

# Dynamic Process Model of Social Capacity Development for Environmental Management

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## Abstract

Based on the social capacity for environmental management (SCEM) framework, we propose a dynamic process model of SCEM by integrating the three stages of SCEM development, i.e., 1) system making, 2) system working and 3) self-management. The integration is carried out based on government activities. For the system to start, a perturbation is assumed to initiate the system of relationships between environmental actors (government, firms and citizens). The data is compiled from Geo Data Internet portal maintained under United Nations Environment Programme. To estimate the model parameters we have used structural equations with latent variables. Behaviors of SCEM actors at different stages are assumed to be theoretical constructs (latent variable) based on different observed variables that characterize the SCEM stages.

**Key Words:** indicator, development stage, social capacity development process, structural equation model

## 1. Introduction

Environmental management is a process that entails (i) the recognition of the environmental problems; (ii) emergence of public awareness and political commitment to address environmental problems; (iii) formulation of environmental problems; (iv) envision of policies in regulations and legislation and; (v) implementation and enforcement of policies (Lovei and Weiss, 1998). Besides it is a complicated process resulting from the complexity of the environmental problems, because most of the problems are closely related to each other and solution of one problem might induce another problem. Because of this,

environmental management requires a concerted effort in order to achieve improved environmental quality.

In this regard, a necessary but not sufficient condition for controlling environmental problems is the social capacity to locate and/or recognize them, and then to take necessary steps for perpetual environmental management. Social capacity is defined as “society’s ability to identify and solve environmental problems” (OECD, 1994). Agenda 21<sup>1</sup> states that “a country’s ability to develop more sustainably depends on the capacity of its people and institutions to understand complex environment and development issues so that they can make the right development choices”<sup>2</sup>. Thus, concepts such as capacity development and/or capacity building<sup>3</sup> have been introduced to support sustainable development<sup>4</sup> without environmental degradation.

Capacity building is the process of establishing or improving human, scientific, technological, organizational, and institutional and resource capabilities of a country (Sen, 1993). The goal is to enhance the ability to evaluate and address the crucial questions related to policy choices and modes of implementation among development options, based on an understanding of environment potentials and limits and of needs perceived by the people of the country concerned (Sen, 1993).

From the perspective of international development, capacity development refers to institutional development, which covers a broad range from individual organizations and institutions to groups of organizations as well as inter-organizational networks (Qualman and Morgan, 1996). Capacity development addresses complex, multi-faceted problems, such as those related to the environment. Thus, it requires the participation of various actors, organizations as well as new institutions. Indeed, the development of institutional capacity and the development of capacity in the society as a whole are both essential ingredients to sustainable development. The ultimate impacts of capacity development are macro-level changes in society and the economy: a broad area ranging from education to economy as well as to the societal and spatial organization in a country. In general, this might be coined as a new paradigm of development for nations.

Two important tasks that supports capacity development at all stages of development are the development of indicators and modeling of the capacity development process. The first task, development and use of indicators becomes important when determining the key problem areas, and gauging progress and focus with respect to the attainment of sustainable development by improving (poor) performance that is easily visualized by good indicators; moreover they also serve as tools for “learning for sustainability” and “sustainable livelihood” strategies (Bell and Morse, 1999, 2001). The second task, modeling of capacity development directly refers to defining a process within the framework of sustainable development and it is crucial in attaining the global objectives in acceptable margins and time frames. As Arrow et al. (1995) note: development of institutions is, *inter alia*, closely related to understanding ecosystem dynamics and to appropriate indicators of ecosystem change.

The importance of capacity increases when we deal with the environmental problems that the world might face in the future<sup>5</sup>. Because in the next 50 years or so, the population of the world in the beginning of the new millennium is expected to increase approximately by 50 percent<sup>6</sup> and almost all of the population increase is expected to occur in developing countries<sup>7</sup> (UN, 2004). Moreover, almost of all of the urbanization and most of the new industrialization is expected to occur in these countries (UN, 2004). Already the urban areas flooded with newcomers in the developing world lack many basic services ranging from clean water supply to unpaved streets. These initial conditions are termed as poverty related issues by Bai and Imura (2000)<sup>8</sup>. As economical facilities especially industrial production burgeons,

these poverty related issues decreases. But in turn, environmental problems from rapid industrial growth increase.

At the early stages of economic development, the ability of developing countries to address environmental problems and respond to concerns about environment is restricted. Because a developing country, given its priority to economic development, generally places low value on pollution control. Besides institutions of these countries do not have a good correspondence with the established rules for environmental control and management. Besides, the social and physical infrastructure to institute the environmental problems in these countries is on most of the instances insufficient<sup>9</sup>. But once a country gains a sufficient degree of affluence, this in turn might support and improve the social and the physical infrastructures, which underlie institutional change environmental management. If this gained affluence (or income effect) is strong enough, it might cause some environmental problems to decline. For example, for certain pollutants such as sulfur oxides, suspended particulates mainly released from point sources, course of development looks like an inverted U curve named as the Environmental Kuznets Curve (EKC).

But economic development is not at all a panacea for environmental quality (Arrow et al., 1995); in environmental management, what is important is the array of inputs and outputs and their relation to the nature as well as to each other (Costanza and Patten, 1995). Additionally, for developing countries, it might be the case that when critical (or maximum) turning points on the EKC are added up, the result might be well above the carrying capacity of the earth. In other words, for environmental protection or rehabilitation, the decrease with respect to past conditions is not as important as the decrease in absolute numbers with respect to the environmental carrying capacity.

Besides, types of pollution that do not follow EKC, non-EKC pollution stays as a serious problem for the whole world (e.g., green house gases, see Firor, 1990). Bai and Imura (2000) characterize this as Type III pollution, which is more difficult to abate. One primary cause of this might be the dependence of the energy production mainly on carbon related materials (coal, fuel oil, etc.); carbon consumption inevitably produces CO<sub>2</sub> causing global warming by trapping the sunlight reflected from the earth. High income economies are the largest contributor to CO<sub>2</sub> emissions in absolute terms. Recognizing this, policies and instruments for the reduction of CO<sub>2</sub> emissions were instituted in several advanced industrial countries (e.g., Clean Air Act Amendments in USA,) or discussed publicly<sup>10</sup>, but decline of CO<sub>2</sub> emissions in these countries does not show much significance<sup>11</sup> up to now. CO<sub>2</sub> emissions in low income countries have been growing at more rapid rates than those of the advanced economies<sup>12</sup> Their share will continue to increase with greater industrialization and more energy use per capita, which would accompany economic growth.

One solution is the social capacity development for environmental management (SCEM) proposed for the developing countries (Matsuoka et al. 2004), which aims to decouple the economic development and the environmental quality. According to Matsuoka et al. (2004), SCEM is the capacity to manage environmental problems in an interactive social system composed of three main social actors- government, firms and citizens, and their interrelationships. Based on extensive reviews about previous research, Zhang et al. (2005) re-defined SCEM as the capacity that the whole society, composed of three social actors: government, firms and civil society, makes use of available capital assets (including natural capital, physical capital, financial capital, human capital, and social capital) to deal with environmental problems toward sustainable states through the learning process under the influence of actors' co-existence, inter-actor interactions and future uncertainty. SCEM is a dynamic process and consist of three

consecutive stages that are i.) system making, ii.) system working and iii.) self-management. Although their integrity in terms of successive proceeding is noted, proceeding of these three stages has not been integrated yet. In this study, we incorporate these three stages into a dynamic process model for social capacity development in environmental management, which logically integrates these three stages.

This study consists of four sections. In section two, we review SCEM. In section three, dynamic process model and structural equations with latent variables are briefly explained along with the data set. In this section, we also present parameter estimates of the structural equations. Section four concludes the study.

## **2. Social Capacity Development for Environmental Management**

In Matsuoka et al. (2004), social capacity development for environmental management (SCEM) is assumed to consist of three temporally ordered constituent stages: system making stage, system working and self-management stages. Although the three actors- government, citizens and firms, are same at each stage, behaviors of these actors change structurally and significantly, besides their interrelationships get complex and interactive in time. Before proceeding to explain individual SCEM stages, we shall explain the environmental actors in brief.

### **2.1. Environmental actors in SCEM**

The basic function of the government is to establish and maintain institutions and governmental organizations for environmental management. Government carries out these by its administrative and judicial units, in ways that are derived from different decision-making systems<sup>13</sup>.

Citizens are simply individuals or groups of individuals trying to achieve the most desired environmental conditions. Citizens and citizen groups can be effective in environmental issues up to the point that they are aware of the problems that they face, and awareness of the environmental problems can be kept fresh by using the information either supplied by other actors or collected by their own efforts. At least, to collect information by themselves citizens have to have proper rights to acquire information; but more importantly even the institutions exist, getting and using (environmental) information requires human capacity that is improved by ways of education and/or affluence<sup>14</sup>.

Citizen groups such as NGOs might be activist organizations aimed at protecting the environment or consist of specialists carrying out policy analyses and researches on environmental friendly technologies. There are several ways that citizens might affect the government decision making: one might be via public hearing, which is the basic instrument for the governments in order to have the opinions of the citizens before carrying out a major change in environmental legislation or undertaking projects that might affect the environment; the other way of citizen participation into governmental decision making processes might be through technical advisory committees that help political pressures decrease in time: the cases of pollution reduction programs started in Ube city (see Tanimoto, 1960) fits to this schema.

Firms constitute the organizations that produce goods and services. In most of the instances firms pollute environment as a result of their production and other facilities. During system making stage, it is assumed that firms are polluting the environment significantly, but environmental pollution after reaching a maximum state begins to decrease during system working and self-management stages.

## 2.2. System making stage

The first stage, system making stage is initiated by institutionalizing the environmental management system. This initiation is assumed to be a result of newly increased public concern on environmental issues and taken by the government actor.

The basic tenet of system making stage is to establish the institutional and administrative framework needed for environmental management. Institutions are the collection of both of the informal (norms, customs, etc.) and formal rules (basic laws, statutes, property rights, contracts, etc.) of actions and interactions. In a repeated game, institutions as information sources constitute the logical foundations of cooperative actions. To state this from the reverse, incomplete information requires institutions to police the deviations from the desired or expected moves (North, 1990). History of development of institutions suggests that they are path dependent, and their developments are evolutionary rather than revolutionary (North, 1990). For institutions to be effective, administrations are needed in order to carry out or facilitate them.

Historical evidence shows that institutional and administrative framework might not be exhaustive or comprehensive but rather be sporadic and immature. In SCEM framework, it is expected that in the later stages, institutions improve with the help of cooperative inputs from both citizens and firms, once the system works properly.

During system making stage, in general, institutional approach to the environmental problems stays as sporadic judicial activities, and earlier developments are generally designed as add-ons to the existing administrative system (see Honda (2003) for developments in various East Asian countries). Instead of comprehensive institutions for an integrated environmental management system, institutions are set up in order to meet the public concerns in most of the instances. Historically, public awareness to the environmental problems have emerged not as a result of the whole environmental problems, but rather as a result of a small set of specific problems mainly caused by industrial production<sup>15</sup>.

In general, system making stage is characterized with the command-and-control, which have to evolve or change into market based policies in the later stages.

## 2.3. System working stage

During system working stage, environmental management system seeks a new equilibrium induced by the new institutional change emerged in the system making stage. Both citizens and firms get more active at this stage because of the new institutions and organizations; thus, the relations between actors get intensified.

This stage is characterized with the comprehensive environmental policy making and involvement of the stakeholders other than government- firms and citizens in decision-making processes. Thus, at this stage, the sporadic jurisdictional activities are combined under general laws and existing environmental agencies if scattered are combined to constitute a ministry which enhances the scope of environmental protection.

At this stage, the type II environmental pollution (Bai and Imura, 2000) follows an EKC curve due to the decrease of industrial pollution either at smokestacks or at end-of-pipes. The main hypothesis of EKC is that emission of a certain class of pollutants [related to industrial production mainly such as SO<sub>2</sub>] firstly increases with production because of scale effects, but later on, emissions decreases as income per capita passes certain threshold. This threshold might be due to a shift in the composition of production (from manufacturing to services), or a change in techniques used to eliminate pollutants, or to a techno-

logical change in the production processes. Especially, the latter two changes generally occur with the adoption of the new policies. If we assume that the environmental quality is a normal good supplied by the government, then higher income levels increase demand for better environment; this points to new environmental policies by the government. However, at this stage the demand for environmental quality cannot be kept high unless the public is evoked by the new findings by non-governmental agencies or groups of scientists (some global examples are Greenpeace, World Wildlife Fund, Union of Concerned Scientists).

At initial stages of economic development, the increasing scale of economic activity as well as the changing composition of production from agricultural towards industrial activities generates more pollution. Therefore at these stages of economic development, environmental problems increase. However, as income rises, demand for environmental quality increases and more stringent environmental regulation leads to the replacement of old industrial production technologies by environmentally less harmful ones. With economic development, economies change structurally from industrial production to postindustrial economic activities, this puts downward pressure on environmental problems caused by industrial production. Eventually, as income per capita passes some threshold level, income and composition effects outweigh the scale effect and the income-environment relationship becomes downward sloping.

#### **2.4. Self-management stage**

Lastly, the system supposed to reach a new partial equilibrium during the self-management stage that requires cyclic interactions between actors. At this stage, society is supposed to define environmental problems it faces and produce relevant solutions by the synergy and the well-established information channels between environmental actors in the new institutional environment.

In Japan, in early 1980s when minister responsible for environment has declared his formal opposition to antipollution measures, he faced strong opposition from the public and local governments as well as trading partners and had to change his position and reconfirm his commitment to the environmental protection (Lovei and Weiss, 1998). This event marks a typical functioning of policing deviations from societal commitments already put in place. All of the actors at this stage have an effect on the functioning of the other actors. While democratic institutions allow citizens and firms to lobby their priorities to the government, firms also find ways to affect citizens (or consumers) by adopting voluntary programs in environmental management. The same is also true for the relationships between firms and government. Government can use incentives to get the firms adopt environmental friendly ways. ISO 14000 series, British Standards 5750 and 7750, EMAS<sup>16</sup> are examples of voluntary environmental management schemas that can be applied by firms. By eco-labeling, this is well advertised in order to attract customers who are willing-to-pay higher prices for environmentally friendly products<sup>17</sup>.

### **3. Dynamic Process Model**

An essential hypothesis of the SCEM proposed by Matsuoka et al. (2004) is that it is temporally sequenced in stages, i.e., system making, system working and self-management. Although sequence is rightfully addressed, transition from one stage to another has not been studied explicitly. In the current model, we propose linking these three stages by meaningful transition linkages that are in compliance with the development and welfare theory<sup>18</sup>. In this regard, SCEM can be expressed as the building block of a generic process model. In this process model, we approach government as a key catalyst. Because,

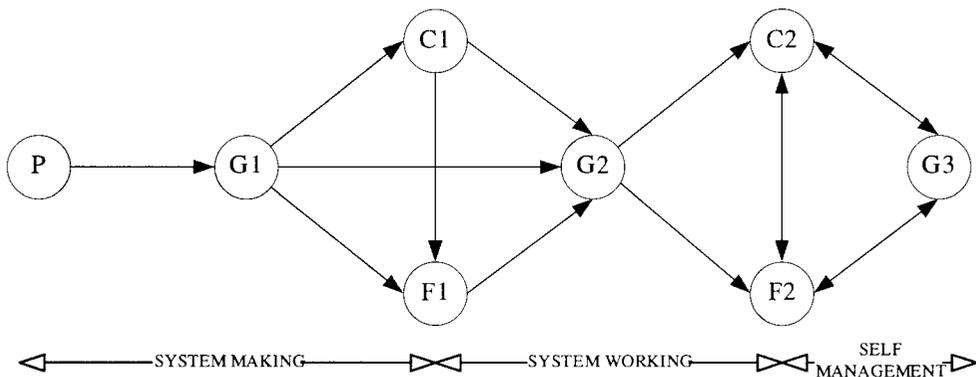
to establish formal institutions and make them workable mostly requires (at least) governmental mechanisms such as legislation, administration and its relations to other actors.

Figure 1 shows the model structure, which is inked by government at different stages. In the early stages we assume that government enforces itself ( $G1 \rightarrow G2$ ) with the introduction of new legislation and unification of environmental policies under ministerial organization. However note that although this is a necessary condition for a comprehensive environmental management and it is not a sufficient condition, hence inputs from actors are needed. In the last stage, government which is put in the middle of the relations previously allows smooth or evolutionary institutional change by affecting with other actors ( $G2 \rightarrow C2$  and  $G2 \rightarrow F2$ ).

In the model, we assume that chain of reactions are started with a perturbation given to the government; with this perturbation, system making stage starts by establishing relevant formal institutions, the effects of which should be observed during the system making stage.

During system working stage, we assume that the economy develops and income per capita, thus well being of citizens improves with the proceedings of the stages from left to right in Figure 1. To keep the well being or quality of life at least non-decreasing in time, citizens begin to exert pressure on the private sector (firms) to comply with the standards needed to maintain or improve their environmental performance. In response, private sector has to balance this pressure in order to maintain the material well being of themselves. Besides, private sector is subject to more pressure from government as involvement in international treaties indicates determination in improving environmental quality, which is assumed to affect the environmental performance of the private sector.

During self-management, all actors become active in affecting one another and the system works in two-way relationships. We name the model as DPM-SCEM (Dynamic Process Model for Social Capacity Development for Environmental Management). In summary, DPM-SCEM model uses the framework for multi-stage development of SCEM; using government as the catalyst for proceeding from one stage to another, DPM-SCEM extends SCEM modeling. By using relevant data available, the DPM-SCEM model is estimated by using the structural equations model (SEM) with latent variables. The next section gives a brief introduction to SEM with latent variables.



**Figure 1.** Dynamic process model (P: Perturbation, G: Government, C: Citizens, F=Firms).

### 3.1. Structural equation modeling with latent variables

SEM with latent variables consists of two constituent models: the structural and measurement models (see Bollen, 1989). In the model, structural model captures the relationships between latent variables, and measurement model relates latent variables to observed variables.

Consistent with the LISREL model (see Jöreskog and Sörbom, 1993), let the structural model can be expressed as

$$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

where

$\eta$  is a  $m \times 1$  vector of latent endogenous variables,

$\xi$  is a  $n \times 1$  vector of latent exogenous variables,

$B$  is a  $m \times m$  matrix of coefficients,

$\Gamma$  is a  $m \times n$  matrix of coefficients, and

$\zeta$  is a  $m \times 1$  vector of random errors.

The measurement models take forms as follows respectively:

$$y = \Lambda_y \eta + \varepsilon \quad (2)$$

$$x = \Lambda_x \xi + \delta \quad (3)$$

where

$y$  is a  $p \times 1$  vector of observed endogenous variables,

$x$  is a  $q \times 1$  vector of observed exogenous variables,

$\Lambda_y$  is a  $p \times m$  matrix of coefficients,

$\Lambda_x$  is a  $q \times n$  matrix of coefficients,

$\varepsilon$  is a  $p \times 1$  vector of random errors, and

$\delta$  is a  $q \times 1$  vector of random errors.

The stochastic errors of the above model are assumed to satisfy the following conditions:

1.  $\varepsilon$  is uncorrelated with  $\eta$ ,
2.  $\delta$  is uncorrelated with  $\xi$ ,
3.  $\zeta$  is uncorrelated with  $\xi$ , and
4.  $\varepsilon$ ,  $\delta$  and  $\zeta$  are mutually uncorrelated.

The covariance matrices of  $\xi$ ,  $\zeta$ ,  $\varepsilon$  and  $\delta$  are denoted by, respectively,  $\Phi$  ( $n \times n$ ),  $\Psi$  ( $m \times m$ ),  $\Theta_\varepsilon$  ( $p \times p$ ) and  $\Theta_\delta$  ( $q \times q$ ).

The above system of equations is estimated by a maximum likelihood where unknown model coefficients are determined by equating the observed covariance matrix of  $y$  and  $x$ , and the covariance matrix of these variables implied by the model (see Bollen, 1989), i.e., by letting

$$\Sigma = \Sigma(\Theta) \quad (4)$$

The covariance matrix on the left hand side is the sample covariance matrix; the one on the right hand side is the model-derived covariance matrix that is obtained by applying expectation operator on the

equation system above. Namely, by expressing  $y$  and  $x$  using equations then the model-derived covariance matrix is as follows:

$$\begin{aligned} \Sigma &= \begin{pmatrix} Var(y) & Cov(y,x) \\ Cov(x,y) & Var(x) \end{pmatrix} \\ &= \begin{pmatrix} \Lambda_y A (\Gamma \Phi \Gamma' + \Psi) A' \Lambda_y' + \Theta_\epsilon & \Lambda_y A \Gamma \Phi \Lambda_x' \\ \Lambda_x \Phi \Gamma' A' \Lambda_y' & \Lambda_x \Phi \Lambda_x' + \Theta_\delta \end{pmatrix} \end{aligned} \quad (5)$$

where  $A = (I - B)^{-1}$

The maximum likelihood method is applied to achieve the equality in equation (6) with the assumption that  $y$  and  $x$  have a multivariate normal distribution and consequently the variance-covariance have a Wishart Distribution. By replacing sample covariance  $S$  with population covariance  $\Sigma$  in Equation 4, maximization of the logarithm likelihood function (see Bollen, 1989, pp.131-135) is equivalent to the minimization of the following function:

$$F_{ML} = \log |\Sigma(\Theta)| + tr(S \Sigma^{-1}(\Theta)) - \log |S| + (p + q) \quad (6)$$

where  $S$  is the sample covariance matrix.

### 3.2. The data

We have used data items from the United Nations Geo Data portal<sup>19</sup> where data has been compiled from various global organizations. In the model estimation, the variables selected to represent different stages are assumed to be good indicators of what have been intended in the general DPM-SCEM model. Besides, the model has been estimated on aggregated values over years for individual countries, e.g., mean values, maximum values, etc., and in the model estimation, we do not keep the basic assumption that temporally sequenced stages strictly follows temporal ordering of the observed variables. This is because, as ratification of international treaties have been utilized to stand for government activities in the system making stage, international treaties on environmental protection starts from early 1970s (1971, Ramsar Convention on Wetlands) to the end of the 1990s (1997, Kyoto Protocol), but rather we keep a logical tract of changes that are assumed to be associated with the proceeding of the SCEM framework.

The perturbation needed to make governments be included in the international treaties concerning environment are assumed to be collected under three groups of variables- economic variables, environmental conditions and disasters. The variables that refer to the structure of the economy are assumed to be trade that is the sum of imports and exports, share of manufacturing and services in GDP. Environmental conditions are characterized by the emissions of CO<sub>2</sub> (from manufacturing and construction activities) and SO<sub>2</sub>, both of these emissions are computed as per value added in manufacturing. The third group of perturbation variables are collected under disasters, all of the variables refer to the affected people of disasters the cause of which might be the global or local environmental changes: floods, heat waves, etc. (Table 1). It can be hypothesized that the stress imposed by the perturbation variables makes individual countries ratify the international treaties<sup>20</sup>, which marks system making in the countries.

**Table 1.** Descriptive statistics of perturbation variables.

	N	Minimum	Maximum	Mean	Std. Deviation
Ratio of trade in GDP-mean value for years 1960-1999	181	15.03	330.19	75.45	41.45
Value added as a ratio of GDP-manufacturing-1960-2000	176	.00	37.29	15.09	8.10
Value added as a ratio of GDP-services-mean value for years 1960-2000	178	20.63	83.75	49.42	12.83
SO2 emissions-mean value for years 1990 and 1995 (thousand metric tons)	231	.00	30055.02	641.03	2637.25
CO2 per capita-mean value for years 1980-2001 (thousand metric tons)	199	.03	48.97	4.70	6.47
Number of people affected by extreme temperatures-maximum value for years 1975-1999	249	0	3000000	22009.69	208379.23
Number of people affected by floods-maximum value for years 1975-1999	249	0	240553156	2105902.10	17849725.62

In the system making, citizens are observed by the level of development, indicators such as Human Development Index (HDI) developed under United Nations Development Programme (UNDP), GDP per capita, etc. Firms or private sector is observed by the CO<sub>2</sub> emissions per value added dollars. During system working, government is affected by citizens and private firms but not an interactive way (see Figure 1). During self-management it is assumed that all actors affects each other in an interactive way. Table 2 presents the relevant variables used for three of the SCEM stages used in the DPM-SCEM model.

**Table 2.** Descriptive statistics of the variables selected for system making, working and self-management stages.

	N	Minimum	Maximum	Mean	Std. Deviation	
System making and working	Ratio of of treaties ratified (of 11)	249	.00	1.00	.60	.35
	Mean HDI 1975, 1980, 1985, 1990, 1995, 2001	174	.26	.91	.66	.18
	Mean total emissions CO2 by manufacturing sector for years 1960-1999 (thousand metric tons)	131	15.00	822326.55	31505.33	98666.92
	Mean aid assistance 1970-2000	138	.02	108.59	25.43	27.05
	Mean government consumption per capita	148	10.97	6818.07	890.88	1501.14
	Mean household consumption per capita 1960-1999	141	88.05	22835.77	2901.12	4327.14
Self management	Mean recycling-glass 1985-2000	26	13.00	73.60	42.50	18.88
	Mean green energy production 1960-1999	249	.00	150.74	2.42	12.80
	Mean Tv sets per thousand 1991-1999	218	.00	54794.67	479.40	3704.40

**Table 3.** Correlation matrix between observed variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Ratio of trade in GDP-mean value for years 1960-1999	1															
2 Value added as a ratio of GDP-manufacturing-1960-2000 (in US \$)	.01	1.00														
3 Value added as a ratio of GDP-services-mean value for years 1960-2000 (in US \$)	.30**	.02	1.00													
4 SO2 emissions-mean value for years 1990 and 1995 (thousand metric tons)	-.21**	.31**	-.09	1.00												
5 CO2 per capita-mean value for years 1980-2001 (metric tons per person)	.28**	.20**	.22**	.15*	1.00											
6 Number of people affected by extreme temperatures-maximum value for years	-.07	-.04	.08	.10	.14	1.00										
7 Number of people affected by floods-maximum value for years 1975-1999	.00	.07	.07	-.02	-.01	-.01	1.00									
8 Ratio of treaties ratified (of 11)	-.06	.21**	.02	.11	-.10	.05	-.03	1.00								
9 Mean HDI 1975, 1980, 1985, 1990, 1995, 2001	.22**	.37**	.38**	.00	.41**	.11	.08	.09	1.00							
10 Mean total emissions CO2-mean value for years 1960-1999 (thousand metric	-.23	.33**	-.09	.96**	.14	.05	-.03	-.01	-.04	1.00						
11 Mean aid assistance 1970-2000 (in US \$)	-.12	-.42**	-.27**	-.18*	-.39**	-.06	-.08	-.12	-.52**	-.15	1.00					
12 Mean government consumption per capita (in current US \$)	.08	-.24**	.51**	.11	.69**	.09	.18*	.14	.49**	.16	-.33**	1.00				
13 Mean household consumption per capita 1960-1999	.06	-.28**	.52**	.13	.68**	.12	.06	.09	.50**	.20*	-.49**	.93**	1.00			
14 Mean recycling-glass 1985-2000 (ratio of apparent sales)	-.13	.27**	.29**	.13	.25**	.13*	-.03	.23**	.37**	.15	-.16	.78**	.79**	1.00		
15 Mean green energy production 1960-1999 (thousand tons of oil equivalent)	-.12	.14	.24**	.28**	.20**	.14*	.32**	.11	.13	.34**	-.09	.48**	.41**	.32**	1.00	
16 Mean Tv sets per thousand 1991-1999	.15	.36**	.35**	-.02	.13	.00	-.01	-.01	.78**	.05	-.47**	.61**	.62**	.00	-.01	1.00

\*\* Correlation is significant at the 0.01 level (2-tailed).

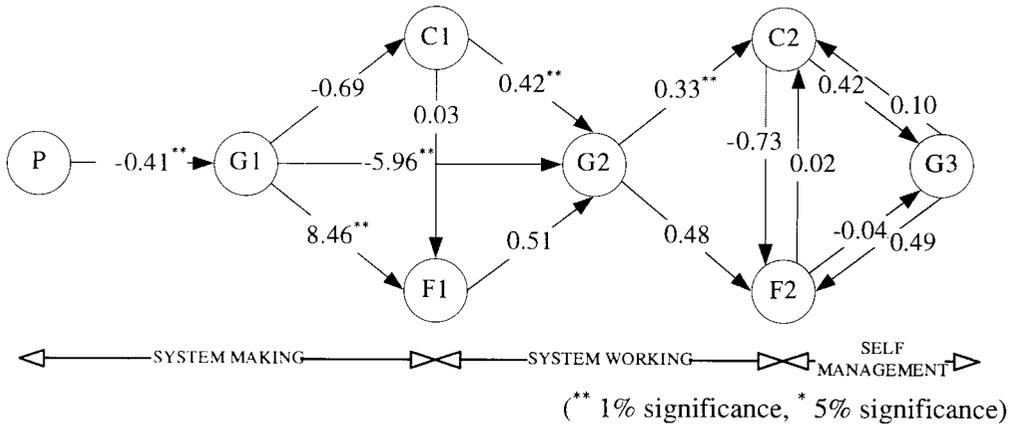
\* Correlation is significant at the 0.05 level (2-tailed).

The correlation matrix of the variables given in Table 1 and Table 2 is given in Table 3. Of special interest in the correlation matrix are the significant correlation between HDI and CO<sub>2</sub>emissions and negative correlation of the mean aid assistance (row 11-column 11 of Table 3) with all of the other variables including HDI. Regarding the emissions, this is almost consistent with the remarks in various studies that poor countries are the least polluters.

### 3.3. Estimation results

The estimation of the model proposed in Figure 1 with the data given in the previous section is done with LISREL software package. Overall, including the free correlations between some of the observed variables, 55 parameter values have been estimated based on the data and the model in Figure 1. Information on detailed relationships and estimation results are given in the Appendix to this study, in this section, we present and interpret the parameter estimates between theoretical constructs: government, citizens and firms (Figure 2). Note that the parameter estimates are directly affected by the choice of the observed variables that are thought to be good proxies for theoretical constructs.

Although overall model results turn out to be good, some of the parameters turn out to be insignificant, especially the parameter value for the perturbation effect on environmental convention ratification by governments, which is thought to be a or primary importance along side the combining function of the government across stages. However, perturbation effect can be divided into two of three homogeneous sub-groups consistent with the variable groups for economy, environment and disasters mentioned in the previous section. With the data set used, the model with multiple perturbations has not converged but offers promising improvement over the basic model produced in this study and it stays as a future study in front of us. During system making and working, government activities are also thought to be associated with the aid dependence. Activities of citizens and private sector during the early stages contribute to decrease of the aid dependence from abroad, but initial perturbation conditions contribute to



**Figure 2.** Parameter estimates of the DPM-SCEM model.

aid dependency positively. Government activities at the end of system making inaugurate self-management in by pointing positive effects to both citizens and the private sector. This is supportive of the general understanding that once the system has been established and found to be working, its contribution to the activities in the next stage, self-management is positive. An indirect result from this might be the importance of the system making and system working on the relationships of the self-management system. The results obtained in the self-management apart of the model mostly comply with the basics that have been set in this study. However the parameter values that turned out to be negative are subject to further scrutiny.

#### 4. Conclusions

This study is a preliminary attempt to advance the basic SCEM framework that has been developed by Matsuoka (2003) and Matsuoka et al. (2004). We have proposed a dynamic process model for SCEM. DPM-SCEM has given government a pivotal importance especially in the system making and system working stages. The first two stages are characterized with a logical combination to each other in a way that separating one from another has become more difficult. Self-management stage is characterized with the two way simultaneous relationships between different actors as proposed in the SCEM framework.

Model framework has been estimated with the data that, we think, fit to the SCEM framework. Eleven of the thirteen available international conventions or protocols have been used for a start of the system making stage in individual countries. However it might be the case that a country, which has ratified these conventions or protocols, might have started system making well before being a signatory. This might pose a serious problem for a model that claims to capture the actual proceeding of the SCEM framework by using time series data by anchoring at land mark dates such as signing an international agreement, passing a law, etc. In this regard, North's (1990) conceptualization of the institutional change might be useful that purports institutional change as an evolutionary and path dependent process; we believe that institutions change as a result of posterior expectations conditioned on previous developments (although we have exact information on them), hence, in a study like this, taking prior develop-

ments and disregarding the outcomes might be fallacious. In this regard, our proposal is to include aggregate information of the institutional change.

DPM-SCEM has been estimated with the data compiled from various international organizations; although the model yields good results in terms of fit indices (see Appendix), some of the parameters turn out to be insignificant and on the unexpected side. This is mostly due to the relative simplicity in terms of observed variables, thus model needs further refinements in terms of observed variables.

Besides, this study requires further research in several directions. One would be the inclusion of the perturbation into the model system as an endogenous model element. But this might increase the complexity of the model significantly, which might consequently induce serious problems in the model estimation. Another further study area, also a drawback of the current proposed model, is the lack of the inclusion or control for any heterogeneity between different countries, especially developed and developing countries, which might have strong effects during perturbation stage. Country-city level study of the DPM-SCEM might be the last further research area that this study might suggest. This kind of study might reveal significant results on the coupling of the SCEM framework with alternative policies applied in the urban areas of various parts of the world, especially the transportation and the resultant air pollution problem.

## Notes

- (1) Agenda 21 is a global sustainability agenda for the 21<sup>st</sup> Century, agreed upon during the United Nations Conference on Environment and Development in 1992.
- (2) <http://www.iisd.org/rio+5/agenda/chp37.htm> (Accessed: 2004.10.06)
- (3) An underlying difference between two concepts can be made on the supply of energy to increase capacity. In this regard, capacity development is associated with internal agent(s) while capacity building is associated with external agents. The concept “capacity development” is adopted by United Nations Development Programme (UNDP), Japan International Cooperation Agency (JICA) and Canadian International Development Agency (CIDA). The concept “capacity building” is adopted by World Bank and OECD.
- (4) The concept of sustainable development has become one of the most important global issues in the past decade (UNDP, 1995 and 1996; UNDS, 2000; UNECOSOC, 2001). In the 19<sup>th</sup> century, problem of sustainability has been emerged as the efficiency-consumption paradox (or dilemma) (Jevons, 1865); later in 1970s, sustainability is reconsidered with limits-to-growth doomsday scenarios revival Malthusian population-consumption paradox (Meadows et al. 1972); in the dawn of the 21<sup>st</sup> Century, sustainability question mainly revolves around the greenhouse gases. Lately, sustainability has been broadened in order to include economic, social, institutional and environmental dimensions in order to combat key global problems such as environmental degradation, income inequity, poverty and threats to peace and security (WCED, 1987; Koptmüller et al., 2001; Spangenberg, 2002 and 2004).
- (5) In their seminal book, Meadows et al. (1972) gives different scenarios based on the projected population, consumption trends on one side, and production of renewable and non-renewable (limited resources) on another side. Most of the scenarios draws not a bright picture for the human kind in the future. Last edition of the same book in 2004 includes social development vis-à-vis environmental degradation. It is similar to social capacity.
- (6) According to medium estimates which assumes that the total fertility of each country will reach below replacement levels and remain at those levels for about 100 years, the world population increases to 8.9 billion in 2050 from 6.1 billions of people in 2000.

- (7) According to medium estimates, more developed countries will have stable populations in the next 50 years, less developed and least developed countries are expected to increase by 2.8 billions (from 4.9 billions) and 1 billion (from 0.7 billions) respectively.
- (8) Bai and Imura (2000) has proposed three types of pollution associated with poverty-related issues (Type I), rapid-growth issues (Type II) and consumption and life-style related issues (Type III). Type I pollution is expected to decrease smoothly with economic development, Type II pollution is expected to follow an EKC, Type III pollution is expected to increase. Note that typology proposed by Bai and Imura (2000) is intended for the urban areas; but without not much loss of generality we carry the same typology to the country level.
- (9) For example, the telephone systems that do not work, long waiting times to get permits, political nepotism show signs of deficiencies in the institutions in these countries.
- (10) Environment Minister of Japan sounds her support for Carbon Tax in an interview appeared in The Japan Times, 3 October 2004.
- (11) Between 1960 and 1970, CO<sub>2</sub> emissions increased 35% in high income countries; this figure has been decreased to 12% increase between 1990 and 2000. The reduction in the previous might be due to the technological advances in production. But the decrease in reduction rate in the later period might be due to the increased consumption.
- (12) Between 1960 and 1970, CO<sub>2</sub> emissions increased 45% in low income countries, this has been slowed to 25% between 1990 and 2000. For medium income countries, the increase was 50% between 1960 and 1970, from 1990 to 2000, there is no increase in total CO<sub>2</sub> emissions in these countries.
- (13) In corporatist decision making system, where decisions are taken by a small groups of representative elites in the name of the larger populations (e.g., Europe, Japan). In pluralist systems, decisions are taken by the involvement of the interest groups (e.g., USA).
- (14) In fact, both affluence and education follow each other as in chicken-egg problem.
- (15) Love canal (New York, USA) incident is a typical case that can be given as an example in this setting. Besides strong odor, children and dogs developed skin irritation when exposed. (Levine, 1982). After a while, the Department of Environmental Conservation of New York (DEC) got involved and made clear that Love Canal was a serious health threat, accordingly actions were taken to clean up love Canal (Regenstein, 1982).
- (16) Eco-Management and Audit System
- (17) For example, European Union uses flower symbol for eco-labeling.
- (18) At least in the sense that Sen (1993) has proposed in his capability theory.
- (19) <http://geodata.grid.unep.ch/index.php> (Accessed: 2004.10.06)
- (20) International Treaties covered are as follows:
  1. Basel Convention on the Control of Tranboundary Movements of Hazardous Wastes and their Disposal
  2. Convention on Biological Diversity
  3. Convention on International Trade in Endangered Species of Wild Fauna and Flora
  4. Convention on the Conservation of Migratory Species of Wild Animals
  5. Kyoto Protocol
  6. Ramsar Convention on Wetlands
  7. United Nations Convention on the Law of the Sea
  8. United Nations Convention to Combat Desertification
  9. United Nations Framework Convention on Climate Change (UNFCCC)
  10. Vienna Convention and Montreal Protocol
  11. World Heritage Convention

Note the remaining two conventions: Rotterdam Convention and Stockholm Convention on Persistent Organic Pollutants are not covered for technical reasons. For detailed information on these conventions, refer to the UNEP homepage at <http://www.unep.org>

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## Appendix

### The list of latent variables (theoretical constructs):

- P : perturbation
- G1 : government (system making)
- G2 : government (system working)
- G3 : government (self management)
- C1 : citizens (system making)
- C2 : citizens (system working, self management)
- F1 : firms (system making)
- F2 : firms (system working, self management)

**The list of observed variables****Observed P variables**

- MTRADE : Ratio of trade in GDP-mean value for years 1960-1999  
 MMAN : Value added as a ratio of GDP-manufacturing-1960-2000 (in US \$)  
 MSERV : Value added as a ratio of GDP-services- mean value for years 1960-2000 (in US \$)  
 MSO2 : SO2 emissions-mean value for years 1990 and 1995 (thousand metric tons)  
 MCO2PC : CO2 per capita-mean value for years 1980-2001 ( metric tons)  
 MAXHEAT : Number of people affected by extreme temperatures-maximum value for years 1975-1999  
 MAXFLOOD : Number of people affected by floods-maximum value for years 1975-1999

**Observed G1 and G2 variables**

- TOTAL : Ratio of treaties ratified (of 11)-**G1**  
 M\_AID : Mean aid assistance 1970-2000 (ratio of government expenditures)-**G1** and **G2**  
 M\_GOVCON : Mean government consumption per capita (in US \$)-**G2**

**Observed G3 variables**

- MG\_ENG : Mean green energy (from wind, solar or tide) production 1960-1999 (thousand tons of oil equivalent)

**Observed C1 variables**

- MHDI : Mean HDI 1975, 1980,1985,1990,1995,2001

**Observed C2 variables**

- MHCONP : Mean household consumption per capita 1960-1999 (US \$)  
 MTV : Mean TV sets per thousand 1991-1999

**Observed F1 variables**

- MCO2 : Mean total emissions CO2-mean value for years 1960-1999 (thousand metric tons)

**Observed F2 variables**

- MW\_GL : Mean recycling-glass (ratio of apparent sales) 1985-2000

**Overall Model Fit Information**

- Degrees of Freedom = 81  
 Root Mean Square Error of Approximation (RMSEA) = 0.0485  
 90 Percent Confidence Interval for RMSEA = (0.0 ; 0.0821)  
 P-Value for Test of Close Fit (RMSEA < 0.05) = 0.548  
 Goodness of Fit Index (GFI) = 0.93  
 Adjusted Goodness of Fit Index (AGFI) = 0.82  
 Parsimony Goodness of Fit Index (PGFI) = 0.69

**Relations from exogenous to endogenous variables:  $T$** 

	P
G1	-0.41 (-2.59)

**Relations among endogenous variables:  $B$** 

t-scores are given in parentheses where applicable.

	G1	C1	F1	G2	C2	F2	G3
G1	—	—	—	—	—	—	—
C1	-0.69 (-1.61)	—	—	—	—	—	—
F1	8.46 (2.70)	0.03 (0.39)	—	—	—	—	—
G2	-5.96 (-2.82)	0.42 (4.83)	0.51 (0.39)	—	—	—	—
C2	—	—	—	0.33 (5.69)	—	0.02 (0.34)	0.10 (1.84)
F2	—	—	—	0.48 (1.46)	-0.73 (-0.65)	—	0.49 (1.92)
G3	—	—	—	—	0.42 (1.50)	-0.04 (-0.09)	—

**Relations among latent-endogenous and observed variables:  $A_y$** 

t-scores are given in parentheses where applicable.

	G1	C1	F1	G2	C2	F2	G3
TOTAL	1.00	—	—	—	—	—	—
MHDI	—	1.00	—	—	—	—	—
MCO2	—	—	1.00	—	—	—	—
M_AID	-1.12 (-1.94)	—	—	-0.69 (-9.25)	—	—	—
M_GOVCON	—	—	—	1.00	—	—	—
MHCONP	—	—	—	—	2.39 (7.60)	—	—
MW_GL	—	—	—	—	—	1.00	—
MG_ENG	—	—	—	—	—	—	1.00
MTV	—	—	—	—	1.00	—	—

**Relations between latent-exogenous and observed variables:  $\Lambda_x$** 

t-scores are given in parentheses where applicable.

	P
MTRADE	1.00
MMAN	-0.74 (-3.96)
MSERV	1.26 (6.43)
MSO2	-3.30 (-6.69)
MCO2PC	0.70 (3.98)
MAXHEAT	-1.70 (-6.27)
MAXFLOOD	-3.13 (-6.86)