	123.3	*n.a*	*n.a*	*n.a*
Computing	100.0	105.2	110.1	115.5	120.6	124.5	126.1	129.2	129.6	136.7
Telecommunication	100.0	106.8	107.9	114.7	122.2	125.6	125.8	123.2	120.7	120.1
Content	100.0	103.4	110.1	112.6	115.3	121.0	122.2	130.1	130.6	131.9
Technology	***100.0***	***105.2***	***110.1***	***115.5***	***120.6***	***124.5***	***126.1***	***129.2***	***129.6***	***136.7***
PEOPLE PARAMETERS										
Products Penetration	-	100.0	113.2	116.7	119.7	121.6	121.8	121.0	-	-
Services Penetration	-	100.0	116.7	115.7	114.7	106.6	132.7	142.2	-	-
Literacy Rate	-	100.0	119.5	127.0	126.6	142.3	154.2	163.9	-	-
Information Access	-	**100.0**	**115.5**	**117.6**	**118.1**	**118.1**	**132.2**	**137.5**	-	-
Academic	-	100.0	102.8	103.9	105.5	107.2	108.1	-	-	-
Professionals	-	100.0	100.7	101.4	101.7	102.0	103.1	-	-	-
Student	-	100.0	100.4	100.9	102.7	103.5	104.3	-	-	-
Graduates	-	100.0	114.3	122.8	129.2	134.1	138.1	-	-	-
Capability Building		**100.0**	**106.7**	**110.7**	**114.2**	**116.6**	**118.7**	-	-	-
Learning Institutions	-	100.0	101.0	101.7	102.2	103.4	103.1	-	-	-
Regulatory	-	100.0	100.6	98.3	100.3	100.8	103.4	-	-	-
Technology Flows	-	100.0	120.8	132.7	143.3	149.0	152.1	-	-	-
Enabling	-	100.0	100.1	100.9	100.9	101.7	104.0	-	-	-
Capacity Building		**100.0**	**105.8**	**108.5**	**111.5**	**113.3**	**115.2**	-	-	-
Acculturation	-	***100.0***	***105.3***	***108.8***	***110.8***	***112.6***	***114.4***	-	-	-

Source: Raw data from Reeds Micro Electronics, Telecommunications Industry; ITPD Mimos Berhad

Table2 : Population Dynamics by Labour Force and Education Status



Source:
Survey Data, LFS, 1998/1999
Statistics Pemburuhan & Sumber Manusia, 1994-1998
Perangkaan Penting, NITC Estimates
Note: M as Million

Table 3: Knowledge Development Imperatives By State

	Affordability, Connectivity, Interactivity and Content Indicators						Index of Disparity				
States	Mean Income (RM)	Residential Telephone Per 1000 people	Business Telephone Per 1000 people	Internet Per 1000 people	English Per 1000 people	Non-English Per 1000 people	Mean Income (RM)	Business Telephone Per 1000 people	Internet Per 1000 people	English Per 1000 people	Non-English Per 1000 people
	(1997)	(1997)	(1997)	(1997)	(1997)	(1997)	(1997)	(1997)	(2000)	(1997)	(1997)
Johor	2772	187.6	92.9	30.3	27.8	154.9	4.69	6.4	-12.7	-16.7	44.4
Kedah/ Perlis	1590	140.7	69.6	18.1	20.0	86.6	-28.9	-13.8	-29.6	-23.0	-28.2
Kelantan	1249	76.7	37.9	12.5	6.2	60.8	-38.59	-41.4	-37.3	-34.2	-55.6
Melaka	2276	186.3	92.2	28.6	51.2	147.1	-9.41	5.8	-15.1	2.2	36.1
Negeri Sembilan	2378	180.9	89.5	27.0	42.2	141.8	-6.51	3.5	-17.3	-5.1	30.5
Pahang	1632	127.2	63.0	18.0	19.6	104.9	-27.71	-19.6	-29.7	-23.3	-8.7
Perak	1940	185.4	91.7	27.3	39.6	106.0	-18.95	5.4	-16.8	-7.2	-7.5
Pulau Penang	3130	259.0	128.2	1.9	88.9	93.8	14.86	37.1	17.1	32.6	-20.5
Sabah	2057	80.8	40.0	16.6	5.4	61.6	-15.63	-39.5	-31.6	-34.8	-54.7
Sarawak	2242	110.3	54.6	21.5	29.6	72.1	-10.37	-26.9	-24.8	-15.3	-43.6
Selangor	4006	309.1	153.0	84.9	129.2	137.9	39.76	58.6	62.7	65.2	26.4
Trengganu	1497	102.9	50.9	17.1	9.1	82.5	31.54	-30.1	-30.9	-31.9	-32.5
W.P. K.L.	4768	239.8	118.7	103.9	136.3	253.1	61.41	28.8	88.9	70.9	148.7
Malaysia	2607	172.7	85.5	39.5	48.5	113.1					

Source: NITC Secretariat , 2001 (MIMOS Berhad)

Table 4: Distribution of Employed By Occupational Category

	Professional	Managerial / Administrative	**Knowledge Workers**	Clerical	Sales Workers	Service Workers	**Information Workers**	Production & Labourers	Agricultural
1983	7.0	2.4	**9.4**	9.5	9.6	10.9	**30.0**	29.8	30.8
1984	7.4	2.1	**9.5**	9.7	10.8	11.5	**32.0**	28.2	30.4
1985	7.5	2.3	**9.8**	9.8	11.1	11.4	**32.3**	27.5	30.4
1986	7.8	2.4	**10.2**	9.5	11.1	11.9	**32.5**	26.8	30.5
1987	7.6	2.0	**9.6**	9.5	11.9	11.8	**33.2**	26.5	30.8
1989	7.4	2.1	**9.5**	9.4	11.9	11.8	**33.1**	26.9	30.6
1990	7.5	2.0	**9.5**	9.5	11.4	11.4	**32.3**	29.3	28.9
1991	7.8	2.2	**10.0**	9.8	11.3	11.4	**32.5**	31.3	26.2
1992	8.3	2.7	**11.0**	10.4	10.8	11.2	**32.4**	34.6	22.0
1993	8.7	3.0	**11.7**	10.7	10.5	11.9	**33.1**	34.0	21.3
1994	9.9	3.2	**13.1**	10.9	10.9	11.1	**32.9**	33.9	20.1
1995	10.0	3.6	**13.6**	10.8	11.1	11.2	**33.1**	33.7	19.6
1996	9.9	3.2	**13.1**	10.9	10.9	11.1	**32.9**	33.9	20.1
1997	10.0	3.6	**13.6**	10.8	11.1	11.2	**33.1**	33.7	19.6
1998	10.5	3.8	**14.3**	11.2	10.7	11.5	**33.4**	34.5	17.7
1999	10.6	4.0	**14.6**	11.0	10.9	11.7	**33.6**	32.7	19.0

Source: Labour Force Survey Report, Department of Statistics & NITC Estimate

9. A WAY FORWARD

The foregoing briefly illustrates the parameters and imperatives required for the development of knowledge system in the information era. However, the challenge remains developing a full-fledged KIX Model for public policy consideration. Towards this, the paper suggests briefly a number of way forward initiatives, as follows:-

- Realign the present statistical system in the wake of information age developments by reviewing and updating the scope and coverage of industry, product, occupation and trade classification systems; incorporate information age concepts into the on-going national surveys; incepting web-based data collection and collation mechanism using Internet Service Provider (ISP) registration system; and Internet Service Provider database as an additional source of probability sampling frame;
- Incept new statistical studies pertaining to information age developments covering household, establishment and public sectors; developing new statistical models for information era; initiating new research on emerging issues such as Teleworking, Rise of Knowledge Worker, Lifelong learning, Sovereignty, Governance and Globalization in the Information Age;
- Strengthen the data collection and collation as well as key users institutional arrangement by forming appropriate working committees constituting central planning agencies and providing adequate resources in terms of allocation and manpower.

10. CONCLUSION

Conceptually, KIX is a unique socio-technology model based on the premise people is increasingly becoming an integral of contemporary information, communication, knowledge and entertainment system. Structurally, the model provides linkages between technology and societal domains, framework and statistical criteria for identifying and apportioning knowledge development variables. The model also provides methodology for developing composite and disparity measures. The composite measure appropriately aggregates attributes and variates of differing meaning, scale, magnitude and unit of measurement by defining logarithm of a variable as a measure of development level; while, index of disparity provides measure on state differential. Recognizing the emerging data need, the paper also proposes briefly a number of way forward strategies for public policy formulators and statistical community considerations.

References::

i) *Conference Proceedings – IT For Competitive Advantage: Opportunities For Development, September 17-20, 1990, Putra World Trade Centre, Kuala Lumpur, Malaysia: "Impact of Information Technology on Human Society and Options for Developing Countries" by Mohammad Azizur Rahman, Executive Chairman, Bangladesh Computer Council*

ii) *Using Information Technology – A Practical Introduction to Computers & Communications Brian K Williams, Stacy C Sawyer and Sarah E Hutchinson, 1995: Publisher Richard D Irwin Incorporated.*

iii) *Yearbook of World Electronics Data 1993 Vol. 2: America, Japan & Asia Pacific , Elsevier Advanced Technology*

iv) *Mathematics : A Concise History and Philosophy by W.S Anglin, Springer-Verlag*

v) *Knowledge Societies : Information Technology for Sustainable Development by Robin Mansell and Uta When for the United Nations Commission on Science and Technology for Development, Oxford University Press 1998*

vi) *Information Technology : Sink or Swim? The Australian Academy of Technological Sciences and Engineering, 1997*

vii) *Toward The Next Economics and Other Essays by Peter Drucker*

Jun,, 2000 Ver.Tokyo ISIÓ,
RRC