FUTURES OF GLOBAL INTERDEPENDENCE MODELING SYSTEM: INTEGRATED GLOBAL MODEL FOR SUSTAINABLE DEVELOPMENT

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Summary

The FUGI (Futures of Global Interdependence) global modeling system has been developed as a scientific policy simulation tool of providing global information to the human society and finding out possibilities of policy coordination among countries in order to achieve sustainable development of the global economy under the constraints of rapidly changing global environment.

The FUGI global model M200 classifies the world into 200 countries/regions where each national/regional model is globally interdependent through international trade, export/import prices, financial flows, ODA, private foreign direct investment, exchange rates, stock market prices and policy information etc. The FUGI global modeling system (**FGMS200**) has been used by United Nations UNCTAD Secretariat since 1998 for the projections of the global economy and policy simulations.

1. Introduction

In the 21st century it is expected that integrated progress of science, technology, and new economic development will be seen in the human society where consists of a globally interdependent complex system. The information technology innovation will give tremendous impacts on human life, culture and economic development. Historically speaking, human behaviors under the global economic, environmental and cultural changes imposed by the increasingly interdependent global human society are a rather new experience and challenge for the human society. On the other hand, it is also expected that the 21st century will be an age of terrorism and refugees. Under these circumstances, the **FUGI** (*Futures of Global Interdependence)* global modeling system seems likely to play a significant role in efforts to envisage the future of global interdependence and to provide global information on the economic development and environmental changes through alternative policy scenario simulations for the sustainable development.

Project FUGI was started in 1976 with the cooperation of three Japanese institutions, namely, the University of Tokyo, Osaka University and Soka University, under the sponsorship of the National Institute for Research Advancement in Tokyo. The original FUGI model consisted of three parts: a Global Input-Output Model (GIOM), a Global Resources Model (GRM), and a Global Economic Model (GEM), Types I, M15. Yoichi Kaya, Faculty of Engineering, the University of Tokyo, Yutaka Suzuki, Faculty of Engineering, Osaka University, and the author coordinated the designing of these models, respectively (Onishi 1977). Work in progress was reported at the IIASA global modeling symposium in 1977 and the years following. The first generation FUGI global economic model (Type I, M15) designed by the author was the development of the Multi-Nation Economic Model which was originally designed by the author in 1965 and applied the 15 countries in Asia for the purpose of projections of the Asian economy (Onishi 1965). Drawing on experiences with global modeling in the 1970s, the author developed a fourth-generation FUGI global economic model (Type IV, M62) that divided the world into 62 countries/regions and consisted of approximately 30,000 equations. It was first made public at a seminar on comparative simulations of global economic models held at Stanford University, June 25-26, 1981(Onishi 1981). The United Nations Secretariat, Department of International Economic and Social Affairs, Projections and Perspective Studies Branch for the purpose of long-term projections and policy simulations of the world economy soon afterward adopted this model for use. It was used from 1981 to 1991, when it was replaced by the new generation FUGI global model, Type VII, M80.

For the period 1985-86, a new generation of the FUGI global model was designed as a *global early warning system for displaced persons* (Onishi 1986, 1987, 1990) during the period 1990-95, the FUGI model 7.0 M80 was designed as an integrated global model for sustainable development (Onishi 1993, 1994a, 1994b, 1995). During the period 1991-1999, the author designed a significant new software system for global modeling. This expert software system, named as FGMS (FUGI Global Modeling System) using an IBM R/S 6000 workstation was researched and developed as a package for specific use in making computations for the FUGI global model 9.0 (Type IX) M200/80 (Onishi 1991,1993,1994a,1994b,1995,1998,1999,2001a) and M200 (0nishi,2000).

In 2000, this expert system has entered the new stage of **FGMS 200** using a personal computer (Windows 2000/xp) for running the FUGI global model 9.0, M200PC. This latest M200 model, consisting of more than 150,000 equations, classifies the world into 200 countries/regions so that the model can produce the forecast simulations of the sustainable global development with interdependent 200-national/regional developments (Onishi 2001b, 2001c, 2002a, 2002b, 2003c, 2003b, 2005). The global model simulation exercises using FGMS200 cover the baseline projection of the global economy, 2001-2020. The model can provide information not only on the baseline projections but also alternative policy scenario simulations.

2. Outline of FUGI Global Modeling System

2.1. Regional Classification

The FUGI global model 9.0 M200 divides the world into 200 countries and regions. For three major groupings there are (1) developed or advanced market economies (AME), (2) developing economies (DGE) and (3) economies in transition (EIT). The AME grouping contains the following sub-groupings; these are developed market countries including the developed Asia-Pacific, North America, 15 member countries of the EU and other Western Europe. The DGE grouping contains the following sub-groupings as Asia-Pacific (subdivided into East Asia, Southeast Asia, Southwest Asia and Pacific Islands); Middle East; Africa (subdivided into North Africa and Sub-Saharan Africa); Latin America & Caribbean; and Mediterranean. The EIT grouping includes two sub-groupings: (a) East Europe and (b) CIS, the former USSR. Ultimately, this global model divides the world as a whole into 200 countries/regions. Because all most of all developed market economies, developing economies and economies in transition are treated as country units, the model has the advantage of being able to analyze precise country-specific relationships within the framework of global interdependence. (see Table 1). We have designed seven global table formats such as CGM (above-mentioned regional classification), EU (for the European Commission), IMF (for IMF classification), UN (for the United Nations classification), UNCTAD (for UNCTAD classification), UNESCAP (for the United Nations ESCAP classification) and WB (for the World Bank classification). It is worth noting that a user of FGMS200 can easily make his own format, namely, G20 (G-20 countries groups) and CEPAL (UN Committee for Latin America).

Regions	No...	Code	Country name		Regions	No.	Code	Country name
Developed Market Economies						56	SLB	Solomon Islands
Asia-Pacific	1	JPN	Japan			57	TON	Tonga
	2	AUS	Australia			58	TUV	Tuvalu
	3	NZL	New Zealand			59	WSM	Western Samoa
North America	4	CAN	Canada			60	VUT	Vanuatu
	5	USA	United States		Middle East Asia	61	BHR	Bahrain
Western Europe	6	BEL	Belgium			62	IRN	Iran, I.R. of
	7	DNK	Denmark			63	IRQ	Iraq
	8	FRA	France			64	ISR	Israel
	9	DEU	Germany			65	JOR	Jordan
	10	GRC	Greece			66	KWT	Kuwait
	11	IRL	Ireland			67	LBN	Lebanon

	12	ITA	Italy			68	OMN	Oman
	13	LUX	Luxembourg			69	QAT	Qatar
	14	NLD	Netherlands			70	SAU	Saudi Arabia
	15	PRT	Portugal			71	SYR	Syrian Arab Rep
	16	ESP	Spain			72	ARE	United Arab Emirates
	17	GBR	United Kingdom			73	YEM	Yemen Rep
	18	AUT	Austria		North Africa	74	DZA	Algeria
	19	FIN	Finland			75	EGY	Egypt
	20	ISL	Iceland			76	LBY	Libya
	21	NOR	Norway			77	MAR	Morocco
	22	SWE	Sweden			78	TUN	Tunisia
	23	CHE	Switzerland		Sub-Saharan Africa	79	AGO	Angola
Developing Economies						80	BEN	Benin
Far East Asia	24	CHN	China: mainland			81	BWA	Botswana
	25	HKG	China: Hong Kong			82	HVO	Burkina Faso
	26	MAC	China: Macau			83	BDI	Burundi
	27	TWN	Taiwan(Province of china)			84	CMR	Cameroon
	28	KOR	Korea, Republic of			85	CPV	Cape Verde
	29	PRK	Korea, North			86	CAF	Central African Rep.
Southeast Asia	30	BRN	Brunei			87	TCD	Chad
	31	IDN	Indonesia			88	COM	Comoros
	32	MYS	Malaysia			89	COG	Congo
	33	PHL	Philippines			90	DJI	Djibouti
	34	SGP	Singapore			91	ERI	Eritrea
	35	THA	Thailand			92	GNQ	Equatorial Guinea
	36	KHM	Kampuchea Dem			93	ETH	Ethiopia
	37	LAO	Lao P. D. Rep			94	GAB	Gabon
	38	BUR	Myanmar (Burma)			95	GMB	Gambia, The
	39	VNM	Viet Nam			96	GHA	Ghana
South West Asia	40	AFG	Afghanistan			97	GIN	Guinea
	41	BGD	Bangladesh			98	GNB	Guinea Bissau
	42	BTN	Bhutan			99	CIV	Ivory Coast
	43	IND	India			100	KEN	Kenya
	44	MNG	Mongolia			101	LSO	Lesotho
	45	NPL	Nepal			102	LBR	Liberia
	46	PAK	Pakistan			103	MDG	Madagascar
	47	LKA	Sri Lanka			104	MWI	Malawi
Pacific Islands	48	FJI	Fiji			105	MLI	Mali
	49	PYF	French Polynesia			106	MRT	Mauritania
	50	GUM	Guam			107	MUS	Mauritius
	51	KIR	Kiribati, Rep. of			108	MOZ	Mozambique
	52	MDV	Maldives			109	NAM	Namibia
	53	NRU	Nauru			110	NER	Niger
	54	NCL	New Caledonia			111	NGA	Nigeria
	55	PNG	Papua New Guinea			112	REU	Reunion
Regions	No.	Code	Country name		Regions	No	Code	Country name
	113	RWA	Rwanda			158.	NIC	Nicaragua
	114	SHN	St. Helena			159	PAN	Panama
	115	STP	Sao Tome & Principe			160	PRY	Paraguay
	116	SEN	Senegal			161	PER	Peru
	117	SYC	Seychelles			162	PRI	Puerto Rico
	118	SLE	Sierra Leone			163	KNA	St. Kitts Nevis

	119	SOM	Somalia		164	LCA	St. Lucia
	120	ZAF	South Africa		165	SPM	St. Pierre Miquelon
	121	SDN	Sudan		166	VCT	St. Vincent
	122	SWZ	Swaziland		167	SUR	Suriname
	123	TZR	Tanzania		168	TTO	Trinidad and Tobago
	124	TGO	Togo		169	URY	Uruguay
	125	UGA	Uganda		170	VEN	Venezuela
	126	ZAR	Congo, Dem.Republic	Mediterranean	171	CYP	Cyprus
	127	ZMB	Zambia		172	MLT	Malta
	128	ZWE	Zimbabwe		173	TUR	Turkey
Latin America &	129	ARG	Argentina		174	BIH	Bosnia and Herzegovina
the Caribbean	130	ATG	Antigua and Barbuda		175	CRO	Croatia
	131	BHS	Bahamas The		176	SVN	Slovenia
	132	BRB	Barbados		177	MDN	TFYR Macedonia
	133	BLZ	Belize		178	SIM	Serbia/Montenegro
	134	BMU	Bermuda	*Economies in Transition*			
	135	BOL	Bolivia	Eastern Europe	179	ALB	Albania
	136	BRA	Brazil		180	BGR	Bulgaria
	137	CHL	Chile		181	CZE	Czech Republic
	138	COL	Colombia		182	HUN	Hungary
	139	CRI	Costa Rica		183	POL	Poland
	140	CUB	Cuba		184	ROM	Romania
	141	DMA	Dominica		185	SLO	Slovakia
	142	DOM	Dominican Republic	CIS	186	ARM	Armenia
	143	ECU	Ecuador		187	AZE	Azerbaijan
	144	SLV	El Salvador		188	BLS	Belarus
	146	GRD	Grenada		190	GEO	Georgia
	147	GLP	Guadeloupe		191	KAZ	Kazakhstan
	148	GTM	Guatemala		192	KYR	Kyrgyzstan
	150	GUY	Guyana		194	LTU	Lithuania
	151	HTI	Haiti		195	MOL	Republic of Moldova
	152	HND	Honduras		196	RUS	Russian Federation
	153	JAM	Jamaica		197	TJK	Tajikistan
	154	MTQ	Martinique		198	TKM	Turkmenistan
	155	MEX	Mexico		199	UKR	Ukraine
	156	MSR	Montserrat		200	UZB	Uzbekistan
	157	ANT	Netherlands Antilles				

Table1: Regional classification of FUGI global modeling system (FGMS200)

2.2. Scientific Design Concept of the Global Modeling System

The *scientific integrated economics* design concept of FUGI global modeling system has been influenced by the recent advancement of life science, biotechnology and information technology. The keywords are given below. (1) *Lifeinformatic economics* coupled with life science, information technology and economics. (2) *Global dynamic cooperation and policy coordination* among the countries, (3) *Self-organization* in accordance with changing environment, (4) *automatic error correction system*, (5) *Brain physiology* economics in collaboration with right and left brain, (6) *Fluctuation* *phenomenon (yuragi* in Japanese*)* considering alternative composite policy scenario projections under *uncertainty* world and (7) *Global early warning* system for geographical and global risks. It is worth noting that quick policy prescription and coordinated policy actions might be feasible through early recognition on possible global risks, since FUGI global modeling system will be able to provide up-to-date global information on *alternative futures* within very much limited time span. Econometrics has thus come forward as a powerful tool that radically supersedes former theoretical models based on abstract logical methodologies. Of course, the appropriately estimated structural parameters using long-term time series data will have a fairly high degree of stability over time, but econometric models nevertheless face the dilemma that certain degree of their structural environments are indeed changeable, thus posing a problem of *fluctuation* in forecasting. Indeed, this type of *fluctuation* phenomenon seen in *life phenomena* always threatens forecasts of the future using econometric methods.

In a similar way, the appearance of complex and interrelated global issues such as environment, energy, development, peace and security, human rights and displaced persons, and so on, has posed problems whose solution is quite impossible within the traditional frameworks of economics. Integrated life-supporting systems require a new methodology of *Lifeinformatic economics* (life science + information technology + economics) beyond econometrics (economics + statistics). At the same time, there is increasing need for a new system design methodology on fuzzy systems that can manipulate *soft* variables that are not so easily quantified.

These facts help explain why, since the early 1970s, research was begun on the design of *integrated global models*. There has come into use an integrated global modeling which supplements this weak point in econometric models. Known as System Dynamics or SD for short, it is the method used in the World System Dynamics Model developed by Jay Forrester, who gained rapid recognition for discussions of the model in the *Limits to Growth* report to the Club of Rome prepared by Dennis Meadows et al. The most distinguishing point about the SD method is it's seeing reality in terms of dynamic (i.e. active and continually developing) structures for systems. Systems used in such models have a number of variables, which govern the ways in which change *pattern recognition* methods take place in the past, present, and future.

It is a fact that SD methods are the object of various types of criticism; in particular, by econometric methods. Econometrics methods have achieved qualitative improvements through the advancement of information technology. Thus, *IT economics* (Information technology + economics) has appeared as seen in *the FUGI global modeling system.* In any case, the main distinguishing feature of econometric models is the fact that the models' structural parameters are inferred from real statistical data by stochastic methods. Compared with econometric methodology, the structural parameters used in SD models are not necessarily as appropriate, especially in the case of Forrester's world model, since his model seems to be too "deterministic," neglecting stochastic natures of the systems. Consequently, criticisms are often voiced alleging that with the relatively rough parameters used in SD models, forecasts about the future must therefore have a low credibility. *SD seems likely to be an outgrowth of old-fashioned Newtonian dynamics systems* that are too deterministic to allow for stochastic fluctuations of systems. Furthermore, Forrester's world model does not classify the world into regions or country groups, so it cannot discuss global interdependence as North-South issues.

However, it is difficult to assert that these are fundamental faults in the SD method. This method's most outstanding characteristic lies in its comprehensive, *intuitive pattern recognition* of social and economic phenomena as being a complicated loop of cause-and-effect relationships. In this process, there is the problem of how to estimate stochastic structural parameters as intermediaries in determining the cause-and-effect links among the variables. In spite of these serious defects of not regarding stochastic phenomenon, the SD method, which can easily accommodate a nonlinear fuzzy system, may be said to be relatively versatile in comparison with the econometric method. Of course this is not to say that an econometric model is incapable of handling a nonlinear fuzzy system. But it cannot be denied that the econometric method is less flexible than the SD modeling method when we include non-economic and non-quantifiable *soft variables* such as terrorism, peace and human rights.

We are now faced with the task of deepening our understanding of the various methodologies and creating a new approach that includes the best features of all of them. The author should like to call such an approach, which will ideally exercise both the left and the right hemispheres of the human brain, a stochastic and fuzzy "*dynamic soft systems analysis*" (DSSA), using human-intelligence oriented modeling. For purposes of making simulations of the future global economy it is necessary to quantify reality and make analyses by means of computer-aided modeling; yet there is at the same time a need to make qualitative analyses, i.e. scenario analyses because the future should have certain *fluctuation phenomena* to be called by biotechnology and life science within the range of optimistic or pessimistic futures in accordance with human behaviors. To gain a grasp of not just a part of economic reality but of its whole, a method of *systems engineering* is indispensable. The *dynamic soft systems analysis* (DSSA) is indispensable for the analysis of a world in which the whole of socioeconomic and environmental reality is constantly changing and developing over time. DSSA is an attempt to offer practical prescriptions by which we can respond to the "*crisis problematiques*" facing humankind, as Aurelio Peccei, founder of the Club of Rome, suggested. The prescriptions derived from a model of interdependent dynamic system structures, patterned after the real world and subjected to human-intelligence-oriented modeling, in turn allow us to elaborate probable or possible pictures of our world in the future, depending on various possible "*scenarios*" and "*policy exercises*."

Stimulated by our joint research with the United Nations University on a "*global early warning system for displaced persons*" (1986d), we have felt the need for our FUGI model to go beyond its present capacities centered on an econometric model in the rather traditional, restricted sense of the term. We have therefore developed an integrated global model for sustainable development that can make future simulations of "global problematiques" or "global complexes of symptoms," including various types of environmental problems and the displaced persons issue (1987, 1995b, 2003a, 2003b). See Onishi A. (2003b) FUGI global model for early warning of forced migration (http://www.forcedmigration.org) Forced Migration Online, Refugee Studies Centre, University of Oxford. The FUGI global model is presently being expanded in scope to deal with such issues by using *Lifeinformatic economics*.

The latest FUGI model 9.0 M200 treats almost all countries, regardless of how large or small, as having the possibility of being dealt with as country units. It is designed to be a comprehensive system model that can not only deal with economic problems but also incorporate subsystems to take account of environmental issues, population, energy, food, indicators of quality of life, as well as issues concerning human rights, peace, and security. Although our methodology is first and foremost based on various country or regional studies, we have felt it desirable, using these country or regional studies as a base, to adopt an orientation that further gives consideration to a highly sophisticated global modeling system.

The "*dynamic soft systems analysis*", derived from Lifeinformatic economics, reflects the astounding development of information technology, particularly in the field of computers during the 1970s, 1980s, and 1990s. Extraordinarily sophisticated handling of information has become possible. In this regard, too, the software which computers use, that is to say utilization techniques, have made notable strides toward what we might call *economic systems engineering.*

This approach is supported not only by the so-called soft sciences but also by developments in a number of interrelated fields of the frontier human sciences. For example, our understanding of the human brain has greatly advanced through developments in *brain physiology*. As a result, it is seen that the right brain perceives images of reality, while the left brain analyzes these in logical and conceptual ways and constructs logical models. As a part of its own division of labor, the brain's central ridge facilitates high-level flows or exchanges of information between the left and right hemispheres. Through a skillful treatment of the organically linked functions of the left and right brains, one can develop a soft system model. In a similar way, what we have tried to develop for our present purpose is not a model that merely collects information but a model that skillfully collects information, analyzes it, and provides a sophisticated global information system based upon *economics of brain physiology.*

The developments in life sciences are making ever clearer the conceitedness between individual cells of the human body and the human body as a whole organic entity. Individual cells contain information pertaining to the entire body. Thus, at times of special stress, the individual cells invoke a regulatory mechanism by which they pool their forces, working together in the face of difficulties. This is an extraordinarily important capacity, which living things possess, and we in fact need to incorporate just this sort of capacity into any global modeling system to prevent or mitigate, through international cooperation, undesirable phenomena in the global human society.

It is worth noting that first-generation modern economics is based upon *Newtonian dynamics and Darwinism*. Second-generation economics is *econometrics*, which has been greatly developed through progress with particle physics, stochastic statistics and economic modeling. The third generation might be called the dynamic integrated systems analysis or *Lifeinformatic economics*, reflecting progress in life sciences, biotechnology, ecology, and soft systems science and information technology.

In the twenty-first century, we may expect that economic models will come to have much *softer* dynamic systems. The information revolution, often known as the *third wave*, has had a great impact on the field of economic research, and through the extraordinary progress being made with computer hardware and software systems, great changes are being made in the traditional methods of economic research. With the advent of large-scale capabilities for data processing by personal computers, FUGI global modeling system has become accessible to economists, and as a result we look forward to greatly improved capacities for research on economic theory and economic policies. The making of policy proposals and the building of theoretical economic models, formerly dependent on professional economists with rich experience, sharp intuition, and outstanding capacities for judgment and analysis, can now, through intelligent expert systems, be achieved to a large extent by ordinary researchers. Consequently, *FUGI global modeling system for sustainable development as Lifeinformatic economics is about to enter an age of global interdependence when it can justly claim pride of place as a science of economics.*

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Biographical Sketches

Akira ONISHI, born in 1929, is Director, Centre for Global Modeling, professor emeritus, former vice president, Soka University, economics and global modeling educator. His academic background is both economics and systems engineering. He got Ph.D. in Economics from Keio University and Ph.D. in Engineering from Tokyo Institute of Technology. He had an opportunity to work at the United Nations ESCAP and the ILO, 1966-70. Then he has served at Soka University, Tokyo. Dean, Department of Economics, 1976-91. Dean, Graduate School of Economics, 1976-1991. Director, Soka University Institute for Systems Science (SUISS), 1990- 2001. Dean, Faculty of Engineering, 1991-95. Dean, Graduate School of Engineering, 1995-99. Vice President, 1989-2001.Visiting professor, Westminster Business School, 2002. He served as President of Japan Association of Simulation and Gaming, 1993-97. He received many academic awards. The International Biographical Roll of Honor to the Global Modeling Profession from American Biographical Institute, USA, 1989. The first Supreme Article Award from the Japanese Association of Administration and planning, 1991. The 20th Century Award for Achievement from the International Bibliographic Centre, Cambridge, England to Global Modeling, 1993. The Excellent Article Award from ECAAR, 1997. The Japan Assn. Simulation and Gaming Award, 1998. 2000 Outstanding Intellectuals of the 20th Grand from the IBC, 1999. He was selected as First Five Hundred in 2000 for the service to Economics by the IBC. He has made a great contribution to global modeling through numerous articles and conferences. He is well known as an original designer of **FUGI** (*Futures of Global Interdependence)* global model. The United Nations Secretariat, Department of International Economic and Social Affairs adopted this model for the long-term projections and policy simulations of the world economy from 1981-1991. During the period, 1985-86, he designed the Global Early Warning Systems for Displaced Persons (GEWS) under the auspices by the United Nations Independent Committee of Human Rights. See Onishi A. (2003b) *FUGI global model for early warning of forced migration* (http://www.forcedmigration.org) Forced Migration Online, Refugee Studies Centre, University of Oxford.

The UNCTAD Secretariat has officially adopted the FUGI global model for the projections of the world economy and policy scenario simulations since 2000. He has served as an honorable theme editor of Integrated Global Models of Sustainable Development in Encyclopedia: EOLSS, UNESCO.

Masahiro ONISHI, born in 1976, is a son of Akira ONISHI and research fellow of The University of Tokyo, Faculty of Engineering. He got Ph.D. in Media and Governance from Keio University, Shonan Fujisawa Campus. Kanagawa-ken , Japan. He is interested in designing innovative electric vehicles, in particular, to reduce global warming gas and the sustainable development of the global economy. He has collaborated with the UNESCO-EOLSS project by assisting his father in his work as an Honorary Theme Editor.

It is worth noting that Japan is widely known in the field of pioneering research and development of electric vehicles. By the middle of the 21st century, it is reasonably expected that electric vehicles, including hybrid cars, will replace the present internal combustion engine vehicles. He is working for not only designing innovative electric vehicles, but also developing driver assist systems, in particular, for elderly persons. In the developed countries, it is seen that aging society has already come to a considerable size. This is why he has made greater efforts to design innovative vehicles for safety of human life in the sustainable development of our global society.