DR²AD Model (Ver. 1.4)

Application Operation Manual

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Chapter 1 DR²AD Model Structure

1 DR²AD Model Overview

1.1 DR²AD Model Overview

"Disaster Risk Reduction Investments Accounts for Development (DR²AD)" model is a Ramsey-based macroeconomic simulation model capable of quantitatively evaluating the benefit of disaster risk reduction (DRR) investment from a long-term perspective. Quantitatively comparing the cost of DRR with the expected benefit enables an optimum DRR investment allocation. The DR²AD model serves as a basis and a useful tool in forming policy policies for disaster risk mitigation and sustainable development.

The following list details the main objectives in the development of the DR^2AD model.

- 1. To evaluate the economic impact of DRR investment
 - The DR²AD model is a dynamic model used to correlate disasters with household income and consumption as well as corporate production.

2. To evaluate the economic impact of multiple DRR investment policies.

- The DR²AD model can provide feasibility analysis of the optimum mix of direct and indirect measures to configure a DRR investment policy.
- <u>3. To evaluate the contribution of DRR investment made toward international</u> goals such as MDG's.

• The DR²AD model can evaluate the effect on disasters per household income levels and per socio-economic level.



Fig. 1-1 Evaluation of economic growth versus DRR investment

1.2 History behind the development of the DR²AD model

The Third UN World Conference on Disaster Risk Reduction held in Sendai in 2015 resulted in the The Sendai Framework, which aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years. To accomplish achieve these objectives, 7 targets and 4 priority actions have been set. In particular, the targets require investment to reduce the economic loss in the global GDP caused by disaster, and the priority actions require investment to improve disaster prevention.

Natural disasters occurring in developing countries is likely to have a significant negative impact on national economic development, national stability, and efforts to eliminate poverty. Most of the poor are not protected by insurance or social security programs despite being generally susceptible to the impact of damage caused by disasters.

The United Nations Disaster White Paper in 2015 claims that an investment of 6 billion dollars per year in disaster risk management strategies throughout the world could reduce risk by as much as 360 billion dollars in damage despite such a modest investment representing only 0.1% of new urban infrastructure. In other words, investment that could result in profit and investments to reduce disaster risk could be the determining factor in achieving national and international targets such as eliminating poverty, expanding health care and education programs, and ensuring sustainable and equitable growth.

These circumstances appear to be the result of not having a suitable means of evaluating the benefit of DRR investment beforehand while awareness of the importance of disaster prevention continues to increase. The current extent of information on evaluating the benefit of DRR investment beforehand can be summarized by the statement in the United Nations Development Program (UNDP) that says "Every dollar invested into DRR saves seven dollars in disaster aftermath." In other words, a method has not yet been established that can clearly evaluate levels of DRR investment on a national scale or the benefit of disaster DRR with regard to economic growth and poverty issues.

We believe it is vital to develop a method to analyze and illustrate the potential benefit of DRR investment in developing countries. As this leads to actual disaster reduction investment, this will also help the economic development of developing countries as well as resolve poverty issues.

Therefore, through project research conducted by JICA, we developed the Disaster Risk Reduction Investment Accounts for Development (DR²AD Model) as a DRR investment evaluation model capable of evaluating the benefit of DRR investment in developing countries on economic growth, poverty reduction, and others.

2 Basic Structure of the DR²AD Model

2.1 Basic Model Structure

The DR²AD model is a macro-economic model that incorporates DRR investment concepts into a Ramsey-based optimal growth model from neoclassical economic growth theory. The purpose of this model is to be utilized as a policy decision-making tool by displaying the contribution of DRR investment on the economic growth of developing countries. The following figure illustrates the basic structure of this model.



The natural disaster occurred in period t is defined by the negative impacts on human capital, physical assets, financial assets and land, in terms of the damage rates.
Through factor market, impact on GDP of period t is considered.

Fig. 2-1 DR²AD Model Structure

The DR²AD model is capable of displaying differences in levels of long-term economic growth quantitatively depending on whether DRR investment is conducted or not. DRR investment improves resiliency against natural disasters and protects human capital investments and physical assets from natural disasters, which results in a positive effect on long-term economic growth. On the other hand, without DRR investment continuous damage to assets from natural disasters will have a negative impact on people's life leading to negative cycles and creating poverty traps.

The following figure are conceptual images representing economic growth versus DRR investment, which can be demonstrated using the DR^2AD model.





Fig. 2-2 Conceptual image as demonstrated using the DR²AD model of the effect on disasters

2.2 Features of the DR^2AD Model (Ver. 1.4)

The following lists describe the main features of the DR²AD model.

2.2.1 Overall Structure

- Evaluates the benefit of DRR investment with regard to economic growth and poverty reduction.
- Simulate closed economies configured with two economic agents: households and firms.
- Households can be classified into five income classes, which enables the evaluation of issues specific to particular classes, such as poverty.
- The economy is closed within each class, which enables equilibrium between households and firms thorough the market to be achieved within each class.

2.2.2 Household

- Five income classes are available for households.
- Household behavior assumes a representative individual in each income group.
- Household behavior is fully reasonable and informative to disaster risk. (That is to say, households decide the level of consumption, investment, and saving so that they can maximize their expected lifetime utility.)
- Households provide production factors (labor, production capital, land) to firms in return for income (labor income, capital income, and land rent).
- A human capital has been incorporated to represent the connection between the accumulation of human capital and the reduction in poverty. This model assumes that education causes growth of human capital, and so reproduces the positive effect of increases in human capital on production efficiency by setting the education index of the mean years of schooling as the proxy variable for human capital.

2.2.3 Firm

- We assume a representative firm in each income class.
- The production technology assumes a constant return to scale.
- Firms are modeled as fully reasonable argents having a myopic perspective toward maximizing the expected profit each term.
- Firms demand production factors (labor, production capital, land) from households and supply these households with the final goods (durable goods and non-durable goods). (Models also assume that household savings are recirculated as production capital for businesses provided through banks.)
- Rapid technological growth due to the transformation of socio-economic structures is not included in this model.

2.2.4 Market equilibrium

• Both good's market and production factor's market are assumed to be perfectly competitive.

2.2.5 Disasters

- Five different disaster scale settings are available, including no occurrence of disasters, for each type of disaster. Every period, the disaster rank (including no disasters) is determined through stochastic process.
- Disasters occur in accordance with an occurrence process independent for each type of disaster.
- Disaster reduction behavior models such as insurance are not included. Reductions in disaster damage ratios can only be generated by DRR investment provided exogenously. However, DRR investment costs are not accounted for in this model.

2.2.6 Output

- The GDP function is a Cobb-Douglas form derived from human capital, production capital, and land.
- Disasters occur in accordance with a stochastic process, and so Monte Carlo simulations are used to analyze average DRR investment benefits.
- As illustrated in the following figure, the occurrence of disasters causes damage to human capital and production factors, which leads to a decrease in production capacity and therefore GDP.
- When DRR investment is conducted, damage can be reduced, which mitigate the decreases in production capacity.
- The DR²AD model focuses on the DRR investment benefits as the differences in GDP, depending on whether DRR investment is conducted.



Fig. 2-3 Conceptual images of reduction in GDP when disasters occur

2.3 DR²AD Model (Ver. 1.4) Formulation

2.3.1 List of Endogenous Variables

The following table lists the endogenous variables used in this model.

Number	Name	Symbol	Unit of measure	Definition	Comments
1	Instantaneous utility	u	_	Representative household utility at one period	Assumes the Stone-Geary form.
2	Expected lifetime utility	V	_	Expected lifetime utility for a representative household	
3	Consumption	c^l	\$	Amount of consumption of non-durable goods (excluding houses and household goods)	Consumption amount is determined after the occurrence of a rank l disaster.
4	Human capital	h	Year	Mean years of schooling	Uses the mean years of schooling as a proxy variable. Assumes that increases in the mean years of schooling leads to improved labor productivity.
5	Human capital formation (Education time)	m^l	Year	Time invested in education	Education time is determined after the occurrence of a rank l disaster.
6	Amount of human investment cost	$\eta^l(m^l)$	\$	Amount of cost invested in education	Amount of cost invested in education is determined after the occurrence of a rank l disaster.
7	Physical assets	Z	\$	Amount of non-durable assets (houses and household goods)	
8	Physical asset formation	ξ	\$	Amount of cost invested in physical assets	
9	Financial assets (Production capital)	b	\$	Amount of financial assets (Amount of new savings in each period equals income minus expenditure)	Financial assets is assumed to be completely used as productive capital through banks.
10	Total assets	а	\$	Total amount of assets held by households (Sum of physical assets and financial assets)	
11	Wages	w _l	\$/year	Wages for one unit of human capital	Wages are determined after the occurrence of a rank l disaster.
12	Interest rate	r_l	_	Interest rate in relation to productive capital (financial assets).	Interest rate is determined after the occurrence of a rank l disaster.
13	Land rent	π_l	\$/ha	Land rent in relation to one unit of land available for production	Land rent is determined after the occurrence of a rank l disaster.
14	Income	In	\$	Total of wage income, capital income, and land rent	

15	15ExpenditureEx\$Total of consumption, physical asset formation, and education investment.		Total of consumption, physical asset formation, and education investment.		
16	Discount factor	Λ		Discount factor in relation to future utility	
17	Production (GDP)	Y	\$	Gross domestic production (GDP)	Assumes a Cobb-Douglas form.
18	Total factor productivity (TFP)	В	_	Total factor productivity (TFP)	Productivity of factors except for one of labor, capital, and land
19	Amount of human capital investment	Н	Year	Sum of human capital per income class	
20	Amount of production capital investment	K	\$	Sum of production capital per income class	
21	Total production cost	ТС	\$	Sum of firm's production cost about labor and capital input	
22	Firm's profit	$\widetilde{\Pi}_l$	\$	Firm's profit per income class	Firm's profit is determined after the occurrence of a rank l disaster. Distributed to households as land rent.

2.3.2 Exogenous Variable List

The following table lists the exogenous variables used in this model.

Number	Name	Symbol	Unit of	Definition	Comments
			measure		
1	Population per income class	n	People	Total population per income class	Populations per income class are currently configured to be equal.
2	Subsistence level of consumption	Ē	\$	Subsistence level of consumption	Variable added for consideration of poverty traps.
3	Time preference rate	ρ		Time preference rate in relation to utility	Tendency to focus on current utility as the number increases.
4	Relative risk aversion	θ	_	Household attitude toward risk	Tendency to avoid risk as the number increases.
5	Share parameter of consumption	Υi		Rate of preference for consumption and physical assets	Calculated with production input-output tables or calibration. $i \in \{1,2\}$
6	Human investment coefficient	η_i	_	Function coefficient that represents the relationship between the amounts of education investment and mean years of schooling.	Calculated with calibration. $i \in \{0,1,2\}$
7	Correction coefficient for human capital formation	ς	_	Coefficient used to correct the relationship between the amounts of education investment and mean years of schooling.	Configured to adjust certain parameters (calibration).
8	Total land area in the economic space	\overline{T}	ha	Total land area	$\overline{T} = \widetilde{T} \times$ Number of income class
9	Total land area per income class	Ĩ	ha	Total land area per income class	$\tilde{T} = T \times n$
10	Land area held by representative households	Т	ha	Land area held by representative households	The land rent allocation is determined in accordance with the land area in possession.
11	Human capital depreciation ratio	δ_h	_	Rate that human capital depreciates each period.	Expresses degradation of knowledge and changing of generations.
12	Physical assets depreciation ratio	$\delta_{ m z}$		Rate that physical assets depreciate each period.	
13	Production capital depreciation ratio	δ_k	_	Rate that production capital depreciates each period.	
14	Exogenous growth coefficient	B ₀		Initial total factor productivity	Calculated with calibration.
15	Exogenous growth rate	g_b	_	Degree of technological	Configured with calibration or default values
16	Share parameter	α		Rate of input for	$i \in \{1, 2, 3\}$

Number	Name	Symbol	Unit of	Definition	Comments
			measure		
	for the			production factors	
	production function				
17	Disaster probability	μ^l	_	Probability of occurrence of a rank l disaster.	
18	Physical asset damage ratio	φ^l	_	Ratio of physical assets lost during a disaster	
19	Production capital damage ratio	ψ^l	_	Ratio of production capital (financial savings) lost during a disaster	
20	Human capital damage ratio	ω^l	_	Ratio of human capital affected during a disaster	
21	Land damage ratio	$ au^l$	_	Ratio of land affected during a disaster	
22	Value function coefficient	ν_i	—		Calculated with calibration. $i \in \{0,1,2\}$
23	Total assets (initial)	a(0)	\$	Total amount of assets held by initial households (Sum of physical assets and financial savings)	
24	Human capital (initial)	h(0)	Year	Initial mean years of schooling	

2.3.3 Basic Constitutive Equations

The following table lists the basic constitutive equations used in this model.

Number	Name	Basic Constitutive Equations
1	Instantaneous utility function	$u(c^{l}(t), (1-\varphi^{l})z(t)) := \frac{[(c^{l}(t)-\bar{c})^{\gamma_{1}}\{(1-\varphi^{l})\cdot z(t)\}^{\gamma_{2}}]^{1-\theta}-1}{1-\theta}$
2	Human capital accumulation process	$\begin{aligned} h(t+1) &= (1-\delta_h) \cdot h(t) + \varsigma \cdot m^l(t) \\ &= h(t) + H^l(t) \\ H^l(t) &:= -\delta_h \cdot h(t) + \varsigma \cdot m^l(t) \end{aligned}$
3	Human investment cost function	$\eta^{l}(m^{l}) = \eta_{0} + \eta_{1} \cdot m^{l} + \eta_{2}^{l} \cdot (m^{l})^{2}$
4	Physical assets accumulation process	$z(t+1) = (1 - \delta_z)(1 - \varphi^l)z(t) + \xi(t),$
5	Income	$\ln(t) = r_l(t)(1-\psi^l)\mathbf{b}(t) + w_l(t)\cdot(1-\omega^l)\mathbf{h}(t) + \pi_l(t)\cdot(1-\tau^l)T$
6	Expenditure	$\operatorname{Ex}(t) = c^{l}(t) + \eta^{l}\left(m^{l}(t)\right) + \xi(t)$
7	Financial savings accumulation process	$b(t+1) = (1-\psi^l)b(t) + \ln(t) - \operatorname{Ex}(t)$ = {1+r _l (t)}(1-\psi^l)b(t) + w _l (t) · (1-\omega^l)h(t) + \pi_l(t) · (1-\tau^l)T - c^l(t) - \eta^l(m^l(t)) - \xi(t)
8	Total assets accumulation process	$\begin{split} a(t+1) &= a(t) + w_l(t) \cdot (1-\omega^l)h(t) + [r_l(t) - \{1+r_l(t)\} \cdot \psi^l] \cdot a(t) \\ &+ [(1-\varphi^l)(1-\delta_z) - \{1+r_l(t)\}(1-\psi^l)]z(t) + \pi_l(t) \cdot (1-\tau^l)T - c^l(t) \\ &- \eta^l(m^l(t)) \\ &= a(t) + A^l(t), \\ (t) &:= w_l(t) \cdot (1-\omega^l)h(t) + [r_l(t) - \{1+r_l(t)\} \cdot \psi^l] \cdot a(t) \\ &+ [(1-\varphi^l)(1-\delta_z) - \{1+r_l(t)\}(1-\psi^l)]z(t) + \pi_l(t) \cdot (1-\tau^l)T \\ &- c^l(t) - \eta^l(m^l(t)) \end{split}$
9	Value function	$\mathbb{V}(a(t),h(t),B(t))\cdot\left(\frac{1}{1+\rho}\right)^{t} = \max \mathbb{E}\left[\sum_{t'=t}^{\infty} u(c^{l}(t'),(1-\phi^{l})z(t'))\cdot\left(\frac{1}{1+\rho}\right)^{t'}\right]$
10	Discount factor	$\Lambda = \left(\frac{1}{1+\rho}\right)$
11	First-order conditions to maximize expected	$u_c(c^l,(1-\varphi^l)z) = \Lambda \cdot V_a$

Number	Name	Basic Constitutive Equations	
	lifetime utility		
	(consumption)		
	First-order		
	conditions to		
	maximize		
12	expected	$\sum \mu^{l} \{ u_{z}(c^{l}, (1-\varphi^{l})z) + \Lambda \cdot V_{a} \cdot (1-\varphi^{l})(1-\delta_{z}) \} = \Lambda \cdot V_{a} \sum \mu^{l} \{ F_{b} + (1-\psi^{l})(1-\delta_{k}) \}$	
	lifetime utility		
	(physical		
	assets)		
	First-order		
	conditions to		
	maximize		
13	expected	$V_h \cdot \varsigma = V_a \cdot \eta^{l'}(m^l)$	
	lifetime utility		
	(education		
	time)		
	Production	$V(t) = E(D(t) (1 - t))U(t) (1 - t)V(t) (1 - t)\tilde{T})$	
14	function	$F(t) = F(B(t), (1 - \omega) H(t), (1 - \psi) K(t), (1 - \tau) I)$ $P(t) (1 - \omega) H(t) g(1) (1 - \psi) K(t) g(2) (1 - \tau) I)$	
	(GDP)	$= B(t)\{(1-\omega)H(t)\}^{\omega}\{(1-\psi)K(t)\}^{\omega}\{(1-\tau)I\}^{\omega}\}$	
	Total factor	$P(t) = P - (1 + c)t^{-1}$	
15	productivity	$B(t) = B_0 \cdot (1 + y_b)$	
16	Amount of	$H(t) = m \cdot h(t)$	
10	human capital	$n(t) = n \cdot n(t)$	
	Amount of		
17	production	$K(t) = n \cdot b(t)$	
	capital		
18	Total cost	$\Gamma(t) = w_{1}(t) \cdot (1 - \omega^{l})H(t) + \{r_{1}(t) + \delta_{1}\} \cdot (1 - \psi^{l})K(t)$	
10	function	$G(t) = W_{1}(t) (1 w) f(t) + (f_{1}(t) + o_{k}) (1 \psi) f(t)$	
		$\widetilde{\Pi}_l(t) = Y(t) - TC(t)$	
19	Profit function	$= F(B(t), (1 - \omega^{l})H(t), (1 - \psi^{l})K(t), (1 - \tau^{l})\tilde{T}) - w_{l}(t) \cdot (1 - \omega^{l})H(t) - \{r_{l}(t) + \delta_{k}\}$	
		$\cdot (1-\psi^l)K(t)$	
	First-order		
	conditions to		
20	maximize		
	profit	$\frac{\partial F(B(t), (1-\omega^{l})H(t), (1-\psi^{l})K(t), (1-t^{l})I)}{\partial H} = w_{l}(t) \cdot (1-\omega^{l})$	
	(amount of		
	human capital		
	investment)		

Number	Name	Basic Constitutive Equations				
	First-order					
	conditions to					
	maximize					
21	profit	$\frac{\partial F(B(t), (1-\omega^{l})H(t), (1-\psi^{l})K(t), (1-\tau^{l})\tilde{T})}{\partial W} = \{r_{l}(t) + \delta_{k}\} \cdot (1-\psi^{l})$				
	(amount of	ΟΚ				
	production					
	capital)					
	Land rent per					
22	unit of	$\widetilde{\Pi}_l(t) \qquad \widetilde{\Pi}_l(t)$				
22	productive	$\pi_l(\tau) = \frac{1}{(1-\tau^l)\tilde{T}} = \frac{1}{(1-\tau^l)nT}$				
	land					

2.3.4 Expanded Description of Basic Constitutive Equations

(1) Household

The representative household behaves in the following manner to maximize the expected lifetime utility. In this case, the representative household behaves in this manner while recognizing disaster risk and allocating income (wage income, interest income, and land rent) and total assets (accumulated equity) per period to consumption, physical investment, human investment, and financial savings.

$$E\left[\sum_{t=0}^{\infty} u(c^{l}(t), (1-\varphi^{l})z(t))\left(\frac{1}{1+\rho}\right)^{t}\right],\tag{1}$$

where

E: Expected value operation *u*: Instantaneous utility *c*^l: Consumption (non-durable goods) (after a rank *l* disaster) *z*: Physical assets (durable goods)

 ρ : Time preference rate

The instantaneous utility function is a Stone-Geary type of function that can express the scenario of representative households falling into poverty traps. In other words, when the consumption c^{l} approaches the subsistence level of consumption, the marginal utility of consumption increases, consumption is given priority, and capital formation such as human capital and financial savings are set aside. As a result, this can express a scenario in which households cannot escape poverty traps. All income classes have the same preference.

$$u(c^{l}(t),(1-\varphi^{l})z(t)) := \frac{[(c^{l}(t)-\bar{c})^{\gamma_{1}}\{(1-\varphi^{l})\cdot z(t)\}^{\gamma_{2}}]^{1-\theta}-1}{1-\theta},$$

(2)

s.t.

$$\gamma_1 + \gamma_2 = 1 \ (0 < \gamma_1, \gamma_2 < 1),$$

 $\theta > 0,$

where

 \bar{c} : Subsistence level of consumption γ_i : Consumption share parameter, *i* ∈ {1,2} θ : Relative risk aversion

The representative household saves money for future consumption. Configuring income per period for the representative household (wage income, interest income, and land rent) to In(t) and expenditure (consumption, human capital, and physical investment) to Ex(t), results in the difference between income and expenditure represented as new financial savings Δb generated per peiod

$$\Delta b(t) = \ln(t) - Ex(t),$$

$$\begin{aligned} \ln(t) &= r_l(t)(1 - \psi^l) \mathbf{b}(t) + w_l(t) \cdot (1 - \omega^l) \mathbf{h}(t) + \pi_l(t) \cdot (1 - \tau^l) T, \\ \operatorname{Ex}(t) &= c^l(t) + \eta^l \left(m^l(t) \right) + \xi(t). \end{aligned}$$

where

b: Financial assets (production capital)

T: Land area held by a representative household

 w_l : Wage rate (after the occurrence of a rank l disaster)

 r_l : Interest rate (after the occurrence of a rank *l* disaster)

 n_l : Land rent (after the occurrence of a rank l disaster)

 δ_k : Production capital depreciation ratio

 ω^{l} : Human capital damage ratio (rank *l* disaster)

 ψ^l : Production capital damage ratio (rank *l* disaster)

 τ^{l} : Land damage ratio (rank l disaster)

 η^l : Human capital investment costs (after the occurrence of a rank l disaster)

 m^l : Human capital formation

 ξ : Physical asset formation

Due to a rank l disaster, human capital, financial assets (production capital), and land are all affected by the damage represented by ψ^l, ω^l, τ^l , which causes the income of representative households to decrease as the scale of disaster increases.

Based on this, the accumulation process of financial assets b is expressed as follows.

$$b(t+1) = (1-\psi^{l})b(t) + \Delta b(t)$$

= $(1-\psi^{l})b(t) + \ln(t) - Ex(t),$
= $\{1 + r_{l}(t)\}(1-\psi^{l})b(t) + w_{l}(t)\cdot(1-\omega^{l})h(t) + \pi_{l}(t)\cdot(1-\tau^{l})T - c^{l}(t) - \eta^{l}(m^{l}(t)) - \xi(t)$
(4)

Whereas consumption specifies non-durable goods, physical assets specify durable goods. Specifically, this represents the stock of houses and household goods. Physical assets depreciate at the ratio of δ_z and also incur a loss at the ratio of φ^l when a disaster occurs.

The physical assets accumulation process is expressed as follows.

$$z(t+1) = (1 - \delta_z)(1 - \varphi^l)z(t) + \xi(t),$$
(5)

Human capital is assets related to labor productivity. As human capital increases, more wage income can be obtained. This does not experience loss due to disaster, but the assumption employed that human capital for the period in which a disaster occurs temporarily decreases, which leads to a decrease in labor productivity.

As with physical assets, human capital depreciates at the ratio of δ_h every period. As a result, this expresses a scenario in which knowledge deteriorates if left alone while also reflecting turnover of

(3)

generations (older generations of human capital dies while younger generations are born) by taking into account depreciation that includes exchanges due to obsolescence of knowledge and turnover of the labor population.

The human capital accumulation process is expressed as follows.

$$\begin{split} h(t+1) &= (1-\delta_h) \cdot h(t) + \varsigma \cdot m^l(t) \\ &= h(t) + H^l(t), \\ H^l(t) &:= -\delta_h \cdot h(t) + \varsigma \cdot m^l(t), \end{split}$$

where

δ_h : Human capital depreciation ratio

ς : Correction coefficient for human capital formation

Actual data on labor productivity that represents human capital, the mean years of schooling is used as a proxy variable. Though other possible proxy variables include the average education ratio and the average literacy rate, the mean years of schooling is considered more applicable when handled as a stock (education ratio and literacy rate is either 1 or 0 on the individual level). There are actually gaps in time between human capital growth and labor productivity, but for this application, it is assumed that increases in human capital will immediately lead to increases in labor productivity.

The correction coefficient ς linked to temporal adjustment costs was configured to adjust specific parameters (calibration), which is necessary for case studies. If such adjustment is not necessary, set ς equal to one.

Typical households own a certain amount of land as landlords from the initial point, which generates land rent by renting out all land to companies.

$$T = \frac{\tilde{T}}{n'}$$
$$\bar{T} = \sum_{j} \tilde{T}$$

where

 \tilde{T} : Total land area per income class

 \overline{T} : Total land area in the economic space

n: Population per income class

(7)

(6)

(2) Firms

Firms produce in accordance with the following Cobb-Douglas function. This assumes that production requires labor, capital, and land. Production is performed after the occurrence of a disaster, and the amount of investment into production factors is affected by the damage from the disaster.

$$\begin{split} Y(t) &= F \Big(B(t), (1 - \omega^l) H(t), (1 - \psi^l) K(t), (1 - \tau^l) \tilde{T} \Big) \\ &= B(t) \{ (1 - \omega^l) H(t) \}^{\alpha \, 1} \{ (1 - \psi^l) K(t) \}^{\alpha \, 2} \{ (1 - \tau^l) \tilde{T} \}^{\alpha \, 3}, \\ B(t) &= B_0 \cdot (1 + g_b)^{t - 1}, \\ H(t) &= n \cdot h(t), \\ K(t) &= n \cdot b(t), \end{split}$$

s.t.

 $\alpha_1 + \alpha_2 + \alpha_3 = 1 \quad (0 < \alpha_1, \alpha_2, \alpha_3 < 1),$

where

Y: Production function

B: Total factor productivity

- B_0 : Exogenous growth coefficient
- g_B : Exogenous growth rate
- H: Amount of human capital
- K: Amount of production capital
- α_i : Share parameter for the production function, $i \in \{1,2,3\}$

(8)

(9)

(10)

The share parameter for the production function α_i represents the distribution ratio for production factors in perfect markets.

Firms pay wages and interest as compensation for labor and production capital provided by households. Production capital stock assumes depreciation at a rate of δ_k every period, and the total cost of which is taken into account.

$$TC(t) = w_l(t) \cdot (1 - \omega^l) H(t) + \{r_l(t) + \delta_k\} \cdot (1 - \psi^l) K(t),$$

where

TC: Total production cost

Based on this, the firm's profit function is configured as follows. Firms behave toward maximizing profit, which is the amount of production minus total production costs. Profit is distributed to each household as land rent.

$$\begin{split} \tilde{\Pi}_{l}(t) &= Y(t) - TC(t) \\ &= F \Big(B(t), (1 - \omega^{l}) H(t), (1 - \psi^{l}) K(t), (1 - \tau^{l}) \tilde{T} \Big) - w_{l}(t) \cdot (1 - \omega^{l}) H(t) - \{ r_{l}(t) + \delta_{k} \} \\ &\cdot (1 - \psi^{l}) K(t). \end{split}$$

(3) Market Equilibrium

1) Maximization of Utility

Total assets are the total of financial assets and physical assets held by the representative household. Physical capital formation, which is a control variable, can be canceled out by configuring the total assets.

$$a(t) \coloneqq b(t) + z(t),$$

(11)

(12)

where

a: Total assets

By calculating Expression (11) for the t + 1 period and using Expression (4) in relation to b(t + 1) and Expression (5) in relation to z(t+1):

$$\begin{aligned} a(t+1) &= b(t+1) + z(t+1) \\ &= \{1 + r_l(t)\}(1 - \psi^l)b(t) + w_l(t) \cdot (1 - \omega^l)h(t) + \pi_l(t) \cdot (1 - \tau^l)T - c^l(t) - \eta^l \left(m^l(t)\right) - \xi(t) + \\ &\quad (1 - \delta_z)(1 - \varphi^l)z(t) + \xi(t) \\ &= \{1 + r_l(t)\}(1 - \psi^l)b(t) + w_l(t) \cdot (1 - \omega^l)h(t) + \pi_l(t) \cdot (1 - \tau^l)T - c^l(t) - \eta^l \left(m^l(t)\right) + \\ &\quad (1 - \delta_z)(1 - \varphi^l)z(t) \end{aligned}$$

Here, by substituting b(t) = a(t) - z(t) into Expression (12) and simplifying the right hand side of the expression, the physical assets accumulation process can be expressed as follows.

$$a(t+1) = a(t) + w_{l}(t) \cdot (1 - \omega^{l})h(t) + [r_{l}(t) - \{1 + r_{l}(t)\} \cdot \psi^{l}] \cdot a(t) + [(1 - \varphi^{l})(1 - \delta_{z}) - \{1 + r_{l}(t)\}(1 - \psi^{l})]z(t) + \pi_{l}(t) \cdot (1 - \tau^{l})T - c^{l}(t) - \eta^{l} (m^{l}(t)) = a(t) + A^{l}(t), A^{l}(t) \coloneqq w_{l}(t) \cdot (1 - \omega^{l})h(t) + [r_{l}(t) - \{1 + r_{l}(t)\} \cdot \psi^{l}] \cdot a(t) + [(1 - \varphi^{l})(1 - \delta_{z}) - \{1 + r_{l}(t)\}(1 - \psi^{l})]z(t) + \pi_{l}(t) \cdot (1 - \tau^{l})T - c^{l}(t) - \eta^{l} (m^{l}(t)).$$
(13)

The optimization problem for representative household is expressed as follows. The value function represents the maximum value of the expected lifetime utility generated as a result of representative household optimizing consumption, human capital, and physical asset formation. The problem of maximizing the expected lifetime utility can be resolved by configuring the value function.

$$V(a(t), h(t), B(t)) \cdot \left(\frac{1}{1+\rho}\right)^{t} = \max E\left[\sum_{t'=t}^{\infty} u\left(c^{l}(t'), (1-\phi^{l})z(t')\right) \cdot \left(\frac{1}{1+\rho}\right)^{t'}\right],$$
(14)

s.t.

$$b(t+1) = \{1 + r_l(t)\}(1 - \psi^l)b(t) + w_l(t) \cdot (1 - \omega^l)h(t) + \pi_l(t) \cdot (1 - \tau^l)T - c^l(t) - \eta^l (m^l(t)) - \xi(t),$$

$$z(t+1) = (1 - \delta_z)(1 - \varphi^l)z(t) + \xi(t),$$

$$h(t+1) = h(t) + H^l(t).$$
(15)

Configuring the total assets as the total of financial assets and physical assets, the conditional expression for the constraints of Expression (15) is expressed using the following two expressions.

$$a(t + 1) = a(t) + A^{l}(t),$$

 $h(t + 1) = h(t) + H^{l}(t).$

Afterwards, the section for the time preference rate is configured as follows.

Λ

$$= \left(\frac{1}{1+
ho}\right).$$

(17)

(16)

To obtain the Bellman equation¹ for Expression (14):

$$V(a(t), h(t), B(t)) = \max E \left[u \left(c^{l}(t), (1 - \varphi^{l}) z(t) \right) + \Lambda \cdot V(a(t+1), h(t+1), B(t+1)) \right]$$

= max $E \left[u \left(c^{l}(t), (1 - \varphi^{l}) z(t) \right) + \Lambda \cdot V \left(a(t) + A^{l}(t), h(t) + H^{l}(t), B(t) + B^{\circ}(t) \right) \right],$
(18)

where $B^{\circ}(t) = B(t+1) - B(t)$. Approximating the second polynomial on the right side in Expression (18) results in:

$$V(a(t), h(t), B(t)) = \max \sum_{l} \mu^{l} \left[\frac{u(c^{l}(t), (1 - \varphi^{l})z(t))}{+A \cdot \{V + V_{a} \cdot A^{l}(t) + V_{h} \cdot H^{l}(t) + V_{B} \cdot B^{\circ}(t)\}} \right].$$
(19)

$$(1 - \Lambda) \cdot V(a(t), h(t), B(t))$$

$$= \max \sum_{l} \mu^{l} \left[u\left(c^{l}(t), (1 - \varphi^{l})z(t)\right) + \Lambda \cdot \{V_{a} \cdot A^{l}(t) + V_{h} \cdot H^{l}(t) + V_{B} \cdot B^{\circ}(t)\} \right].$$
(20)

Using the first-order conditions (differential of the objective function using c^{l} , z, m^{l}) from Expression (20) to maximize the expected lifetime utility:

$$\frac{\partial V(a,h,B)}{\partial c^{l}} = 0,$$
$$\frac{\partial V(a,h,B)}{\partial z} = 0,$$
$$\frac{\partial V(a,h,B)}{\partial z} = 0,$$

$$\frac{\partial V(a,h,B)}{\partial m^l} = 0.$$
(21)

Using Expression (21), the following three equations are obtained.

$$c^{l} : u_{c}(c^{l}, (1 - \varphi^{l})z) = \Lambda \cdot V_{a},$$

$$(22)$$

$$z : \sum_{l} \mu^{l} \{ u_{z}(c^{l}, (1 - \varphi^{l})z) + \Lambda \cdot V_{a} \cdot (1 - \varphi^{l}) \cdot (1 - \delta_{z}) \} = \Lambda \cdot V_{a} \sum_{l} \mu^{l} (1 - \psi^{l}) \{ r(t) + 1 \},$$

$$m^l$$
: $V_h \cdot \varsigma = V_a \cdot \{\eta^l(m^l)\}'$.

(24)

(23)

2) Profit Maximization

Firms behave toward the maximization of the following profit function.

$$\begin{aligned} &\text{Max} \quad \widetilde{\Pi}_{l}(t) = Y(t) - TC(t) \\ &= F \Big(B(t), (1 - \omega^{l}) H(t), (1 - \psi^{l}) K(t), (1 - \tau^{l}) \widetilde{T} \Big) - w_{l}(t) \cdot (1 - \omega^{l}) H(t) - \{ r_{l}(t) + \delta_{k} \} \cdot (1 - \psi^{l}) K(t) \end{aligned}$$

$$(25)$$

where

$\widetilde{\Pi}_l$: Firm profit (after the occurrence of a rank *l* disaster)

Using the first-order conditions (differential of the objective function using H and K) from Expression (25) to maximize profit results in:

$$\frac{\partial \widetilde{\Pi}_l}{\partial H} = 0,$$
$$\frac{\partial \widetilde{\Pi}_l}{\partial K} = 0.$$
(26)

Using Expression (26), the following two equations are obtained.

$$H : \frac{\partial F(B(t), (1 - \omega^{l})H(t), (1 - \psi^{l})K(t), (1 - \tau^{l})\tilde{T})}{\partial H} = w_{l}(t) \cdot (1 - \omega^{l}),$$

$$K : \frac{\partial F(B(t), (1 - \omega^{l})H(t), (1 - \psi^{l})K(t), (1 - \tau^{l})\tilde{T})}{\partial K} = \{r_{l}(t) + \delta_{k}\} \cdot (1 - \psi^{l}),$$
(28)

s.t.

where

μ^l : Disaster probability (rank 1 disaster)

 $0 < \mu^{l} < 1$,

The first-order conditions represent that the amount of elemental investment is determined so that the amount of this limited production is equal to the marginal cost regarding labor and production capital.

All firm's profit $\tilde{\Pi}_l$ is distributed to household as land rent. The amount of distribution is determined in accordance with the ratio of land area owned.

$$\pi_l(t) = \frac{\widetilde{\Pi}_l(t)}{(1-\tau^l)\widetilde{T}} = \frac{\widetilde{\Pi}_l(t)}{(1-\tau^l)nT}.$$
(29)

3) Market Equilibrium

The market equilibrium is uniquely determined by simultaneously solving the five equations produced from calculating Expressions (22), (23), and (24), which are the first-order conditions to maximize expected lifetime utility, and Expressions (27) and (28), which are the first-order conditions to maximize profit. Each equation is rewritten here.

$$c^{l} : u_{c}(c^{l}, (1 - \varphi^{l})z) = \Lambda \cdot V_{a},$$

$$z : \sum_{l} \mu^{l} \{u_{z}(c^{l}, (1 - \varphi^{l})z) + \Lambda \cdot V_{a} \cdot (1 - \varphi^{l}) \cdot (1 - \delta_{z})\}$$

$$= \Lambda \cdot V_{a} \sum_{l} \mu^{l} (1 - \psi^{l}) \{r(t) + 1\},$$

$$m^{l} : V_{h} \cdot \varsigma = V_{a} \cdot \{\eta^{l}(m^{l})\}',$$

$$H : \frac{\partial F(B(t), (1 - \omega^{l})H(t), (1 - \psi^{l})K(t), (1 - \tau^{l})\tilde{T})}{\partial H} = w_{l}(t) \cdot (1 - \omega^{l}),$$

$$K : \frac{\partial F(B(t), (1 - \omega^{l})H(t), (1 - \psi^{l})K(t), (1 - \tau^{l})\tilde{T})}{\partial K} = \{r_{l}(t) + \delta_{k}\} \cdot (1 - \psi^{l}).$$
(30)

(4) Social Optimization

Externalities do not exist in this model, and so the market equilibrium equation is equivalent to the social optimization solution. The following equation is used to equalize the amount of production and the amount of distribution.

$$F(B(t), (1 - \omega^{l})h(t), (1 - \psi^{l})b(t), (1 - \tau^{l})T)$$

= $w_{l}(t) \cdot (1 - \omega^{l})h(t) + \{r_{l}(t) + \delta_{k}\} \cdot (1 - \psi^{l})b(t) + \pi_{l}(t) \cdot (1 - \tau^{l})T.$
(31)

As with Expression (4), this can be rewritten using Expression (31).

$$\begin{split} b(t+1) &= \{1 + r_l(t)\}(1 - \psi^l)b(t) + w_l(t) \cdot (1 - \omega^l)h(t) + \pi_l(t) \cdot (1 - \tau^l)T - c^l(t) - \eta^l\left(m^l(t)\right) - \xi(t) \\ &= \{r_l(t) + \delta_k\}(1 - \psi^l)b(t) + w_l(t) \cdot (1 - \omega^l)h(t) + \pi_l(t) \cdot (1 - \tau^l)T - c^l(t) - \eta^l\left(m^l(t)\right) - \xi(t) \\ &+ (1 - \delta_k)(1 - \psi^l)b(t) \\ &= F(B(t), (1 - \omega^l)h(t), (1 - \psi^l)b(t), (1 - \tau^l)T) - c^l(t) - \eta^l\left(m^l(t)\right) - \xi(t) \\ &+ (1 - \delta_k)(1 - \psi^l)b(t). \end{split}$$

(32)

(33)

As with Expression (31), this can be rewritten using Expression (12). a(t + 1) = b(t + 1) + z(t + 1)

$$= w_{l}(t) \cdot (1 - \omega^{l})h(t) + \{1 + r_{l}(t)\}(1 - \psi^{l})b(t) + \pi_{l}(t) \cdot (1 - \tau^{l})T - c^{l}(t) - \eta^{l}(m^{l}(t)) + (1 - \delta_{z})(1 - \varphi^{l})z(t)$$

$$= w_{l}(t) \cdot (1 - \omega^{l})h(t) + \{r_{l}(t) + \delta_{k}\}(1 - \psi^{l})b(t) + \pi_{l}(t) \cdot (1 - \tau^{l})T - c^{l}(t) - \eta^{l}(m^{l}(t)) + (1 - \delta_{z})(1 - \varphi^{l})z(t) + (1 - \delta_{k})(1 - \psi^{l})b(t) + \pi_{l}(t) \cdot (1 - \tau^{l})T - \{\delta_{k} + (1 - \delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t) - \eta^{l}(m^{l}(t)) - \{(1 - \psi^{l})(1 - \delta_{k}) - (1 - \varphi^{l})(1 - \delta_{z})\}z(t)$$

$$= a(t) + F(B(t), (1 - \omega^{l})h(t), (1 - \psi^{l})b(t), (1 - \tau^{l})T) - \{\delta_{k} + (1 - \delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t) - \eta^{l}(m^{l}(t)) - \{(1 - \psi^{l})(1 - \delta_{z})\}z(t)$$

$$= a(t) + A^{l}(t),$$

$$A^{l}(t) \coloneqq F(B(t), (1 - \omega^{l})h(t), (1 - \psi^{l})T) - \{\delta_{k} + (1 - \delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t) - \eta^{l}(m^{l}(t)) - \{(1 - \psi^{l})(1 - \delta_{k}) - (1 - \varphi^{l})(1 - \delta_{z})\}z(t).$$

The social optimization solution has fewer expressions and variables and so is generally easier to calculate than the market equilibrium solution. For this reason, analysis is performed in this model using

the social optimization problem. Thus, for the remaining sections, only households are the focus of problem solutions as it is assumed that the economy is managed by responsible social planners trying to maximize the expected lifetime utility for a representative household.

$$\mathbb{V}(a(t),h(t),B(t))\cdot\left(\frac{1}{1+\rho}\right)^{t} = \max \mathbb{E}\left[\sum_{t'=t}^{\infty} u\left(c^{l}(t'),(1-\varphi^{l})z(t')\right)\cdot\left(\frac{1}{1+\rho}\right)^{t'}\right],$$
(34)

s.t.

$$b(t+1) = F(B(t), (1-\omega^{l})h(t), (1-\psi^{l})b(t), (1-\tau^{l})T) - c^{l}(t) - \eta^{l} \left(m^{l}(t)\right) - \xi(t)$$

 $+ (1 - \delta_k)(1 - \psi^l)b(t),$ $z(t+1) = (1 - \delta_z)(1 - \varphi^l)z(t) + \xi(t),$ $h(t+1) = h(t) + H^l(t).$

(35)

Configuring the total assets as the total of financial assets and physical assets, the conditional expression for the constraints of Expression (35) is expressed using the following two expressions.

$$a(t+1) = a(t) + A^{l}(t),$$

$$h(t+1) = h(t) + H^{l}(t).$$
(36)

The section for the time preference rate is configured as follows.

$$\Lambda = \left(\frac{1}{1+\rho}\right). \tag{37}$$

To obtain the Bellman equation² for Expression (34):

$$V(a(t), h(t), B(t)) = \max E \left[u \left(c^{l}(t), (1 - \varphi^{l}) z(t) \right) + \Lambda \cdot V \left(a(t+1), h(t+1), B(t+1) \right) \right]$$

= max E $\left[u \left(c^{l}(t), (1 - \varphi^{l}) z(t) \right) + \Lambda \cdot V \left(a(t) + A^{l}(t), h(t) + H^{l}(t), B(t) + B^{\circ}(t) \right) \right],$

(38)

where $B^{\circ}(t) = B(t+1) - B(t)$. Approximating the second polynomial on the right hand side using the Taylor expansion results in:

$$V(a(t), h(t), B(t)) = \max \sum_{l} \mu^{l} \left[u \left(c^{l}(t), (1 - \varphi^{l}) z(t) \right) + \Lambda \cdot \left\{ V + V_{a} \cdot A^{l}(t) + V_{h} \cdot H^{l}(t) + V_{B} \cdot B^{\circ}(t) \right\} \right]$$
(39)

The objective function can be expressed as follows by binding the left side of Expression (39) with V.

$$(1 - \Lambda) \cdot V(a(t), h(t), B(t)) = \max \sum_{l} \mu^{l} \left[u\left(c^{l}(t), (1 - \varphi^{l})z(t)\right) + \Lambda \cdot \{V_{a} \cdot A^{l}(t) + V_{h} \cdot H^{l}(t) + V_{B} \cdot B^{\circ}(t)\} \right],$$

$$(40)$$

Applying the first-order conditions for social optimization to the objective function (40) results in:

$$\frac{\partial V(a, h, B)}{\partial c^{l}} = 0,$$

$$\frac{\partial V(a, h, B)}{\partial z} = 0,$$

$$\frac{\partial V(a, h, B)}{\partial m^{l}} = 0.$$
(41)

As a result, the following three equations are obtained.

$$c^{l} : u_{c}(c^{l}, (1 - \varphi^{l})z) = \Lambda \cdot V_{a},$$

$$(42)$$

$$z : \sum_{l} \mu^{l} \{ u_{z}(c^{l}, (1 - \varphi^{l})z) + \Lambda \cdot V_{a} \cdot (1 - \varphi^{l})(1 - \delta_{z}) \} = \Lambda \cdot V_{a} \sum_{l} \mu^{l} \{ F_{b} + (1 - \psi^{l})(1 - \delta_{k}) \},$$

$$(43)$$

$$m^{l}: V_{h} \cdot \varsigma = V_{a} \cdot \{\eta^{l}(m^{l})\}'.$$

Thus, the social optimization solution is obtained by solving the following equation.

$$c^{l} : u_{c}(c^{l}, (1 - \varphi^{l})z) = \Lambda \cdot V_{a},$$

$$z : \sum_{l} \mu^{l} \{ u_{z}(c^{l}, (1 - \varphi^{l})z) + \Lambda \cdot V_{a} \cdot (1 - \varphi^{l})(1 - \delta_{z}) \}$$

$$= \Lambda \cdot V_{a} \sum_{l} \mu^{l} \{ F_{b} + (1 - \psi^{l})(1 - \delta_{k}) \},$$

$$m^{l} : V_{h} \cdot \varsigma = V_{a} \cdot \{ \eta^{l}(m^{l}) \}',$$

s.t.

$$\begin{aligned} a(t+1) &= a(t) + A^{l}(t), \\ A^{l}(t) &= F(B(t), (1-\omega^{l})h(t), (1-\psi^{l})b(t), (1-\tau^{l})T) - \{\delta_{k} + (1-\delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t) \\ &- \eta^{l} \left(m^{l}(t)\right) - \{(1-\psi^{l})(1-\delta_{k}) - (1-\varphi^{l})(1-\delta_{z})\}z(t) \end{aligned}$$

$$\begin{split} h(t+1) &= h(t) + H^l(t), \\ H^l(t) &= -\delta_h \cdot h(t) + \varsigma \cdot m^l(t). \end{split}$$

b : b(t) = a(t) - z(t),

(45)

2.3.5 Formulations to Simplify the Calculations

(1) Configuring the Formation of the Value Function

The formation of the value function is unknown, and so the previously described first-order conditions cannot be solved without modification. For this reason, it is assumed that the marginal utility decreases to arrive at the following formation.

$$V(a,h,B) = v_0 + v_1 \cdot (Ba)^{1-\theta} + v_2 \cdot (Bh)^{1-\theta}.$$
(46)

Differentiating expression (46) by the first degree results in the following.

$$V_{a} = \frac{\partial V(a, h, B)}{\partial a} = (1 - \theta) \cdot v_{1}B \cdot (Ba)^{-\theta},$$

$$V_{h} = \frac{\partial V(a, h, B)}{\partial h} = (1 - \theta) \cdot v_{2}B \cdot (Bh)^{-\theta}.$$
(47)

(48)

(2) Configuring the Formation of the Human Investment Cost Function

The cost function related to human investment assumes the following quadratic function as it is assumed that education costs increase as the number of education increases. The coefficient η_2^l as a term in the quadratic m^l is determined by the rank of the disaster.

$$\eta^{l}(m^{l}) = \eta_{0} + \eta_{1} \cdot m^{l} + \eta_{2}^{l} \cdot (m^{l})^{2}.$$
(49)

Differentiating expression (49) by the first degree results in the following.

$$\frac{\partial \eta^l(m^l)}{\partial m^l} = \eta_1 + 2\eta_2^l \cdot m^l.$$
(50)

Other potential formations of the human investment cost function include logarithmic or logistic types, but these functions cannot be statistically identified due to constraints on data. For this reason, the function has been configured as a quadratic function as the current focus is simplification.

2.3.6 Resulting Basic Constitutive Equations and Their Expansion

First-order conditions can be rewritten as follows by substituting first-order differential equations (47), (48), and (50) with first-order conditional equations (42), (43), and (44).

$$c^{l}: u_{c}(c^{l}, (1-\varphi^{l})z) = \Lambda \cdot (1-\theta) \cdot \nu_{1}B \cdot (Ba)^{-\theta},$$

(51)

$$z : \sum_{l} \mu^{l} \{ u_{z} (c^{l}, (1 - \varphi^{l})z) + \Lambda \cdot (1 - \theta) \cdot \nu_{1}B \cdot (Ba)^{-\theta} \cdot (1 - \varphi^{l})(1 - \delta_{z}) \}$$

$$= \Lambda \cdot (1 - \theta) \cdot \nu_{1}B \cdot (Ba)^{-\theta} \sum_{l} \mu^{l} \{ F_{b} + (1 - \psi^{l})(1 - \delta_{k}) \},$$

$$m^{l} : (1 - \theta) \cdot \nu_{2}B \cdot (Bh)^{-\theta} \cdot \varsigma = (1 - \theta) \cdot \nu_{1}B \cdot (Ba)^{-\theta} \cdot (\eta_{1} + 2\eta_{2}^{l} \cdot m^{l}).$$
(52)

Using Expression (51) for
$$c^{l}$$
:

$$= Q_{0}$$

$$c^{l} - \bar{c} = \left\{ \underbrace{\frac{\gamma_{1}}{(1-\theta) \cdot \nu_{1} \cdot B^{1-\theta}}}_{Q_{0}^{P_{0}} \cdot (1-\varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}}} \cdot (1-\varphi^{l}) \underbrace{= P_{1}}_{1-\gamma_{1}(1-\theta)} = P_{2}$$

$$= Q_{0}^{P_{0}} \cdot (1-\varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}}$$
(54)

Using Expression (52) for z,

$$\sum_{l} \mu^{l} \{u_{z} + \Lambda \cdot V_{a}(1 - \varphi^{l})(1 - \delta_{z})\} = \Lambda \cdot V_{a} \cdot \sum_{l} \mu^{l} \{F_{b} + (1 - \psi^{l})(1 - \delta_{k})\}$$

$$\sum_{l} \mu^{l} [u_{z} - \Lambda \cdot V_{a}\{(1 - \psi^{l})(1 - \delta_{k}) - (1 - \varphi^{l})(1 - \delta_{z})\}] = \Lambda \cdot V_{a} \cdot \sum_{l} \mu^{l} \cdot F_{b}$$

$$\sum_{l} \mu^{l} [u_{z} - \Lambda \cdot V_{a}\{\underbrace{(\delta_{z} - \delta_{k})}_{= \delta_{zk}}] + \underbrace{\varphi^{l} - \psi^{l} + \psi^{l} \delta_{k} - \varphi^{l} \delta_{z}}_{= \varphi^{l}_{s}}] = \Lambda \cdot V_{a} \cdot \sum_{l} \mu^{l} \cdot F_{b}.$$
(55)

Here, obtaining the first derivative related to (2) in the instantaneous utility function, (2) results in:

$$u_{z} = \gamma_{2} \cdot z^{\gamma_{2}(1-\theta)-1} \cdot \left\{ Q_{0}^{P_{0}} \cdot (1-\varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}} \right\}^{\gamma_{1}(1-\theta)} \cdot (1-\varphi^{l})^{\gamma_{2}(1-\theta)}$$

$$= \underbrace{\left[\gamma_{2} \cdot Q_{0}^{P_{0}\gamma_{1}(1-\theta)} \right]}_{= Q_{1}} \cdot a^{P_{2}\gamma_{1}(1-\theta)} \cdot \left\{ (1-\varphi^{l}) \cdot z \right\}^{\gamma_{2}(1-\theta)-1+P_{1}\gamma_{1}(1-\theta)} \cdot (1-\varphi^{l}).$$

$$= Q_{1}$$
(56)

The degree of $(1 - \varphi^l) \cdot z$ is $\gamma_2(1 - \theta) - 1 + P_1 \cdot \gamma_1(1 - \theta) = -\frac{\theta}{1 - \gamma_1(1 - \theta)} = -P_2$. So (56) can be

written as follows:

$$u_{z} = Q_{1} \cdot a^{P_{2}\gamma_{1}(1-\theta)} \cdot (1-\varphi^{l})^{-P_{2}+1} \cdot z^{-P_{2}}.$$
(57)

Substituting Expression (57) with Expression (55) results in:

$$\sum_{l} \mu^{l} \{ Q_{1} \cdot a^{P_{2}\gamma_{1}(1-\theta)} \cdot (1-\varphi^{l})^{-P_{2}+1} \cdot z^{-P_{2}} \} = \Lambda \cdot V_{a} \left(\delta_{zk} + \sum_{l} \mu^{l} \cdot \varphi_{s}^{l} + \sum_{l} \mu^{l} \cdot F_{b} \right).$$

$$= Q_{3}$$
(58)

$$\sum_{l} \mu^{l} F_{b} = \underbrace{\sum_{l} \mu^{l} \cdot \alpha_{2} \cdot (1 - \omega^{l})^{\alpha_{1}} (1 - \psi^{l})^{\alpha_{2}} \cdot (1 - \tau^{l})^{\alpha_{3}}}_{= \frac{S_{0} \cdot F(\cdot)}{a - z}} \cdot F(\cdot) \cdot (a - z)^{-1}$$
(59)

Thus, substituting Expression (59) with Expression (58) results in:

$$Q_{1} \cdot a^{P_{2}\gamma_{1}(1-\theta)} \cdot z^{-P_{2}} \left(\sum_{l} \mu^{l} \cdot (1-\varphi^{l})^{-P_{2}+1} \right) = \Lambda \cdot (1-\theta) \cdot \nu_{1} \cdot B^{1-\theta} \cdot a^{-\theta} \left(Q_{3} + \frac{S_{0} \cdot F(\cdot)}{a-z} \right).$$

= Q₂

(6	0)
· ·		/

The degree of *a* is the result of " $P_2 \cdot \gamma_1(1 - \theta) + \theta = P_2$ ", and so Expression (60) is simplified as follows.

$$\frac{Q_1 \cdot Q_2}{Q_3 \cdot \Lambda (1-\theta) v_1 B^{1-\theta}} \cdot a^{P_2} = z^{P_2} \left[1 + \frac{S_0 \cdot F(\cdot)}{Q_3 \cdot (a-z)} \right]$$

$$= S_1$$

$$\left(\frac{Q_1 \cdot Q_2}{Q_3 \cdot \Lambda (1-\theta) \cdot v_1 \cdot B^{1-\theta}} \right)^{\frac{1}{P_2}} \cdot a = z \left[1 + \frac{S_1 \cdot F(\cdot)}{a-z} \right]^{\frac{1}{P_2}}.$$

$$= Q_4$$

$$\left[1 + \frac{S_1 \cdot F(\cdot)}{a-z} \right]^{\frac{1}{P_2}} \cdot z = Q_4 \cdot a.$$
(61)

Using Expression (53) for m^l :

$$m^{l} = \frac{\varsigma \cdot \nu_{2} \cdot a^{\theta} - \nu_{1} \cdot \eta_{1} \cdot h^{\theta}}{2\nu_{1} \cdot \eta_{2}^{l} \cdot h^{\theta}}$$
$$= \frac{1}{2\eta_{2}^{l}} \left\{ \frac{\nu_{2}}{\nu_{1}} \cdot \left(\frac{h}{a}\right)^{-\theta} \cdot \varsigma - \eta_{1} \right\}.$$
(63)

Simplifying Expressions (54), (62), and (63) results in the following.

$$c^{l}: c^{l} - \bar{c} = Q_{0}^{P_{0}} \cdot (1 - \varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}},$$
(64)

$$z : \left[1 + \frac{S_1 \cdot F(\cdot)}{a - z}\right]^{\frac{1}{P_2}} \cdot z = Q_4 \cdot a,$$
(65)

$$m^{l}: m^{l} = \frac{1}{2\eta_{2}^{l}} \left\{ \frac{\nu_{2}}{\nu_{1}} \cdot \left(\frac{h}{a}\right)^{-b} \cdot \varsigma - \eta_{1} \right\},$$
(66)

where

$$\begin{split} \mathsf{P}_{0} &= \frac{1}{1 - \gamma_{1}(1 - \theta)}, \\ \mathsf{P}_{1} &= \frac{\gamma_{2}(1 - \theta)}{1 - \gamma_{1}(1 - \theta)}, \\ \mathsf{P}_{2} &= \frac{\theta}{1 - \gamma_{1}(1 - \theta)}, \\ \mathsf{Q}_{0} &= \frac{\gamma_{1}}{\Lambda \cdot (1 - \theta) \cdot \nu_{1} \cdot B^{1 - \theta}}, \\ \mathsf{Q}_{1} &= \gamma_{2} \cdot Q_{0}^{\rho_{0}\gamma_{1}(1 - \theta)}, \\ \mathsf{Q}_{2} &= \sum_{l} \mu^{l}(1 - \varphi^{l})^{-P_{2} + 1}, \\ \mathsf{Q}_{3} &= \delta_{zk} + \sum_{l} \mu^{l} \cdot \varphi_{s}^{l}, \\ \mathsf{Q}_{4} &= \left\{ \frac{Q_{1} \cdot Q_{2}}{Q_{3} \cdot \Lambda \cdot (1 - \theta) \cdot \nu_{1} \cdot B^{1 - \theta}} \right\}^{\frac{1}{P_{2}}}, \\ \delta_{zk} &= \delta_{z} - \delta_{k}, \\ \varphi_{s}^{l} &= \varphi^{l} - \psi^{l} + \psi^{l} \delta_{k} - \varphi^{l} \delta_{z}, \\ \mathsf{S}_{0} &= \alpha_{2} \sum_{l} \mu^{l} (1 - \omega^{l})^{\alpha_{1}}(1 - \psi^{l})^{\alpha_{2}}(1 - \tau^{l})^{\alpha_{3}}, \\ \mathsf{S}_{1} &= \frac{S_{0}}{Q_{3}}. \end{split}$$

(67)

Thus, the basic constitutive equations to be solved by the program are as follows.

$$c^{l}: c^{l} - \overline{c} = Q_{0}^{P_{0}} \cdot (1 - \varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}},$$

$$z: \left[1 + \frac{S_{1} \cdot F(\cdot)}{a - z}\right]^{\frac{1}{P_{2}}} \cdot z = Q_{4} \cdot a,$$

$$m^{l}: m^{l} = \frac{1}{2\eta_{2}^{l}} \left\{ \frac{\nu_{2}}{\nu_{1}} \cdot \left(\frac{h}{a}\right)^{-\theta} \cdot \varsigma - \eta_{1} \right\},$$

$$b: b(t) = a(t) - z(t),$$
s.t.

$$\begin{split} a(t+1) &= a(t) + A^{l}(t), \\ A^{l}(t) &= F(B(t), (1-\omega^{l})h(t), (1-\psi^{l})b(t), (1-\tau^{l})T) - \{\delta_{k} + (1-\delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t) \\ &- \eta^{l} \left(m^{l}(t)\right) - \{(1-\psi^{l})(1-\delta_{k}) - (1-\varphi^{l})(1-\delta_{z})\}z(t), \\ h(t+1) &= h(t) + H^{l}(t), \end{split}$$

$$\begin{split} H^l(t) &= -\delta_h \cdot h(t) + \varsigma \cdot m^l(t), \\ \eta^l(m^l) &= \eta_0 + \eta_1 \cdot m^l + \eta_2^l \cdot (m^l)^2, \end{split}$$

where (The following polynomial variables are given values for exogenous variables, simulation calculations, and configuring constants.)

$$\begin{split} & P_{0} = \frac{1}{1 - \gamma_{1}(1 - \theta)}, \\ & P_{1} = \frac{\gamma_{2}(1 - \theta)}{1 - \gamma_{1}(1 - \theta)}, \\ & P_{2} = \frac{\theta}{1 - \gamma_{1}(1 - \theta)}, \\ & Q_{0} = \frac{\gamma_{1}}{\Lambda \cdot (1 - \theta) \cdot \nu_{1} \cdot B^{1 - \theta}}, \\ & Q_{1} = \gamma_{2} \cdot Q_{0}^{P_{0}\gamma_{1}(1 - \theta)}, \\ & Q_{2} = \sum_{l} \mu^{l}(1 - \varphi^{l})^{-P_{2} + 1}, \\ & Q_{3} = \delta_{zk} + \sum_{l} \mu^{l} \cdot \varphi_{s}^{l}, \\ & Q_{4} = \left\{ \frac{Q_{1} \cdot Q_{2}}{Q_{3} \cdot \Lambda \cdot (1 - \theta) \cdot \nu_{1} \cdot B^{1 - \theta}} \right\}^{\frac{1}{P_{2}}}, \\ & \delta_{zk} = \delta_{z} - \delta_{k}, \\ & \varphi_{s}^{l} = \varphi^{l} - \psi^{l} + \psi^{l} \delta_{k} - \varphi^{l} \delta_{z}, \\ & S_{0} = \alpha_{2} \sum_{l} \mu^{l} (1 - \omega^{l})^{\alpha_{1}}(1 - \psi^{l})^{\alpha_{2}}(1 - \tau^{l})^{\alpha_{3}}, \\ & S_{1} = \frac{S_{0}}{Q_{3}}. \end{split}$$

(68)

2.3.7 Method of Calculations in the Program

The c^l and m^l first-order conditional equations are explicit functions where as z first-order conditional equations are implicit functions. For this reason, solutions are obtained using the following procedure.

① Substitute (input) the exogenous variables in Expression (68) with initial values.

$$c^{l} : c^{l} - \bar{c} = Q_{0}^{P_{0}} \cdot (1 - \varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}},$$

$$z : \left[\mathbf{1} + \frac{\mathbf{S}_{1} \cdot \mathbf{F}(\cdot)}{\mathbf{a} - \mathbf{z}} \right]^{\frac{1}{P_{2}}} \cdot \mathbf{z} = \mathbf{Q}_{4} \cdot \mathbf{a},$$

$$m^{l} : m^{l} = \frac{1}{2\eta_{2}^{l}} \left\{ \frac{\nu_{2}}{\nu_{1}} \cdot \left(\frac{h}{a}\right)^{-\theta} \cdot \varsigma - \eta_{1} \right\},$$

$$b: b(t) = a(t) - z(t),$$

s.t.

$$\begin{aligned} a(t+1) &= a(t) + A^{l}(t), \\ A^{l}(t) &= F(B(t), (1-\omega^{l})h(t), (1-\psi^{l})b(t), (1-\tau^{l})T) - \{\delta_{k} + (1-\delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t) \\ &- \eta^{l} \left(m^{l}(t)\right) - \{(1-\psi^{l})(1-\delta_{k}) - (1-\varphi^{l})(1-\delta_{z})\}z(t), \end{aligned}$$

$$\begin{split} h(t+1) &= h(t) + H^{l}(t), \\ H^{l}(t) &= -\delta_{h} \cdot h(t) + \varsigma \cdot m^{l}(t), \\ \eta^{l}(m^{l}) &= \eta_{0} + \eta_{1} \cdot m^{l} + \eta_{2}^{l} \cdot (m^{l})^{2}. \end{split}$$

(2) Apply a(0) and h(0) to Expression (68).

This results in obtaining m^l from the m^l first-order conditional equation (explicit function).

$$m^{l}: m^{l} = \frac{1}{2\eta_{2}^{l}} \left\{ \frac{\nu_{2}}{\nu_{1}} \cdot \left(\frac{h}{a}\right)^{-\theta} \cdot \varsigma - \eta_{1} \right\}.$$

③ The z first-order conditional equation (implicit function) is solved using Newton's method. Thus, z is obtained.

$$z : \left[1 + \frac{S_1 \cdot F(\cdot)}{a - z}\right]^{\frac{1}{p_2}} \cdot z = Q_4 \cdot a.$$

(4) Substitute z with the c^{l} first-order conditional equation (explicit function). Thus, c^{l} is obtained.

$$c^{l}$$
: $c^{l} - \bar{c} = Q_{0}^{P_{0}} \cdot (1 - \varphi^{l})^{P_{1}} \cdot a^{P_{2}} \cdot z^{P_{1}}$

(5) Substitute the values of a and z obtained in the preceding step with " $a(t) \coloneqq b(t) + z(t)$ " Thus, b is obtained.

$$b:b(t)=a(t)-z(t).$$

(6) Substitute the values of m^l obtained in the preceding step with " $\eta^l(m^l) = \eta_0 + \eta_1 \cdot m^l + \eta_2^l \cdot (m^l)^2$ ". Thus, the value of $\eta^l(m^l)$ is obtained.

$$\eta^{l}(m^{l}) = \eta_{0} + \eta_{1} \cdot m^{l} + \eta_{2}^{l} \cdot (m^{l})^{2}.$$

 $(\widehat{T}) \text{ Substitute } m^{l}, z, c^{l}, b, \text{ and } \eta^{l}(m^{l}) \text{ obtained by the calculations to } A^{l} \text{ and } H^{l}.$ $A^{l}(t) = F(B(t), (1 - \omega^{l})h(t), (1 - \psi^{l})b(t), (1 - \tau^{l})T) - \{\delta_{k} + (1 - \delta_{k}) \cdot \psi^{l}\}a(t) - c^{l}(t)$ $- \eta^{l}(m^{l}(t)) - \{(1 - \psi^{l})(1 - \delta_{k}) - (1 - \varphi^{l})(1 - \delta_{z})\}z(t),$ $H^{l}(t) = -\delta_{h} \cdot h(t) + \varsigma \cdot m^{l}(t).$

(8) By obtaining A^l and H^l , a and h for the next period is calculated.

$$a(t + 1) = a(t) + A^{l}(t),$$

 $h(t + 1) = h(t) + H^{l}(t).$

(9) Apply a(t+1), h(t+1) to Expression (68).

This results in obtaining m^l from the m^l first-order conditional equation (explicit function).

$$m^{l}: m^{l} = \frac{1}{2\eta_{2}^{l}} \left\{ \frac{\nu_{2}}{\nu_{1}} \cdot \left(\frac{h}{a}\right)^{-\theta} \cdot \varsigma - \eta_{1} \right\}.$$

(1) Steps 3 through 9 are repeated hereafter (continues until the calculation period ends).

Chapter2 How to use DR²AD model (Ver1. 4) Application

3 DR²AD model (ver1.4) Application Overview

3.1 What can DR²AD model (Ver1.4) do?

This section describes the functions of the DR²AD model (Ver1.4). Application output is generally divided into 2 types: output for policy explanation / policy maker decision making and output for analysis / supervisor decision making. The output for policy explanation / policy maker decision making can be used for macroeconomic indexes and other broad decision making. The output for analysis / supervisor decision making can be used for analysis of social issues such as economic and social disparity using household budget indexes from different socioeconomic levels.

	Use	Economic Indexes	Output Type
Policy explanation	Used in broad policy	GDP, disaster scale, disaster	Graphs
/ Policy maker	determinations through	frequency, disaster damage	
decision making macroeconomic indexes		ratios, etc.	CSV mes
		GDP per capita (individual	
Analysis	Detailed analysis of household	income), consumption,	
/ Supervisor determinations	standards of living through	physical assets, financial assets,	CCV/ files
	household budget index and	human capital, education time,	CSV mes
	income bracket data	human investments, etc. by	
		class	

Table-1 Output Types (Overview)

3.2 Preparation

3.2.1 Operating Environment

Refer to the Mathworks Inc. website for operating environment information. <u>http://www.mathworks.com/products/matlab/choosing_hardware.html</u>

■Operating Systems

MATLAB performance is similar on Windows®, Mac OS® X, and Linux®

■ 32-bit or 64-bit?

On Windows computers, using 64-bit Windows and the 64-bit version of MATLAB is the right choice for most situations, because it can access the larger amounts of memory in modern computers (see Memory section), and support for 32-bit Windows will end in the next couple of years. Refer to the Platform Road Map for more information. Also refer to Adopting 64-bit Windows for a more detailed discussion of migrating to 64-bit Windows.

On Mac and Linux computers, the 64-bit version of MATLAB is the only version available.

Recommended Specifications (Windows 64 bit)

32-Bit and 64-Bit MATLAB and Simulink Product Families

Operating Systems	Processors	Disk Space	RAM	Graphics
Windows 8.1	Any Intel or AMD	1 GB for MATLAB	1024 MB	No specific graphics
Windows 8	x86 processor supporting SSE2	only, 3–4 GB for a typical	(At least 2048 MB recommended)	card is required. Hardware
Windows 7 Service Pack 1	Instruction set*	Installation		accelerated graphics card
Windows Vista Service Pack 2				supporting OpenGL 3.3 with 1GB GPU memory
Windows XP Service Pack 3				recommended.
Windows XP x64 Edition Service Pack 2				Learn moreabout system requirements for
Windows Server 2012				
Windows Server 2008 R2 Service Pack 1				
Windows Server 2008 Service Pack 2				
Windows Server 2003 R2 Service Pack 2				

Fig. 3-1 Recommended Specifications (Windows 64 bit)

3.2.2 Program set

The following items are required in order to run the application.

- I. MATLB Runtime program
- II. DR²AD model (ver1.4) program set
- III. Sample excel file (for further analysis, excel file prepared by the user)
- IV. World bank data catalog
- V. Statistic data for target country

3.2.3 Starting DR²AD model (ver1.4)

The operation procedure to start the DR^2AD model (ver1.4) which is the coded version of MATLAB is shown below.

I. Click on the DR2AD_Model file as illustrated in the following figure.



II. The screen shown in the figure below should be displayed.

The second secon	1 W WEATING & MILEN CONTRACTOR AND ADDRESS STORES		
	2 TELA	1018	
SH-NUSP ANDE A HIME	The Artist design and the second design and the second sec	212.01	
REPUTATION A STATE	274 M(1) MAR(N) 742 F(1) MB(4) CH(1) 2 H(0) 7/(2010) 220 F2/(0) 242 F2/(0) 102/(0)		
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III. Click run button in editor tab.

🛛 ディター - C:¥Users¥Cruz_lab¥Desktop¥20150709test¥DR2ADModel.m	
ファイル(F) 編集(E) テキスト(T) 移動(G) セル(C) ッフル(o) パック(B) テスクトップ(D) ウィンドウ(W) ヘルプ(H)	X 5 K
12 日本 11 日本 12 11 12 11	▦◧▤◓◙
*■ E■ - 1.0 + + 1.1 × ≪ ≪ ● 1 □classdef DR2ADModel < handle;	

IV. The GUI screen as shown below is displayed on the screen.

3.2.4 Compile DR^2AD model from ver1.4 to ver.2.4

It is necessary to use the MATLAB Compiler of Mathworks to use the DR²AD model (ver1.4) which is the coded version of MATLAB without depending on the operation environment. By compiling the DR²AD model (ver1.4) with MATLAB Compile, it is possible to build the stand-alone type application.

Furthermore, the application version of DR^2AD model (ver1.4) is called DR^2AD model (ver2.4).

To have detailed information about MATLAB Compiler, refer to the homepage of MathWorks.

<Reference : MATLAB Compiler (MathWorks)> http://mathworks.com/products/compiler/

MathWorks Accelerating the pace of a	ngineering and science	United States I Contact Us How To Buy Search Math/Works
ducts Solutions Academia Support C	ommunity Events Company	Create Account 1
MATLAB Compiler MAJOR UPDATE Build standalone applications from MATLAB p Overview Features Videos Webingts BR	rograms Under Sever Construct 4:000) Tower Leading 1:000 Host Le	A Constant of the second of th
VATLAB Compiler [™] lets you share MATLAB also create Microsoft Excel [®] add-ins and integ When used along with MATLAB Compiler SD software components for integration with othe deployment to enterprise systems is supporte	⁶ programs as standalone applications. You o rate them into Excel spreadsheets. K [™] , you can package MATLAB programs int r programming languages. Large-scale d through MATLAB Production Server [™] .	o TRY OR BUY Contact Sales Product Trial Pricing and Licensing
All applications created with MATLAB Compile oyalty-free deployment to users who do not r he application, or have your users download earn more about MATLAB Compiler support	er use the MATLAB Runtime, which enables need MATLAB. You can package the runtime it during installation. for MATLAB and toolboxes.	with What's New From Chetan Rawal, MATLAB Compiler Technical Expert
Key Features Royalty-Free Sharing with Colleagues and Customers Sharing MATLAB Programs as Standalone		 A2A Develops Risk Management Solution for Energy Markets » Email Chetan
Applications Sharing MATLAB Programs with Excel Users Apps for Packaging Your MATLAB Programs Interactively	Product Overview	Technical Resources Support Technical Articles
Documentation fx Functions 📙 Data S	heet 😨 Apps	System Requirements
		Download MATLAB Runtime User Stories User Community
Application Deployment with MATLAB » View webinar	Try MATLAB Compiler » Get trial software	Answers Blog: Loren on the Art of MATLAB File Exchange

4 HOW TO USE APPLICATION

In this chapter, the operation procedure of the application is explained as the scheme shown below.



Fig. 4-1 Application Usage Procedure

4.1 Launching the application

Click on the **DR2AD_Model** file as illustrated in the following figure.



Fig. 4-2 Opening the Application File

The screen shown in the figure below should be displayed.

iocio Economic Parameters File:	
	Brows
Disaster Parameters File:	
	Brows
elect / Specify Calculation Conditions	
Occurrence of Natural Disaster:	💿 Yes 👘 No
Number of Monte Carlo Iterations:	1000
Calculation Period [year]:	20
Condition of Natural Disaster(s):	Disaster1 +Disaster2
Display of above Conditions in Figure:	🖲 Yes 💿 No
xecute DR2AD model	
Save the Results in the Folder:	7
	Brows
Γ	
Calculation	

Fig. 4-3 Opening the Application File

4.2 Configuring the Application

Run the program in accordance with the process described below.

Ver. 2.4 - Main	- - ×	
DR ² AD model (ve	r. 2.4)	
Socio Economic Parameters File:		1. Load the input data
	Browse	1. Load the input data.
Disaster Parameters File:	Browse	
-Select / Specify Calculation Conditions		
Occurrence of Natural Disaster:	💿 Yes 👘 No	2. Specify the calculation
Number of Monte Carlo Iterations:	1000	2. Specify the calculation
Calculation Period [year]:	20	
Condition of Natural Disaster(s):	Disaster1 +Disaster2	
Display of above Conditions in Figure:	Yes <a>No	3 Specify the location to
Execute DR2AD model		5. Specify the location to
Save the Results in the Folder:		save the calculation result.
	Browse	
Onlaulation		
Calculation		4. Run the calculation.
Copyright Japan International Cooperation Agency		

Fig. 4-4 Process to run Ver 2.4 of this application

- ① Loading the input data
- 2 Specifying the calculation conditions.

(Select whether to include a disaster or not and then specify the number of Monte Carlo simulations, calculation period, the type of disaster, and display of calculation conditions)

- ③ Specifying the location to save the calculation result
- (4) Run the calculation

4.3 Operating the Application

This section describes the procedures to operate the application.

4.3.1 Selecting parameter files

This section describes the procedure to configure the input data. Chapter 5 describes the procedure to configure input values for specific data.

The main types of parameters include Socioeconomic and Disaster parameters. Socioeconomic parameters are further divided into Deep parameters for which principle values are not reconfigured and Macroeconomic parameters and Household data used to input data for each country.

Input data created by Excel should be led on the application. Since there are sample data which is filled by the data of Honduras, Pakistan, Peru, Costa Rica and Guatemala. You are able to run application without the setting for the data of the country.

Initial parameters and description are shown in table below.

Data Type		Examples of
		Data
Socio	Deep parameters	Relative risk aversion level, time preference rate, etc.
Economic parameters	Macroeconomic data	Population, GDP, etc.
	Household data	Consumption, savings, investment, etc.
Disaster parameters	Disaster data	Human capital damage, physical asset damage, etc.

Table 4-1 Types of input data

Parameter name	Description	Data source	Sample value
J	The number of income class	<fixed data=""></fixed>	5
L	The number of disaster classes (not including the no-disaster state)	<fixed data=""></fixed>	4
rho	Time preference rate	Recommended value	0.12
theta	Degree of relative risk aversion	Recommended value	2
cbar	The subsistence level of consumption	Recommended value	0
deltaz	Depreciation rate of physical asset	<fixed data=""></fixed>	0.1
deltak	Depreciation rate of production capital	<fixed data=""></fixed>	0.02
gb	Exogenous technological growth rate	Recommended value	0.042
iota	Compensation coefficient between the human capital investment and the years of education.	Those parameters are defined by the assumption. There will be no effect to the model when you use 1.	1
Pop0	Initial population	World Bank data (by Country)	6762426
GDP0	Initial GDP US\$ (2004, from World bank HP, 2005US\$)	World Bank data (by Country)	9120240790
alpha1	Share parameter for human capital	Social Account Matrix/Input Output Table	0.45
alpha2	Share parameter for physical capital	Social Account Matrix/Input Output Table	0.47
alpha3	Share parameter for land	Social Account Matrix/Input Output Table	0.08
c0	Initial consumption per capita: Data of Households' survey 2004	Household Survey /JICA Poverty Profile	$93 \\ 243 \\ 448 \\ 787 \\ 2564$
h0	Initial human capital per capita (using mean years of schooling as a proxy variable)	UNDP data (Mean years of schooling)/Household Survey /JICA Poverty Profile	3.3 4.2 5.0 6.0 6.9
zO	Initial physical asset investment per capita as flow variable	Household Survey /JICA Poverty Profile	112 293 540 949 3091
b0	Initial financial assets per capita	World Bank data (by Country)	321 842 1554 2732 8899
то	Initial land per capita	World Bank data (by Country)	$\begin{array}{c} 0.02 \\ 0.05 \\ 0.08 \\ 0.15 \\ 0.48 \end{array}$
m0	Initial education time per capita	Household Survey /JICA Poverty Profile	0.33

Parameter name	Description	Data source	Sample value
deltah	Depreciation rate of human capital	World Bank data (by Country)	0.004
eta0	Coefficient of human investment cost function	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank	0
eta1	Coefficient of human investment cost function	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank	0
eta2M	Coefficient of human investment cost function	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank	205.8
eta2Mvector	0 < h <= 6 6 < h <= 9 9 < h <= 11 11 < h <= 15 15 < h <= 17 17 < h <= 20 20 < h <= 60	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank	$\begin{array}{c} 205.8\\ 245.3\\ 381.3\\ 1092.6\\ 1504.3\\ 1918.7\\ 5347.2\\ 20000 \end{array}$

Table 4-3 Reference of Input Data of Disaster Parameters

Parameter name	Description	Data source
	Human conital domago	Human capital damage:
omegaV_DISASTER	note due te digaster hu	Desinventar / UNISDR
(1 or 2)	rate due to disaster by	population :
	rank	World Bank data (by Country)
		Physical assets damage :
white DICASTED	Physical assets damage	Desinventar / UNISDR
$pniv_DISASIEK$	rate due to disaster by	Household:
(1 or 2)	rank	Household Survey / JICA Poverty
		Profile
	Production capital	Set following the relationship between
$psiv_DISASTER$	damage rate due to	Capital damage rate and Physical
(1 or 2)	disaster by rank	assets damage rate
tauV_DISASTER	Damage rate of land due	There are no disaster in this case
(1 or 2)	to disaster by rank	study
	Probability of disaster	UNISDE detebage Designantes
mu	occurrence by rank	UNISDA database Desinventar

Parameter name			Sample value			
Disaster Rank	Rank 0	Rank 1	Rank 2	Rank 3	Rank 4	
mu	0.500	0.464	0.019	0.011	0.007	
DRR			Without			
omegaV_DISASTER1	0	0.110046	0.298150	0.400638	0.475017	
phiV_DISASTER1	0	0.000191	0.000488	0.000634	0.000749	
psiV_DISASTER1	0	0.000840	0.002149	0.002789	0.003294	
tauV_DISASTER1	0	0	0	0	0	
DRR			Soft			
omegaV_DISASTER1	0	0	0	0	0	
phiV_DISASTER1	0	0.000191	0.000488	0.000634	0.000749	
psiV_DISASTER1	0	0.000840	0.002149	0.002789	0.003294	
tauV_DISASTER1	0	0	0	0	0	
DRR	Hard1					
omegaV_DISASTER1	0	0	0.078125	0.273375	0.402195	
phiV_DISASTER1	0	0	0.000153	0.000474	0.000656	
psiV_DISASTER1	0	0	0.000671	0.002084	0.002886	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard2			
omegaV_DISASTER1	0	0	0	0.099688	0.313246	
phiV_DISASTER1	0	0	0	0.000200	0.000541	
psiV_DISASTER1	0	0	0	0.000881	0.002380	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard1+soft			
omegaV_DISASTER1	0	0	0	0	0	
phiV_DISASTER1	0	0	0.000153	0.000474	0.000656	
psiV_DISASTER1	0	0	0.000671	0.002084	0.002886	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard2+soft			
omegaV_DISASTER1	0	0	0	0	0	
phiV_DISASTER1	0	0	0	0.000200	0.000541	
psiV_DISASTER1	0	0	0	0.000881	0.002380	
tauV_DISASTER1	0	0	0	0	0	

Table 4-4 Input Data List of sheet1 on Disaster Parameters (Disaster1 =FLOOD)

Parameter name		Sample value						
Disaster Rank	Rank 0	Rank 1	Rank 2	Rank 3	Rank 4			
mu	0.5	0.468048	0.015625	0.009615	0.006711			
DRR			Without					
omegaV_DISASTER2	0	0.000300	0.000928	0.001243	0.001485			
phiV_DISASTER2	0	0.001339	0.003731	0.005008	0.005959			
psiV_DISASTER2	0	0.005893	0.016416	0.022035	0.026222			
tauV_DISASTER2	0	0	0	0	0			
DRR			Soft					
omegaV_DISASTER2	0	0.000300	0.000928	0.001243	0.001485			
phiV_DISASTER2	0	0.001339	0.003731	0.005008	0.005959			
psiV_DISASTER2	0	0.005893	0.016416	0.022035	0.026222			
tauV_DISASTER2	0	0	0	0	0			
DRR								
omegaV_DISASTER2	0	0	0.000139	0.000719	0.00116			
phiV_DISASTER2	0	0	0.000914	0.003369	0.004995			
psiV_DISASTER2	0	0	0.004019	0.014823	0.021976			
tauV_DISASTER2	0	0	0	0	0			
DRR			Hard2					
omegaV_DISASTER2	0	0	0	0.000175	0.000813			
phiV_DISASTER2	0	0	0	0.001179	0.003873			
psiV_DISASTER2	0	0	0	0.005188	0.017041			
tauV_DISASTER2	0	0	0	0	0			
DRR			Hard1+soft					
omegaV_DISASTER2	0	0	0.000139	0.000719	0.00116			
phiV_DISASTER2	0	0	0.000914	0.003369	0.004995			
psiV_DISASTER2	0	0	0.004019	0.014823	0.021976			
tauV_DISASTER2	0	0	0	0	0			
DRR			Hard2+soft					
omegaV_DISASTER2	0	0	0	0.000175	0.000813			
phiV_DISASTER2	0	0	0	0.001179	0.003873			
psiV_DISASTER2	0	0	0	0.005188	0.017041			
tauV_DISASTER2	0	0	0	0	0			

 Table 4-5
 Input Data List of sheet2 on Disaster Parameters (Disaster2 = EARTHQUAKE)

(3) Socio Economic Parameters

Here you can insert socioeconomic data.

Click **Browse** and select the Excel file to load.

Ver. 2,4 - Main				- E X		
CO Select Parameter File	DR ² AD	D model (ver. 2.4)	_			
Socio Economic P	arameters File:					
C:DR2ADver2.4¥Socio	EconomicParameter	rs.xlsx	Bro	Wse		
Disaster Paramete	rs File:]		
Colort / Specify Color	lation Conditions		Bro	9495C		
Select / Specity Calcu	Conditions	tural Disaster: @ Yes	O No			
	📣 Upload the Input Param	neters File				
NI	בשעב 📭 🔍 🔊	ーター 🖡 OS (C:) 🖡 DR2ADver2.4 🖡			✓ +→ DR2AL	Dver2.4の検索
	整理 ▼ 新しいフォル	ダー				E • 🔳
	🧯 ダウンロード 🔺	名前	更新日時	種類	サイズ	
	🔜 デスクトップ	1	2015/07/14 11:17	ファイルフォル		
	💹 最近表示した場所	L CoreFunctions	2015/07/14 10:06	ファイル フォル		
Displa	☆★業務ショートフ	🍌 Executables	2015/07/14 11:19	ファイル フォル		
		📕 Images	2015/07/14 10:06	ファイル フォル		
and the state of the	🧊 ライブラリ	📕 Utilities	2015/07/14 10:06	ファイル フォル		
xecute DR2AD mod	ドキュメント 🗉	DisasterParameters	2015/07/14 10:06	Microsoft Excel	16 KB	
Save the Results	■ ピクチャ	initial_parameters	2015/07/14 10:06	Microsoft Excel	9 KB	
	■ ビデオ	SocioEconomicParameters	2015/07/14 10:06	Microsoft Excel	12 KB	
	→ ミュージック					
	- 20 K K					
	1					
<i>T</i>	1					
Г	P OC (C·)					
	S (C:)					
[S (C:)					
	S (C:)					
	Mos (c:)	イル名(N): SocioEconomicParameters			▼ Excel Fi	ies (*.xls, *.xlsx)

Fig. 4-5 Specifying the Socio Economic parameters file

There are two options to set up Excel file.

First way is to use a sample excel file with already filled with data.

Another way is to create a country's original data.

Option 1	Default value or Sample data
Option 2	Country's original data

<Option 1: Default value or Sample data>

In order to run the application without setting the country's data, you can use 5 country's data below as a sample.

Evcel Eile name	SEPara_Sample	SEPara_Sample	SEPara_Sample	SEPara_Sample	SEPara_Sample
	HONDURAS	PAKISTAN	PERU	GUATEMALA	COSTARICA
J	5	5	5	5	5
L	4	4	4	4	4
rho	0.12	0.12	0.12	0.12	0.12
theta	2	2	2	2	2
cbar	0	0	0	0	0
deltaz	0.1	0.1	0.1	0.1	0.1
deltak	0.02	0.02	0.02	0.02	0.02
gb	0.042	0.042	0.042	0.042	0.042
iota	1	1	1	1	1
Pop0	6762426	155151394	27403845	12367800	4246336
GDP0	9120240790	101704136879	70530831291	26352121441	18855016400
alpha1	0.45	0.52	0.38	0.38	0.45
- alnha9	0.47	0.4	0.54	0.54	0.47
aipiiaz					
alpha3	0.08	0.08	0.08	0.08	0.08
	93	208	295	241	462
-0	243	289	583	545	1032
cu	448	369	926	889 1497	1613
	101 2564	400	1407	1427	2070
	2004	3.9	84	3.5	7.9
	4 2	3.9	8.4	3.5	7.9
h0	5.0	4.2	8.4	3.5	7.9
	6.0	4.4	8.4	3.5	7.9
	6.9	5.6	8.4	3.5	7.9
	112	186	306	364	498
	293	259	605	825	1112
z0	540	331	962	1345	1738
	949	429	1513	2158	2775
	3091	827	3923	5779	7084
	321	1297	1101	1277	1793
b 0	842 1554	1801	2170	2892	4005
UU	1004 9739	2306	5430	4715 7564	9993
	8899	5765	14104	20256	25513
	0.02	0.06	0.03	0.02	0.01
	0.05	0.09	0.05	0.05	0.02
то	0.08	0.11	0.09	0.08	0.03
	0.15	0.15	0.14	0.13	0.05
	0.48	0.28	0.35	0.36	0.13
m0	0.33	0.18	0.31	0.31	0.26
deltah	0.004	0.005	0.005	0.005	0.005
eta0	0	0	0	0	0
-4-1	0	0	0	0	0
etai	205.8	100.9	632	310	1001.9
eta2M	205.8	100.9	032	510	1001.9
	205.8	100.9	555.4	310.0	880.3
	245.3	120.3	632.0	369.8	1001.9
	381.3 1002 G	107.3	1164.9	070.0 1652 2	1006.8
eta2Mvector	1092.0	651 A	1104.0	1000.0 2275 5	2256 0
	1004.5	890.0	1412.9	2275.5	2200.9 9685 6
	5347 2	2064.6	3860 1	8097.9	6183.3
	20000	20000	20000	20000	20000

<Option 2 : Country's original data>

Socioeconomic data is organized as Excel data as shown in the following figure. Open the excel file named "Socioeconomic Parameters" and fill the yellow columns.

To calculate events separately for different countries, in Excel, enter data in cells highlighted in yellow, as shown in the following figure. Refer to the table on the previous page for more information on each parameter.



Fig. 4-6 Enter Socioeconomic parameters file

(4) Disaster Parameters

Here, you can insert disaster damage data.

		File,				
C:DR2ADve	r2.4¥SocioEconomicPa	rameters.xlsx		Browse		
District	arameters File:					
C:DR2ADve	r2.4¥DisasterParamete	rs.xlsx		Browse		
	and the state of the state of the					
-Select / Spe	cify Calculation Cond	itions				
	Upload the Input Disast	er Parameters File				1
	בשעב ו 🕒 🔊	ーター + OS (C:) + DR2ADver2.4			+ ++ DRZAD	Wer2.400 使来
1	整理・ 新しいフォル	ダー				# • 🔟
	ダウンロード *	名前	更新日時	種類	サイズ	
	= デフクトップ		2015/07/14 11:	17 ファイルフォル		
	- / /////	al 1	curdy ary an			
	国最近表示した場所	CoreFunctions	2015/07/14 10:	06 ファイルフォル		
	 ■ シスシトラン 10 最近表示した場所 10 ★業務ショート3 	CoreFunctions	2015/07/14 11: 2015/07/14 11: 2015/07/14 11:	06 ファイル フォル 19 ファイル フォル		
	 ■ スクパック 1 最近表示した場所 ☆ ★業務ショート7 	CoreFunctions Executables	2015/07/14 10: 2015/07/14 11: 2015/07/14 10:	06 ファイル フォル 19 ファイル フォル 06 ファイル フォル		
-Execute DF	 □ スクパック □ 最近表示した場所 ☆ ★業務ショート3 □ ライブラリ 	CoreFunctions Executables Images	2015/07/14 10: 2015/07/14 10: 2015/07/14 11: 2015/07/14 10: 2015/07/14 10:	06 ファイルフォル 19 ファイルフォル 06 ファイルフォル 06 ファイルフォル		
-Execute DF Save the	 ■ メスクリック 1 展述表示した場所 ☆ ★単務ショート3 マイブラリ 1 ドキュメント 	CoreFunctions Executables Images Utilities	2015/07/14 10: 2015/07/14 10: 2015/07/14 11: 2015/07/14 10: 2015/07/14 10:	06 ファイル フォル 19 ファイル フォル 06 ファイル フォル 06 ファイル フォル 05 Wicrosoft Excel	16 KB	
-Execute DF Save the	 ■ メスクリック 1回 最近表示した場所 ☆ ★単務ショート3 マイブラリ 1○ ドキュメント ■ ピクチャ 	CoreFunctions Executables Utilities Utilities DisasterParameters	2015/07/14 10: 2015/07/14 10: 2015/07/14 11: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10:	06 ファイル フォル… 19 ファイル フォル… 06 ファイル フォル… 06 ファイル フォル… 06 ファイル フォル… 06 Microsoft Excel… 05 Microsoft Excel…	15 K用 9 KB	
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-Execute DF Save the	 ■ メスクリック 1 最近表示した場所 ☆ ★単務ショートリ ライブラリ 1 ドキュメント ビクチャ ビデオ シュージック 	CoreFunctions Executables Images Utilities DisasterParameters Diainitial_parameters SocioEconomicParameters	2015/07/14 10: 2015/07/14 10: 2015/07/14 11: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10:	06 ファイル フォルー 19 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 05 Microsoft Excel 05 Microsoft Excel 106 Excel 106 500	15 КВ 9 КБ 12 КВ	
-Execute DF Save the	 ■ メスクリック 1回 最近表示した場所 ☆ ★単務ショートコ デイブラリ 1○ ドキュメント 1○ ビクチャ 1○ ビデオ 1○ ミュージック 	CoreFunctions Executables Images Utilities DisasterParameters C SocioEconomicParameters	2015/07/14 10: 2015/07/14 10:	06 ファイル フォルー 19 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 05 Microsoft Excel 05 Microsoft Excel 19 Soft Excel 10 Soft Excel	15 КВ 9 КБ 12 КВ	
Execute DF	 ■ メスクリック 1回 最近表示した場所 ☆ ★単務ショートコ ※ ライブラリ ※ ドキュメント ※ ピクチャ ※ ピクチャ ※ ビアオ ※ ミュージック 	CoreFunctions Executables Images Utilities DisasterParameters Disinitial_parameters SocioEconomicParameters	2015/07/14 10: 2015/07/14 10:	06 ファイル フォルー 19 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 Microsoft Excel 06 Microsoft Excel 10 Microsoft Excel	16 КВ 9 КВ (2 КВ	
-Execute DF Save the	 ■ メスクリック 1回 最近表示した場所 ☆ ★単務ショートコ ※ ライブラリ ※ ドキュメント ※ ビクチャ ※ ビクチャ ※ ビアオ ※ ミュージック ※ コンピューター 		2015/07/14 10; 2015/07/14 10; 2015/07/14 11; 2015/07/14 10; 2015/07/14 10; 2015/07/14 10; 2015/07/14 10; 2015/07/14 10; 2015/07/14 10; 世球: Microsoft Excel ワ- サイズ; 15.0 KB 更新日時; 2015/07/14 10;	06 ファイル フォルー 19 ファイル フォルー 06 Drイル Dr	16 КВ 9 КВ 12 КВ	
-Execute DF Save the	 ■ メスクリック 1回 最近表示した場所 ☆ ★単務ショートコ ライブラリ ① ドキュメント ■ ピクチャ ■ ピアオ ♪ ミュージック パ コンピューター ▲ OS (C:) 	CoreFunctions Executables Utilities DisasterParameters	2015/07/14 10: 2015/07/14 10: 2015/07/14 11: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: です。Microsoft Excel フ・ サイズ: 15.0 KB 更新日時: 2015/07/14 10	06 ファイル フォルー 19 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 05 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 Directift Excel 06 Microsoft Excel 07 Microsoft Excel	16 КВ 9 КВ 12 КВ	
Execute DF	 ■ メステック 型 最近表示した場所 ☆ *業務ショートコ ライブラリ ドキュメント ビクチャ ビクチャ ビテオ シミュージック パ コンピューター E OS (C:) HP_RECOVERY 	CoreFunctions Executables Utilities Utilities DisasterParameters Disitial_parameters SocioEconomicParameters	2015/07/14 10: 2015/07/14 10: 2015/07/14 11: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 2015/07/14 10: 世球: Microsoft Excel 2- サイズ: 15.0 KB 更新日時: 2015/07/14 10	06 ファイル フォルー 19 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 ファイル フォルー 06 Nurrosoft Excel 06 Nurrosoft Excel 106 Excel	16 КД 9 КВ 12 КВ	

Fig. 4-7 Specifying the Disaster Parameters

There are also two options to set up Excel file.

The first way is to use a sample excel file with already filled data.

You can create a country's original data with Option $2\,$

Option 1	Default value or Sample data
Option 2	Country's original data

<Option 1: Default value or Sample data>

In order to run the application without setting the country's data, you can use 5 country's data below.

				Damege rate of human capital			damage rate of physical asstes				Damage rate of financial assets				
Country(Disaster)	Rank	rate	Proba.	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2
GUATE MALA (FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	43.0%	1/2~1/23	1.44%	0.00%	0.00%	0.00%	0.89%	0.89%	0.00%	0.00%	3.93%	3.93%	0.00%	0.00%
	2	4.3%	1/23~1/56	2.82%	0.00%	1.83%	0.00%	1.62%	1.62%	1.18%	0.00%	7.13%	7.13%	5.20%	0.00%
	3	1.8%	1/56~1/112	3.61%	0.00%	3.30%	2.32%	2.09%	2.09%	1.94%	1.46%	9.20%	9.20%	8.55%	6.43%
	4	0.9%	1/112~1/200	4.26%	0.00%	4.11%	3.81%	2.51%	2.51%	2.45%	2.28%	11.05%	11.05%	10.76%	10.03%
COSTA RICA (FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.5%	1/2~1/56	0.15%	0.00%	0.00%	0.00%	0.03%	0.03%	0.00%	0.00%	0.13%	0.13%	0.00%	0.00%
	2	1.8%	1/56~1/96	0.41%	0.00%	0.09%	0.00%	0.08%	0.08%	0.02%	0.00%	0.36%	0.36%	0.08%	0.00%
	3	1.0%	1/96~1/143	0.55%	0.00%	0.37%	0.12%	0.11%	0.11%	0.07%	0.02%	0.49%	0.49%	0.32%	0.11%
	4	0.7%	1/143~1/200	0.65%	0.00%	0.55%	0.42%	0.13%	0.13%	0.11%	0.08%	0.58%	0.58%	0.48%	0.37%
PAKISTAN(FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.6%	1/2~1/60	0.23%	0.00%	0.00%	0.00%	0.16%	0.16%	0.00%	0.00%	0.72%	0.72%	0.00%	0.00%
	2	1.7%	1/60~1/100	0.68%	0.00%	0.13%	0.00%	0.32%	0.32%	0.21%	0.00%	1.43%	1.43%	0.92%	0.00%
	3	1.0%	1/100~1/146	0.92%	0.00%	0.57%	0.17%	0.42%	0.42%	0.38%	0.27%	1.84%	1.84%	1.67%	1.17%
	4	0.7%	1/146~1/200	1.11%	0.00%	0.89%	0.65%	0.49%	0.49%	0.47%	0.44%	2.15%	2.15%	2.08%	1.93%
PERU(FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.0%	1/2~1/48	0.19%	0.00%	0.00%	0.00%	0.03%	0.03%	0.00%	0.00%	0.15%	0.15%	0.00%	0.00%
	2	2.1%	1/48~1/87	0.49%	0.00%	0.16%	0.00%	0.07%	0.07%	0.04%	0.00%	0.30%	0.30%	0.19%	0.00%
	3	1.1%	1/87~1/136	0.64%	0.00%	0.48%	0.21%	0.09%	0.09%	0.08%	0.05%	0.38%	0.38%	0.35%	0.24%
	4	0.7%	1/136~1/200	0.75%	0.00%	0.66%	0.55%	0.10%	0.10%	0.10%	0.09%	0.46%	0.46%	0.44%	0.40%
HONDURAS (FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.4%	1/2~1/54	11.00%	0.00%	0.00%	0.00%	0.02%	0.02%	0.00%	0.00%	0.08%	0.08%	0.00%	0.00%
	2	1.9%	1/54~1/94	29.82%	0.00%	7.81%	0.00%	0.05%	0.05%	0.02%	0.00%	0.21%	0.21%	0.07%	0.00%
	3	1.1%	1/94~1/142	40.06%	0.00%	27.34%	9.97%	0.06%	0.06%	0.05%	0.02%	0.28%	0.28%	0.21%	0.09%
	4	0.7%	1/142~1/200	47.50%	0.00%	40.22%	31.32%	0.07%	0.07%	0.07%	0.05%	0.33%	0.33%	0.29%	0.24%

 Table 4-6
 Sample Input Data Lists of 5 countries of disaster 1 in Disaster parameters

				Damege rate of human capital damage rate of physical as			physical asstes		Damage rate of financial assets						
Country(Disaster)	Rank	rate	Proba.	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2
GUATE MALA (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	45.7%	1/2~1/43	0.19%	0.19%	0.00%	0.00%	0.31%	0.31%	0.00%	0.00%	1.35%	1.35%	, 0.00%	0.00%
	2	2.3%	1/43~1/82	0.48%	0.48%	0.18%	0.00%	0.78%	0.78%	T 0.25%	0.00%	3.43%	3.43%	1.09%	0.00%
	3	1.2%	1/82~1/133	0.63%	0.63%	0.50%	0.24%	1.03%	1.03%	0.75%	0.32%	4.51%	4.51%	3.32%	1.41%
	4	0.8%	1/133~1/200	0.75%	0.75%	0.67%	0.57%	1.21%	1.21%	1.06%	0.87%	5.33%	5.33%	т — — — т — т — т — т — т — т — т — т —	3.82%
COSTA RICA (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	, 0.00%	0.00%
	1	46.4%	1/2~1/54	0.46%	0.46%	0.00%	0.00%	0.44%	0.44%	T0.00%	0.00%	1.95%	1.95%	, 0.00%	0.00%
	2	1.9%	1/54~1/95	1.29%	1.29%	0.33%	0.00%	1.18%	1.18%	0.34%	0.00%	5.20%	5.20%	1.51%	0.00%
	3	1.1%	1/95~1/142	1.72%	1.72%	1.18%	0.40%	1.58%	1.58%	1.13%	0.44%	6.95%	6.95%	4.96%	1.95%
	4	0.7%	1/142~1/200	2.05%	2.05%	1.72%	1.33%	1.87%	1.87%	1.61%	1.29%	8.21%	8.21%	7.10%	5.67%
PAKISTAN (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	, 0.00%	0.00%
	1	46.7%	1/2~1/61	0.03%	0.03%	0.00%	0.00%	0.53%	0.53%	0.00%	0.00%	2.34%	2.34%	0.00%	0.00%
	2	1.6%	1/61~1/101	0.10%	0.10%	0.02%	0.00%	1.41%	1.41%	0.41%	0.00%	6.20%	6.20%	TT N 1.82%I	0.00%
	3	1.0%	1/101~1/146	0.14%	0.14%	0.08%	0.02%	1.87%	1.87%	1.34%	0.53%	8.24%	8.24%	5.92%	2.34%
	4	0.7%	1/146~1/200	0.16%	0.16%	0.13%	0.10%	2.23%	2.23%	1.91%	1.53%	9.79%	9.79%	8.42%	6.75%
PERU (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	. 0.00%	0.00%
	1	45.4%	1/2~1/39	0.54%	0.54%	0.00%	0.00%	0.63%	0.63%	0.00%	0.00%	2.79%	2.79%	т — — — — — т »I 0.00%I	0.00%
	2	2.6%	1/39~1/77	1.32%	1.32%	0.55%	0.00%	1.60%	1.60%	0.51%	0.00%	7.03%	7.03%	, 2.22%	0.00%
	3	1.3%	1/77~1/128	1.75%	1.75%	1.40%	0.71%	2.06%	2.06%	T — — — — — — I 1.56%	0.69%	9.04%	9.04%	6.87%	3.05%
	4	0.8%	1/128~1/200	1.99%	1.99%	1.86%	1.64%	2.42%	2.42%	2.14%	1.80%	10.63%	10.63%	9.40%	7.90%
HONDURAS (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	I 0.00%I	0.00%
(1	46.8%	1/2~1/64	0.03%	0.03%	0.00%	0.00%	0.13%	0.13%	0.00%	0.00%	0.59%	0.59%	+ + , 0.00%	0.00%
	2	1.6%	1/64~1/104	0.09%	0.09%	0.01%	0.00%	0.37%	0.37%	T — — — — — I 0.09%	0.00%	1.64%	1.64%	i 0.40%	0.00%
	3	1.0%	1/104~1/149	0.12%	0.12%	0.07%	0.02%	0.50%	0.50%	+ 0.34%	0.12%	2.20%	2.20%	1.48%	0.52%
	4	0.7%	1/149~1/200	0.15%	0.15%	0.12%	0.08%	0.60%	0.60%	0.50%	0.39%	2.62%	2.62%	2.20%i	1.709

 Table 4-7
 Sample Input Data Lists of 5 countries of disaster 2 in Disaster parameters

<Option 2: Country's original data>

Disaster damage data is organized as Excel data as shown in the following figure.

To calculate events separately for different countries, in Excel, enter data in cells highlighted in yellow, as shown in the following figur. Blue areas are automatically calculated. You do not need to input any data here.

You can specify different types of disasters for Disaster Type 1 and Disaster Type 2. You can then calculate a compound disaster by entering the probability and damage ratio for each disaster. Refer to the table on the previous page for more information on each parameter.



Fig. 4-8 Entering Socio Economic parameters into the Excel sheet1

4.3.2 Selecting / Specifying the calculation conditions

The following section describes the procedure to configure the calculation conditions of the Excel data.

(1) Selecting the Occurrence of Natural Disasters

You can select the occurrence of Natural disaster by choosing "Yes" or "No". The default value is "Yes". If you need to verify the process of GDP is theoretical or not in case of no occurrence of Natural disaster, you can choose "No".

(2) Specifying the number of Monte Carlo iterations

You can specify the number of desired Monte Carlo iterations. The default value is 1000 iterations.

(3) Specifying the calculation period

You can specify the desired calculation period in the program.

The default value is 20 years.

To ensure stability of the model calculations, the first 3 years is set as the setup period of the model to reconcile any differences. If you need to view the whole period of results, you can refer to csv files.

(4) Specifying the condition of Natural disaster(s)

You can specify the condition of Natural disaster(s) up to two types of disasters. You can also specify single disaster or compound disasters. The default value is "compound disasters"

(5) Displaying the condition of Above Conditions in Figure

You can represent the above conditions such as calculation date, target country, disaster type and number of Monte Calro iteration in figures and csv files. The default value is "Yes".

DR ² AD model (ver. 2.4)	
Socio Economic Parameters File:	
C:DR2ADver2.4¥SocioEconomicParameters.xlsx	Browse
Disaster Parameters File:	
C:DR2ADver2.4¥DisasterParameters.xlsx	Browse
Select / Specify Calculation Conditions	
Occurrence of Natural Disaster:	🗇 No
Number of Monte Carlo Iterations: 1000	
Calculation Period [year]: 20	
Condition of Natural Disaster(s): Disaster1+Disaste	r2
Display of above Conditions in Figure Disaster1 Disaster2	
Execute DR2AD model	
Save the Results in the Folder:	
	Browse
Calculation	

Fig. 4-9 Selecting the Disaster Type

(6) Selecting whether to display the above calculation conditions or not

You can select whether to display the above calculation conditions or not on the graph. The default value is "Yes".

ocio Economic Parameters File:		
D:DR2ADver2.4¥SocioEconomicParameters.xlsx		Browse
Disaster Parameters File:		
D:DR2ADver2.4¥DisasterParameters.xlsx		Browse
elect / Specify Calculation Conditions		
Occurrence of Natural Disaster:	Yes	🔊 No
Number of Monte Carlo Iterations:	1000	
Calculation Period [year]:	20	
Condition of Natural Disaster(s):	Disaster1+Dis	aster2 🔹
Display of above Conditions in Figure:	Yes	© No
cecute DR2AD model		
Save the Results in the Folder:		
		Browse
[
Calculation	b.	

Fig. 4-10 Selecting the display of above conditions in figure

4.3.3 Saving the results in the folder

You can select the location to save the results in the folder. Images and calculations results (csv files) will be saved here. In the figure below, the targeted folder is named "test" in folder DR^2AD (ver2.4).

0				
50	() · コンピューター · OS (C:) · DR2A	Dver2.4 • test	+ + testの接索	
C:Ľ	整理・ 新しいフォルダー		4 2 .	•
Di C:[▲ ダウンロード ち 名前 ■ デスクトップ 12回 最近表示した場所 ☆ ★美語ショート3 13回 ライブラリ 	更新日時 種類 さ 検索条件に一致する項目はありません。	HX	
Sele	 ◎ ドキュメント ■ ビクチャ ■ ビデオ ③ ミュージック ◎ ニノジビューター ▲ OS (C:) ➡ HP_RECOVERY 			
	フォルター: test			
			フォルダーの選択 キャ	ンセル
-				_
	Display of above Cond	itions in Figure: () Yes	🗇 No	
	Display of above Cond	itions in Figure: Yes 	© No	
Exec	Display of above Condi	itions in Figure: Yes 	0 No	
Exec	Display of above Condi cute DR2AD model Ve the Results in the Folder:	itions in Figure: Yes	Browse	
Exec Sa C:D	Display of above Condi cute DR2AD model Ve the Results in the Folder: DR2ADver2.4¥test	itions in Figure: Yes	O No Browse	
-Exec Sa C:E	Display of above Condi cute DR2AD model ve the Results in the Folder: DR2ADver2.4¥test	itions in Figure: Yes	O No Browse	

Fig. 4-11 Specifying the Save Location

4.3.4 Executing the calculation

Click the Run **Calculation** button to perform the automatic calculations and save the result in the specified folder.

er. 2,4 - Main	
DR ² AD model (ver. 2.4)	
Socio Economic Parameters File:	
C:DR2ADver2.4¥SocioEconomicParameters.xlsx	Browse
Disaster Parameters File:	
C:DR2ADver2.4¥DisasterParameters.xlsx	Browse
Condition of Natural Disaster(s): Disaster1+Dis	aster2
Display of above Conditions in Figure: Yes 	() No
xecute DR2AD model	
Save the Results in the Folder:	
C:DR2ADver2.4¥test	Browse
Calculation	

Fig. 4-12 Running the Calculation Screen on the Application

5 Output

This chapter describes the different types of output from the DR²AD model (Ver 2.4). Output is mainly divided into two categories: Policy Description / Policy-making and Analysis / Practical decision-making. The policy description / policy-making output is used to aid large-scale decision-making on the basis of macro-economic indicators. The analysis / practical decision-making output is used to analyze social issues such as social disparity using household economic indicators by income class.

	Purpose	Economic indicator	Output method
Policy description /Policy-making	Used to aid large-scale decision-making on the basis of macroeconomic indicators	GDP, disaster scale, disaster frequency, disaster damage ratio, etc.	Graph CSV file
Analysis/Practical decision-making	Detailed analysis of household standard of living based on household indicators and data by income class	GDP by capita (individual income), consumption, physical asset, financial assets, human capital, education time, human investment, etc. by class	CSV file

 Table 5-1
 Output Classification (Outline) (reproduction of Table 5)

*The next section describes how to read CSV file output.

■ How to read CSV output file



*The startup period data is output in the CSV file, but this data is not used.

Details of output from the DR2AD	etails of output from the DR2AD Model Ver. 2.4						Legend ◎ Save images + csv files							
						対	策別							
Usage application	Name of graph	Outline	Without DRR	Soft	Hard 1	Hard 2	Hard1+Soft	Hard2+Soft	ScenarioA (Without DRR - Hard 1)	ScenarioB (Without DRR - Hard 1 - Hard 2)	by class			
	GDP_DRR.png	GDP trends per measure	Ø	Ø	Ø	Ø	Ø	Ø						
	GDP_DRR_ratio.png	GDP trends per measures (no-policy standard)	Ø	Ø	Ø	Ø	0	Ø						
	GDP_Scenario.png	GDP scenario analysis	©	0	0	Ø			0	۵				
	GDP_Scenario_ratio.png	GDP scenario analysis (no-policy standard)	Ø	0	Ø	Ø	[[0	۵				
Deliau deservition / Deliau-making	DisasterClass.png	Frequency of flood and earthquake occurrence	Ø	Ø	Ø	Ø	۵	Ø	0	0				
Policy description/ Policy-making	DisasterClass_Histogram	Histogram of frequency of flood and earthquake	©	©	©	Ø	©	0	0	0				
	DisasterRate_human	Disaster damage ratio (human capital)	Ø	0	Ø	Ø	0	0	[
	DisasterRate_Phisical	Disaster damage ratio (physical capital)	0	0	0	0	0	0						
	DisasterRate_Financial	Disaster damage ratio (financial capital)	©	©	Ø	Ø	0	0						
	DisasterRate_Land	Disaster damage ratio (land)	©	0	0	Ø	0	0						
	GDP_capita_y.png	GDP trends per capita	•	•	•	•	•	•	•	•	•			
	Consumption_c.png	Consumptions trends per group	•	•	•	•	•	•	•	•	•			
	EducationTime_m.png	Education investment time trends per group	•	•	•	•	•	•	•	•	•			
Analysis/Practical decision-making	FinancialAsset_b.png	Financial asset trends per group	•	•	•	•	•	●	•	•	•			
	HumanCapital_h.png	Human capital trends per group	•	•	•	•	•	•	•	•	•			
	HumanInvestmentCost_eta.png	Human investment costs trends per group	•	•	•	•	•	•	•	•	•			
	PhysicalAsset_z.png	Physical asset trends per group	•	•	•	•	•	•	•	•	•			
Other remarks	GDP_mean.png	GDP trends (average)	0											
Other remarks	GDP_monte.png	GDP trends (Monte Carlo simulation)	0											

5.1 Details of Output for Policy Description / Policy-making

This chapter describes examples of output. The case are as follows

Target country	HONDURAS
Target Disaster	FLOOD

5.1.1 GDP by DRR Measure

You can analyze long-term GDP growth by DRR measure. This analysis assumes the following six types of DRR measures.

1	No policy
2	Soft measures
3	Hard measures 1
4	Hard measures 2
5	Hard measures 1 + Soft measures
6	Hard measures 2 + Soft measures

This analysis is useful in determining the best combination of strategies as the value of soft measures and hard measures differs depending on the type of disaster (floods, earthquakes, etc.).



Table 5-3 Example Output of GDP by DRR Measure (Graph)

Table 12 - Example Output of GDP by DRR Measure (With/Without Comparison) (CSV file)

<file></file>	GDP_DRR_ra	atio.csv		<date></date>	2015/7/14		<country></country>	Pakistan		<disaster< td=""><td>Type></td><td>Flood+Earth</td><td>quake</td><td><montecar< td=""><td>lo(times)></td><td>100</td><td></td><td></td><td></td><td></td><td></td><td></td></montecar<></td></disaster<>	Type>	Flood+Earth	quake	<montecar< td=""><td>lo(times)></td><td>100</td><td></td><td></td><td></td><td></td><td></td><td></td></montecar<>	lo(times)>	100						
[From	above]	Period (year	•)	Soft/Withou	t	Hard1/Witho	ut	Hard2/Witho	ut	(Hard1+Soft	t)/Without	(Hard2+Soft)/Without	*GDP ratio	(with/without	.)						
-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.0007	1.0007	1.0007	1.001	1.001	1.001	1.0011	1.0011	1.0012	1.0012	1.0012	1.0014	1.0014	1.0014	1.0015	1.0015	1.0016	1.0014	1.0014	1.0015	1.0016	1.0017	1.0016
1.0112	1.0172	1.0229	1.0299	1.0355	1.0403	1.0458	1.0495	1.054	1.0582	1.0613	1.065	1.0691	1.0721	1.0751	1.0774	1.0779	1.0793	1.082	1.0838	1.085	1.0876	1.0882
1.0121	1.0182	1.0243	1.0316	1.0375	1.0423	1.0478	1.0522	1.0569	1.0615	1.065	1.0692	1.0736	1.0771	1.08	1.082	1.0826	1.0841	1.0868	1.0886	1.09	1.093	1.0931
1.0112	1.0173	1.0231	1.03	1.0356	1.0403	1.0458	1.0496	1.0541	1.0584	1.0614	1.0652	1.0692	1.0723	1.0752	1.0775	1.078	1.0794	1.0821	1.0839	1.0853	1.0878	1.0883
1.0121	1.0182	1.0243	1.0316	1.0375	1.0424	1.0479	1.0523	1.057	1.0616	1.065	1.0693	1.0737	1.0771	1.08	1.082	1.0827	1.0842	1.0868	1.0886	1.0901	1.0931	1.0931

*The periods -2 through 0 in the CSV file represents the model setup period (3 years).

5.1.2 GDP by Scenario

You can analyze long-term GDP growth by scenario. This analysis assumes the following five types of scenarios.

- ① Implementation of soft measures from the standard year
- ② Implementation of hard measures 1 from the standard year
- ③ Implementation of hard measures 2 from the standard year
- (4) No implementation of DRR measures for the standard year. Implementation of hard measures 1 from the sixth year (scenario A)
- (5) No implementation of DRR measures for the standard year. Implementation of hard measures 1 from the sixth year and hard measures 2 from the eleventh year (scenario B)

You can determine the proper timing and scale of DRR investment by analyzing the growth of GDP by scenario.



Table 5-4 Example Output of GDP by Scenario (Graph)

From large rate of human damage we can understand that soft measure is the most effective, since it can mitigate the human damage rate to the lower level. Besides, we can understand that hard measures are also effective. By comparing each DRR measure and DRR scenario, we can see that the sooner the timing of DRR investment is, the larger the DRR effect becomes.



<file></file>	GDP_Scena	rio.csv		<date></date>	2015/7/14		<country></country>	Pakistan		<disaster< th=""><th>Type></th><th>Flood+Eartho</th><th>quake</th><th><montecar< th=""><th>lo(times)></th><th>100</th><th></th><th></th><th></th><th></th><th></th><th></th></montecar<></th></disaster<>	Type>	Flood+Eartho	quake	<montecar< th=""><th>lo(times)></th><th>100</th><th></th><th></th><th></th><th></th><th></th><th></th></montecar<>	lo(times)>	100						
[From	above]	Period (year))	Without		Soft		Hard1		Hard2		ScenarioA		ScenarioB		*GDP (avera	ige)					
-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
9.92E+10	1.06E+11	1.14E+11	1.22E+11	1.31E+11	1.40E+11	1.51E+11	1.62E+11	1.75E+11	1.88E+11	2.04E+11	2.20E+11	2.38E+11	2.58E+11	2.80E+11	3.04E+11	3.31E+11	3.60E+11	3.91E+11	4.26E+11	4.65E+11	5.06E+11	5.53E+11
9.93E+10	1.07E+11	1.14E+11	1.22E+11	1.31E+11	1.40E+11	1.51E+11	1.62E+11	1.75E+11	1.89E+11	2.04E+11	2.20E+11	2.38E+11	2.58E+11	2.81E+11	3.05E+11	3.31E+11	3.61E+11	3.92E+11	4.27E+11	4.65E+11	5.07E+11	5.54E+11
1.00E+11	1.08E+11	1.17E+11	1.25E+11	1.35E+11	1.46E+11	1.58E+11	1.70E+11	1.84E+11	1.99E+11	2.16E+11	2.34E+11	2.55E+11	2.77E+11	3.01E+11	3.28E+11	3.57E+11	3.89E+11	4.24E+11	4.62E+11	5.04E+11	5.51E+11	6.02E+11
1.00E+11	1.08E+11	1.17E+11	1.26E+11	1.35E+11	1.46E+11	1.58E+11	1.70E+11	1.85E+11	2.00E+11	2.17E+11	2.35E+11	2.56E+11	2.78E+11	3.03E+11	3.29E+11	3.58E+11	3.90E+11	4.25E+11	4.64E+11	5.07E+11	5.53E+11	6.04E+11
9.92E+10	1.06E+11	1.14E+11	1.22E+11	1.31E+11	1.40E+11	1.51E+11	1.62E+11	1.76E+11	1.91E+11	2.08E+11	2.26E+11	2.46E+11	2.68E+11	2.92E+11	3.19E+11	3.47E+11	3.79E+11	4.13E+11	4.52E+11	4.93E+11	5.39E+11	5.90E+11
9.92E+10	1.06E+11	1.14E+11	1.22E+11	1.31E+11	1.40E+11	1.51E+11	1.62E+11	1.76E+11	1.91E+11	2.08E+11	2.26E+11	2.46E+11	2.68E+11	2.92E+11	3.19E+11	3.48E+11	3.80E+11	4.14E+11	4.53E+11	4.94E+11	5.41E+11	5.92E+11

*The periods -2 through 0 in the CSV file represent the modeling setup period (3 years).

5.1.3 Scale and Frequency of Disasters

You can use average values of disaster scale and Monte Carlo simulations to analyze the frequency of disasters. This analysis assumes the following three types of disaster scale and frequency.

- ① Scale and frequency for disaster 1
- 2 Scale and frequency for disaster 2
- ③ Combination disaster scale and frequency (disaster 1 + disaster 2)

This analysis can help determine the proper scale of DRR investment by analyzing the scale and frequency of disasters.



Table 5-6 Example Output of Scale and Frequency of Disasters (Graph)

 Table 5-7
 Example Output of Scale and Frequency of Disasters (CSV file)

2 Disaster Class



*The periods -2 through 0 in the CSV file represent the modeling setup period (3 years).

Period
5.1.4 Disaster Damage Rate

You can analyze average values of disaster damage rate by DRR measure annually. You can visually analyze the impact of each DRR measure on the annual disaster damage rate by creating a graph of the disaster damage rate by DRR measure.



Table 5-8 Example Output of Disaster Damage Rate (Graph)

Table 5-9 Example Output of Disaster Damage Ratios (CSV file)

<file></file>	DisasterRate	-Human.csv		<date></date>	2015/7/14	1	<country></country>	Pakistan		<disaster< th=""><th>Type></th><th>Flood+Earth</th><th>quake</th><th><montecar< th=""><th>lo(times)></th><th>100</th><th></th><th></th><th></th><th></th><th></th><th></th></montecar<></th></disaster<>	Type>	Flood+Earth	quake	<montecar< th=""><th>lo(times)></th><th>100</th><th></th><th></th><th></th><th></th><th></th><th></th></montecar<>	lo(times)>	100						
[From	above]	Period (year)	Without		Soft		Hard1		Hard2		Hard1+Soft		Hard2+Soft		*disaster da	mage rate					
-	2 -1	0	1	2	3	4	5	5 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0.001438	7 0.0013497	0.0012879	0.0018436	0.0016048	0.0015301	0.001663	0.0016231	0.0015476	0.0016378	0.0013679	0.001762	0.0016548	0.0015733	0.0016	0.0016357	0.0017038	0.0013191	0.0013022	0.0013893	0.0014601	0.0017386	0.0014546
0.00020	3 0.000159	0.00018	0.000213	0.000178	0.000152	0.000166	0.000208	8 0.000171	0.000199	0.000204	0.000183	0.000211	0.000205	0.000158	0.000164	0.000185	0.00015	0.00018	0.00015	0.00016	0.000183	0.000145
6.34E-0	5 2.60E-05	0.0002135	0.0002262	6.94E-05	7.40E-05	5.91E-05	0.0002482	0.0001774	0.0003036	0.0001793	0.0002122	0.0001421	0.0002188	0.0001183	2.97E-05	0.0001447	2.33E-05	3.47E-05	2.33E-05	0.0002726	0.0002122	1.49E-05
4.57E-0	6 0	0.0001327	6.88E-05	1.88E-05	1.65E-05	1.65E-05	0.0001225	5 4.96E-05	0.000134	5.46E-05	9.36E-05	8.67E-05	9.59E-05	6.52E-05	0	4.73E-05	2.28E-06	1.19E-05	2.28E-06	0.0001171	9.36E-05	0
2.43E-0	5 0	1.03E-05	2.84E-05	1.22E-05	3.70E-06	1.85E-06	6.33E-05	5.55E-06	3.02E-05	3.87E-05	2.73E-05	4.05E-05	3.39E-05	3.70E-06	3.70E-06	3.02E-05	1.03E-05	2.17E-05	1.03E-05	1.22E-05	2.73E-05	1.85E-06
4 575-0	6 0	2 205-06	1025-05	0.005.00			4000 00		1 0 2 5 0 5	0.155 05	1 105 05	0.155 05	1 405 05	0	0	1 400 00	0.005.00	1 105 05	0.005.00	0.005 00	1 105 05	0

*The periods -2 through 0 in the CSV file represent the modeling setup period (3 years).

5.2 Details of Output for Analysis / Practical Decision-making

This software exports CSV files that include the following data parameters used for quantitative analysis and practical decision-making.

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and financial asset by income class s r income class ncome class	

You can use this data to produce the following graphs and you can analyze.

Table 5-10	Example Output of Consumption by Income Class (CSV file)

<file></file>	Consumptio	n_c_Without.cs	v	<date></date>	2015/7/14		<country></country>	Pakistan		<disaster< th=""><th>Type></th><th>Flood+Earth</th><th>quake</th><th><montecar< th=""><th>lo(times)></th><th>100</th><th></th><th></th><th></th><th></th><th></th><th></th></montecar<></th></disaster<>	Type>	Flood+Earth	quake	<montecar< th=""><th>lo(times)></th><th>100</th><th></th><th></th><th></th><th></th><th></th><th></th></montecar<>	lo(times)>	100						
[From	above]	Period (year)		1st(poorest)	2nd(poor)		3rd(middle)		4th(rich)		5th(richest)										
-2	-1	0	1	2	3	4	5	i 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
210.08	230.96	253.96	278.59	304.05	332.67	364.54	398.65	435.44	476.77	521.34	570.85	625.77	685.5	752.36	828.54	912.43	1004.5	1110.7	1226.3	1357.8	1503.5	1660.3
290.96	313.99	339.91	368	397.19	430.49	467.94	508.19	551.75	600.91	653.99	713.03	778.58	849.79	929.51	1020.3	1120.2	1229.6	1354.4	1488.5	1639.5	1805.4	1984.8
371.19	392.26	417.22	445.05	474.41	508.85	548.3	591.09	637.77	690.93	748.55	812.92	884.6	962.55	1050	1149.2	1257.2	1374.4	1508.4	1652.8	1815.9	1995.3	2189.4
480.13	498.5	522.33	550.14	580.16	616.64	659.35	706.18	757.72	816.98	881.49	953.87	1033.9	1120.3	1216.5	1325.9	1445.4	1575.4	1724.8	1885.9	2068.3	2268.9	2486
917.32	906.78	912.15	928.23	949.71	982.87	1026.6	1077	1134.5	1203.5	1279.7	1366.7	1464.9	1572.3	1693.5	1832.7	1985.4	2152.2	2340.7	2539.5	2760.6	2999.6	3253.3

*The periods -2 through 0 in the CSV file represent the modeling setup period (3 years).



Table 5-11Example Output of Data by Income Class (Graph) (1/2)



Table 5-12Example Output of Data by Income Class (Graph) 2/2

5.3 Details of Other Types of Output

You can also output results of Monte Carlo simulations for other purposes.



 Table 5-13
 GDP Output Examples (Monte Carlo simulations and expected growth)

Chapter 3 Building Data Sets in DR²AD model (Ver. 1.4)

6 Building data sets

This chapter describes the details on the necessary data sets used to test the DR²AD model (Ver. 1.4) as well as explain the basic configuration procedure using actual data. Use the following procedure to build data when you want to evaluate DRR investment benefits using data sets of your country for default values instead of the sample Excel data supplied with the application.

*Operation of the application is not guaranteed except for the five countries included with the supplied sample Excel data.

6.1 Advance preparation

6.1.1 Necessary data

The following table summarizes the data used in the model and their primary sources. Note that most of this data can be generated by combining multiple data sets. Refer to the section on creating individual data sets described later for more information.

Data source	Creatable data
The World Development Indicator	Population, GDP, etc.,
Input Output table / Social Account matrix	α 1, α 2, α 3
Household Survey	c, b, z, etc.,
Mean years of schooling (UNDP)	h, m0
Institute for Statistic (UNESCO)	η

6.1.2 Setting the base year

Specify the base year for the model calculation period.

Typically, it is preferable to avoid setting a model base year that would significantly affect the model behavior, such as a year in which a catastrophic disaster occurs.

*The base year set for the sample program is 2004, as this is the year in which data was retrieved.

6.1.3 Collecting data

This section describes how to collect data from the international organizations which are the main sources of data (World Bank, UNDP, and UNESCE).

- (1) The World Development Indicator (World Bank)
 - ① Access worldbank.org and click "Data"

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Angola	Eritua	Lionnibesep	Sima Leona	South Asia
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8 Guatemala	GTM	Agricultural land (% of land area)	AGLND	AC
9 Guatemala	GTM	Arable Jan (hertanes)	AGUND	AF
10 Guatemala	GTM	Arable land (bectares per person)	AGLND	AF
11 Guatemala	GTM	Arable land (% of land area)	AGUND	AF
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73 (Suotemala	GEM	Proof production index (2004-2006 = 100)	AGPRON	1
24 Guatemala	GTM	Liverstock production index (2004-2006 = 100)	AGPROT	CV.
25 Guatemala	GTM	Surface area (sq. km)	AGSREI	1
26 Guatemala	GIM	Cereal yield (kg per hectare)	AG YED.C	21
27 Guatemala	GTM	Trade In services (% of GDP)	BG.GSR.	NE
28 Guatemala	GTM	Communications, computer, etc. (% of service imports, BoP)	BMGSR	CI.
29 Guatemala	GTM	Primary Income payments (BoP, current US\$)	BMIGSR	eq.
30 Guatemala	GTM	Imports of goods and services (BoP, current US\$)	BM/GSR/	GI
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38 Guatemala	GTM	Foreign direct investment, net outflows (% of GDP)	EM.KLT.	DI
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- (2) Human Development Reports (UNDP)
 - ① Access undp.org and click "Data"



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HDI Rank	Country Very high human development High human development Medium human development Love human development Norway Australia Bietzenand	1980 8.5 4.4 2.5 1.5 9.1 11.6 10.0	1985 8.9 4.9 3.0 2.0 10.0 11.6 9.7	1990 9.5 5.5 3.4 2.3 10.8 11.7 9.7	2000 10.8 7.1 4.5 3.1 11.5 11.9 11.4	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.0	2006 114 77 52 38 127 122 120	2007 11.5 7.8 5.2 3.9 12.7 12.2 12.1	2008 11.5 7.9 5.3 4.0 12.7 12.4 12.1	2009 11.6 8.0 5.4 4.0 12.6 12.5 12.2	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.2	2011 11.7 8.1 5.5 4.2 12.6 12.7 12.2	2012 11.7 8.1 5.5 4.2 12.6 12.8 12.2	2013 11.7 0.1 5.5 4.2 12.6 ¹ 12.8 ¹ 12.2 ¹
HDI Rank	Country Very high human development High human development Medum human development Low human development Australia Sectoriand Netherlands	1980 85 4,4 25 1,5 9,1 11,6 10,0 9,3	1985 8.9 4.9 3.0 2.0 10.0 11.6 9.7 9.7	1990 9.5 3.4 2.3 10.8 11.7 9.7 10.2	2000 10.8 7.1 4.5 3.1 11.5 11.9 11.4 10.8	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.0 11.6	2006 114 7.7 52 3.8 12.7 12.2 12.0 11.8	2007 11.5 7.8 5.2 3.9 12.7 12.2 12.1 11.9	2009 11.5 7.9 5.3 4.0 12.7 12.4 12.1 11.8	2009 11.6 8.0 5.4 4.0 12.6 12.5 12.2 11.8	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.2 11.8	2011 11.7 8.1 5.5 4.2 12.6 12.7 12.2 11.8	2012 11.7 8.1 5.5 4.2 12.6 12.8 12.2 11.9	2013 11.7 8.1 5.5 4.2 12.6 ¹ 12.8 ¹ 12.2 ¹ 11.9 ¹
HDI Rank	Country Very high human development High human development Kedum human development Love human development Love human development Astreals Sectored Netwertands Lobed States	1980 8.5 4.4 2.5 1.5 9.1 11.6 10.0 9.3 11.9	1985 8.9 4.9 3.0 2.0 10.0 11.6 9.7 9.7 12.2	1990 9.5 3.4 2.3 10.8 11.7 9.7 10.2 12.3	2000 10.8 7.1 4.5 3.1 11.5 11.9 11.4 10.8 12.7	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.0 11.6 12.8	2006 154 77 52 38 127 122 120 113 128	2007 11.5 7.8 5.2 3.9 12.7 12.2 12.1 11.9 12.9	2008 11.5 7.9 5.3 4.0 12.7 12.8 12.1 11.8 12.9	2009 11.5 8.0 5.4 4.0 12.6 12.5 12.2 11.8 12.9	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.2 11.8 12.9	2011 11.7 8.1 5.5 4.2 12.6 12.7 12.2 11.8 12.9	2012 11.7 8.1 5.5 4.2 12.6 12.8 12.2 11.9 12.9	2013 11.7 0.1 55 42 12.6 ¹ 12.8 ¹ 12.2 ¹ 11.9 ¹ 12.9 ¹
HDI Rank	Country Very high human development High human development Kedum human development Love human development Love human development Astreals Sectored Noteers Love databas Demany	1980 8.5 4.4 2.5 9.1 11.6 10.0 9.3 11.9 5.7	1985 8.9 4.9 3.0 2.0 10.0 11.6 9.7 9.7 9.7 12.2 6.0	1990 9.5 3.4 2.3 10.8 11.7 9.7 10.2 12.3 8.0	2000 10.8 7.1 4.5 3.1 11.5 11.9 11.4 10.8 12.7 10.5	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.0 11.6 12.8 12.4	2006 11.4 7.7 5.2 3.8 12.7 12.2 12.0 11.8 12.8 12.8	2007 11.5 7.8 5.2 3.9 12.7 12.2 12.1 11.9 12.9 12.8	2008 11.5 7.9 5.3 4.0 12.7 12.4 12.1 11.8 12.9 12.9	2009 11.6 8.0 5.4 4.0 12.6 12.5 12.2 11.8 12.9 12.9	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.6 12.2 11.8 12.9 12.9	2011 11.7 8.1 5.5 4.2 12.6 12.7 12.2 11.8 12.9 12.9	2012 11.7 8.1 5.5 4.2 12.6 12.8 12.8 12.2 11.9 12.9	2013 11.7 0.1 5.5 4.2 12.6 ¹ 12.8 ¹ 12.2 ¹ 11.9 ¹ 12.9 ¹ 12.9 ¹
HORank 	Country Very high human development High human development Loe development	1980 85 44 25 8,1 118 100 9,3 119 5,7 11,8	1985 8.9 4.9 3.0 2.0 10.0 11.6 9.7 9.7 9.7 12.2 6.0 31.7	1990 9.5 3.4 2.3 10.8 11.7 9.7 10.2 12.3 8.0 11.7	2000 10.8 7.1 4.5 3.1 11.5 11.9 11.4 10.8 12.7 10.5 12.0	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.0 11.5 12.8 12.4 12.2	2006 11.4 7.7 52 3.8 12.7 12.2 12.0 11.8 12.8 12.8 12.8 12.3	2007 11.5 7.8 5.2 3.9 12.7 12.2 12.1 11.9 12.9 12.8 12.3	2008 115 7.9 5.3 4.0 127 12.4 12.4 12.9 12.9 12.9 12.4	2009 11.6 8.0 5.4 4.0 12.6 12.5 12.2 11.8 12.9 12.9 12.9 12.4	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.2 11.8 12.9 12.9 12.9 12.5	2011 11.7 8.1 5.5 4.2 12.6 12.7 12.2 11.8 12.9 12.9 12.5	2012 11.7 8.1 5.5 4.2 12.6 12.8 12.8 12.2 11.9 12.9 12.9 12.5	2013 11.7 8.1 5.5 4.2 12.6 ¹ 12.8 ¹ 12.2 ¹ 11.9 ¹ 12.9 ¹ 12.9 ¹ 12.9 ¹ 12.9 ¹ 12.9 ¹

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uerare re	mber of years of education received by n	eople area 25 and older.	converted from edi	cation attainment is	wels using official d	anations of each les	el.					
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Source E	arro and Lee (2013). UNESCO Instit	tute for Statistics (20	13b) and HDRO e	stimates based or	n data on educate	otial attainment fe	om UNESCO Insti	tute for Statistic	cs (2013b) and on)	methodology from	Barro and Les (20
lata in the	tables are those available to the Human I	Development Report Off	ice as of 15 Novemb	er, 2013, unless oth	erwise specified							
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DI D	Course the second secon	1000	1000	10000	(1000	(1000)	6000E	0001	0000	2000	0010	
IDI Rank	Country Very high human development	1980	1985	1990	2000	2005	2006	2007	2008	2009	2010	
IDI Rank	Country Very high human development High is around development	1980 85 44	1985 8.9 4.9	95 55	10.8	2005 11.3 7.6	2006 11.4 7.7	2007 115 78	2008 11.5 7.9	2009 11.6 8	2010 11.7 8.1	
4DI Rank	Country Very high human development High human development Medium human development	1980 85 44 25	1985 8.9 4.9 3	95 55 34	2000 10.8 7.1 45	2005 11.3 7.6 5.1	2006 11.4 7.7 5.2	2007 115 78 52	2008 11.5 7.9 5.3	2009 11.6 8 5.4	2010 11.7 8.1 5.5	
IDI Rank	Country Very high human development High human development Medium human development Low human development	1980 85 44 25 15	1965 8.9 4.9 3 2	1990 95 55 34 23	2000 10.8 7.1 45 3.1	2005 11.3 7.6 5.1 3.8	2006 11.4 7.7 5.2 3.8	2007 115 78 52 39	2008 11.5 7.9 5.3 4	2009 11.6 8 5.4 4	2010 11.7 81 55 41	
IDI Rank	Country Very high human development High human development Low human development Low human development Nonway	1980 85 44 25 15 91	1985 8.9 4.9 3 2 10	1990 95 55 34 23 10.8	2000 10.8 7.1 45 3.1 115	2005 11.3 7.6 5.1 3.8 12.7	2006 11.4 7.7 5.2 3.8 12.7	2007 115 78 52 39 127	2008 11.5 7.9 5.3 4 12.7	2009 11.6 8 5.4 4 12.6	2010 11.7 81 55 41 12.6	
HDI Rank	Country Very high human development Hich human development Low human development Low human development Noneau Austrolis	1980 85 44 25 15 9,1 116	1965 8.9 4.9 3 2 10 11.6	95 55 34 23 108 11,7	2000 108 7.1 45 3.1 115 119	2005 11.3 7.6 5.1 3.8 12.7 12.1	2006 11.4 7.7 5.2 3.8 12.7 12.2	2007 115 78 52 39 127 122	2008 11.5 7.9 5.3 4 12.7 12.4	2009 11.6 8 5.4 4 12.6 12.5	2010 11.7 81 55 41 126 126	
IDI Rank	Country Very high human development High human development Low human development bloneay Austrolia Switzeriend	1980 85 44 25 15 9,1 116 10	1985 89 49 3 2 10 11.6 9.7	1990 95 55 34 23 108 11,7 9,7	2000 10.8 7.1 45 3.1 115 119 11.4	2005 11.3 76 5.1 38 12.7 12.1 12	2006 11.4 7.7 5.2 3.8 12.7 12.2 12	2007 11.5 78 5.2 39 12.7 12.2 12.1	2008 11.5 7.9 5.3 4 12.7 12.4 12.1	2009 11.6 8 5.4 4 12.6 12.5 12.2	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.2	
IDI Rank	Country Very high human development High human development Low human development Low human development Saltandas Sultarentend Nathenbands	1960 85 44 25 15 9,1 116 10 9,3	1985 8.9 4.9 2 10 11.6 9.7 9.7	1990 95 55 34 23 108 11,7 9,7 10,2	2000 108 7.1 45 3.1 115 119 11.4 108	2005 113 76 5.1 38 127 121 12 11.6	2006 1114 7.7 5.2 3.8 12.7 12.2 12 12 11.8	2007 115 78 52 39 127 122 12,1 119	2008 11.5 7.9 5.3 4 12.7 12.4 12.1 11.8	2009 11.6 8 5.4 4 12.6 12.5 12.2 11.8	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.2 11.8	
IDI Rank	Country Very high human development High human development Low human development blorway Australia Switzeniand Nattersing Lutherd States	1960 85 44 25 9,1 116 10 9,3 119	1985 8.9 4.9 3 2 10 11.6 9.7 9.7 12.2	1990 95 55 34 23 108 11,7 9,7 10,2 12,3	2000 108 71 45 31 115 119 114 108 127	2005 113 76 5.1 38 127 121 12 116 128	2006 11.4 77 52 3.8 12.7 12.2 11.8 12.8	2007 115 78 52 39 127 122 12,1 119 129	2008 115 79 53 4 127 124 121 11.8 129	2009 11.6 8 5.4 4 12.6 12.5 12.2 11.8 12.9	2010 11.7 81 55 41 126 126 122 11.8 129	
IDI Rank	Country Vary high human development High human development Matturn human development Low human development Surfaceting Australia Surfaceting Hattanding United States Generating	1980 85 44 25 9,1 116 10 9,3 119 5,7	1985 8.9 4.9 3 2 10 11.6 9.7 9.7 12.2 6	1990 95 55 34 23 108 11,7 9,7 10,2 12,3 8	2000 108 71 45 31 115 119 114 108 127 105	2005 113 76 5.1 38 12.7 121 12 11.6 128 12.8 12.4	2006 11.4 7.7 5.2 3.8 12.7 12.2 12 12 11.8 12.8 12.8	2007 115 78 52 39 127 122 12,1 119 129 128	2008 115 79 53 4 127 124 121 118 129 129	2009 11.6 8 5.4 12.6 12.5 12.2 11.8 12.9 12.9	2010 11.7 81 55 41 126 126 122 11.8 129 129	
HDJ Rank 1 2 3 4 5 5 7	Country Very hich human development Hich human development Makum human development Low human development Nature States Switzerland Nature States Genotics Human States Genotics	1980 85 44 25 91 115 91 116 10 93 119 5.7 11.6	1985 8.9 4.9 2 10 11.6 9.7 9.7 12.2 6 11.7	1990 95 55 34 23 108 11,7 9,7 10,2 12,3 8 11,7	2000 108 7.1 45 3.1 115 119 11.4 108 12.7 10.5 12	2005 113 76 5.1 3.8 12.7 12.1 12 11.6 12.8 12.4 12.4 12.2	2006 11.4 7.7 5.2 3.8 12.7 12.2 12 11.8 12.8 12.8 12.8 12.8	2007 115 78 52 39 127 122 12,1 119 129 128 123	2008 115 79 5.3 4 12.7 12.4 12.1 11.8 12.9 12.9 12.9 12.4	2009 116 8 5.4 4 126 125 122 118 129 129 129 129	2010 11.7 81 55 41 12.6 12.6 12.2 11.8 12.9 12.9 12.9 12.5	
101 Rank	Country Very hish huma development Hish kuran development Makarah kuran development Danisar Antstada Sixilara hind Bathandanda Bathandanda Bathandanda Bathandanda Bathandanda Bathandanda Bathandanda Bathandanda Danisar Canada	1980 85 44 25 91 116 10 53 119 57 116 95	1985 89 49 3 2 10 11.6 9.7 9.7 122 6 11.7 99	1990 95 55 34 23 108 11.7 102 123 8 11.7 10.3	2000 10.8 7.1 4.5 3.1 11.5 11.9 11.4 10.8 12.7 10.5 12 11.1	2005 113 76 5.1 38 12.7 121 12 11.6 12.8 12.4 12.4 12.2 12.3	2006 11.4 7.7 5.2 3.8 12.7 12.2 11.8 12.8 12.8 12.8 12.8 12.8 12.8	2007 115 78 52 39 127 122 121 119 129 128 123 123	2008 115 79 53 4 127 124 121 118 129 129 129 124 123	2009 11.6 8 5.4 12.6 12.5 12.2 11.8 12.9 12.9 12.9 12.9 12.4 12.3	2010 11.7 8.1 5.5 12.6 12.6 12.2 11.8 12.9 12.9 12.9 12.5 12.3	
HDI Rank 1 2 3 4 5 5 7 8 8	Country Very hish huma development Hish kuma development Makera huma development Bansav Anstanla Sultarational Sultarational Sultarational Laheet States Genoticy Meet Zoatand Carsala Sussans	1980 85 44 25 15 91 116 10 93 119 57 116 95 3,7	19985 89 49 3 2 10 116 97 97 122 6 11.7 99 5.1	9990 95 55 34 23 108 11,7 102 12,3 8 11,7 10,3 5,8	2000 108 7.1 45 3.1 115 119 114 108 127 105 12 111 76	2005 113 76 5.1 38 127 12 12 12 12 12 12 128 124 128 124 122 123 84	2006 11.4 7.7 5.2 3.8 12.7 12.2 11.8 12.8 12.8 12.8 12.8 12.3 12.3 8.8	2007 115 78 52 39 127 122 121 119 129 128 123 123 91	2008 11.5 7.9 5.3 4 12.7 12.4 12.1 11.8 12.9 12.9 12.9 12.4 12.3 9.4	2009 11.6 8 5.4 4 12.6 12.5 12.2 11.8 12.9 12.9 12.9 12.9 12.9 12.9 12.9 12.9	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.6 12.2 11.8 12.9 12.9 12.5 12.3 10.1	
IDI Rank	Country Very hish home development Wery hish home development Hish human development biologies from development biorogies bioro	1980 85 44 25 15 91 116 10 93 119 57 116 95 3,7 95 3,7 9	19985 8.9 4.9 2 10 11.6 9.7 9.7 12.2 6 11.7 9.5 1 9.8 5.1 9.8	1990 95 55 34 23 108 11.7 9.7 10.2 12.3 8 11.7 10.3 58 9.6	2000 108 71 45 31 115 119 114 108 127 105 12 11,1 76 105	2005 113 76 51 38 127 121 12 116 128 124 122 123 84 118	2006 11.4 77 52 38 12.7 12 12 12 12 12 12 12 12 12 12 12 12 12	2007 115 78 52 39 127 122 12,1 119 129 128 128 128 128 91 119	2008 115 79 53 4 127 124 121 118 129 129 129 124 123 94 12	2009 11.6 8 5.4 4 12.6 12.5 12.2 11.8 12.9 12.9 12.9 12.4 12.3 9.4 12.1	2010 11.7 8.1 5.5 12.6 12.6 12.2 11.6 12.9 12.9 12.5 12.3 10.1 12.1	
IDI Rank	Country Very hish human development Hish human development Makara human development Law human development Bibansaw Anatodia Sultanziand United Stateon Sultanziand Lahated Stateon Sultanziand Lahated Stateon Sultanziand Lahated Stateon Sultanziand Lahated Stateon Sultanziand Sultanz	1980 85 44 25 15 91 116 10 93 119 57 116 95 37 95 37 95	10985 89 49 2 2 10 11.6 9.7 9.7 1222 6 11.7 9.9 5.1 9.9 5.1 9.9 5.1	1990 95 55 34 23 108 11,7 97 102 123 8 11,7 103 58 9,6 10,4	2000 108 71 45 31 115 119 114 108 127 105 12 11.1 76 105 112	2005 113 76 51 38 127 12 12 128 128 128 128 128 128 123 84 118 114	2006 11.4 7.7 52 38 12.7 12.2 12 12.8 12.8 12.8 12.8 12.8 12.8 1	2007 115 78 52 39 127 122 122 123 129 128 128 123 123 9,1 119 115	2008 115 79 53 4 127 124 121 118 129 129 129 124 123 94 12 115	2009 11.6 8 5.4 4 12.6 12.5 12.2 12.9 12.9 12.9 12.9 12.9 12.3 9.4 12.1 11.6	2010 11.7 8.1 5.5 4.1 12.6 12.2 11.8 12.9 12.5 12.3 10.1 12.1 11.6	
IDJ Rank	Country Very hish horizen development Hish harmen development Hish harmen development biotexise human development biotexise bio	1980 85 44 25 15 01 118 10 93 119 53 7 116 85 3.7 9 9 95 91	10985 89 49 2 10 116 97 97 122 6 11.7 99 5,1 98 10.1 95 5,1	1990 95 55 34 23 108 117 97 102 123 8 117 103 58 9.6 10.4 10	2000 108 71 45 31 115 119 114 108 127 105 12 11 76 105 12 11 76 105 112 11 20	2005 113 76 51 38 127 12 118 128 124 128 124 122 123 84 118 118 114 116	2006 11.4 77 52 38 12.7 12 12 128 128 128 128 128 128 128 128 1	2007 115 78 52 39 127 121 119 128 128 128 123 9.1 119 119 128 129 128 129 129 129 129 129 129 129 129	2008 115 79 53 4 127 124 129 129 129 124 123 94 12 115 116	2009 11.6 8 5.4 4 12.6 12.5 12.2 11.8 12.9 12.9 12.9 12.4 12.4 12.4 12.4 12.1 11.6 11.6	2010 11.7 B1 55 41 12.6 12.2 11.8 12.9 12.9 12.9 12.9 12.9 12.9 12.9 12.5 12.3 10.1 12.1 11.6 11.7	
IDJ Rank	Country Very hish human development Hish human development Makara human development bishcaar development bishcaar Anatodia Sultanariana Luhnat Stateon Sultanariana Luhnat Stateon Sultanariana Sultanari	1000 85 44 25 15 9,1 116 10 9,3 11,9 5,7 11,6 85 3,7 9,5 9,5 9,1 7,4 7,4 7,4	10985 89 49 2 2 10 1116 9.7 9.7 122 6 11.7 9.9 5.1 9.8 10.1 9.8 10.1 9.5 7.9 7.7	1990 95 55 34 29 108 11,7 9,7 102 12,3 8 11,7 10,3 58 9,6 10,4 10 8,4 70	2000 108 7.1 45 3.1 115 119 114 108 127 105 12 11,1 76 105 112 11,2 11 9.3 115	2005 113 76 51 38 127 121 12 128 124 124 122 123 84 118 114 116 99 100	2006 1114 77 52 38 122 12 128 128 128 128 128 128 128 128	2007 115 78 52 39 127 121 129 128 128 128 129 128 129 128 119 115 116 10.1 100	2008 115 79 53 4 127 124 129 129 124 123 94 12 115 116 102 209	2009 11.6 8 5.4 4 12.5 12.2 12.9 12.9 12.9 12.4 12.3 9.4 12.1 11.6 11.6 11.6 11.6 10.3	2010 11.7 81 55 41 126 126 129 129 129 125 123 10.1 121 116 11.7 10.4	
HDJ Rank	Country Very hish homes development Hish harms development Hish harms development biolism human development biologies	1000 85 44 25 15 91 116 10 93 119 57 118 95 37 9 9 91 74 75 75	10085 8.9 4.9 2 2 10 11.6 9.7 12.2 6 6 11.7 9.9 5.1 9.8 10.1 9.5 7.9 7.7 2.7 2.7	1990 95 55 34 23 108 117 102 123 6 117 103 58 9.6 104 10 8 4 79 9.6	2000 108 71 45 31 115 119 114 108 127 105 12 11 78 105 12 11 78 105 112 11 93 116 106	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.8 12.4 12.2 12.3 8.4 11.8 11.6 9.9 12.2 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6	2006 1114 77 52 38 122 12 12 128 128 128 128 128 123 88 119 114 116 10 122 214	2007 115 78 52 39 127 122 121 129 128 123 91 119 115 116 116 116 115	2008 115 79 53 4 124 124 129 129 124 123 94 12 123 94 12 116 116	2009 116 8 54 4 125 122 118 129 129 129 129 129 129 129 129 129 124 123 9,4 116 11.6 11.6 11.6 11.6 123	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.6 12.6 12.6 12.6 12.6 12	
HDI Rank	Country Very hish human development Hish human development Makara human development Law human development Bahtsaat Alastada Bahtsaat Ushatsa Human Bahtsaat Ushatsa Human Bahtsaat Damaata Bahtsaat Bahts	1040 65 44 25 5 9 11 10 93 119 57 118 65 57 118 65 59 55 9 5 174 75 73 67	10985 89 49 3 2 10 11.6 9.7 9.7 12.2 6 11.7 9.9 11.7 9.9 5.1 9.8 10.1 9.5 7.9 2.7 8.2 7.6	1990 95 55 34 23 108 11,7 9,7 102 12,3 6 11,7 103 58 9,6 10,4 10 8,4 10 8,4 9,8 9,8 58 9,6 10,4 10,4 8,4 9,8 9,8 10,4 10,4 10,4 10,4 10,5 10,5 10,5 10,5 10,5 10,5 10,5 10,5	2000 108 7.1 45 3.1 119 114 108 127 108 127 105 12 11,1 105 112 111 93 116 106 87	2005 11.3 7.6 5.1 3.8 12.7 12.1 12 12.8 12.8 12.8 12.4 12.2 12.3 8.4 11.8 11.4 11.6 9.9 12.2 11.4 11.6 9.9 12.2 11.4 9.4	2006 1114 77 52 38 122 122 12 12 12 12 12 12 12 12 12 12 1	2007 115 78 52 39 127 122 129 129 129 128 123 91 119 115 116 10.1 122 115 97	2008 115 79 53 4 127 124 129 129 129 129 129 129 129 129 129 129	2009 11.6 8 5.4 4 12.5 12.5 12.5 12.5 12.9 1	2010 11.7 8.1 5.5 4.1 12.6 12.2 12.8 12.9 12.5 12.9 12.5 12.3 10.1 12.1 11.6 11.7 10.4 12.3 11.8 10.4	
HDI Rank	Country Very hish human development Hish human development Hish human development Selforation trans development Selforation of the selforment Selforation of the selforment Selforation of the selforment Human Selforment Selforation of the selforment Selforation of Selforation Selforation of Selforment Selforation of Selforment S	1000 85 44 25 15 91 116 10 93 119 57 116 95 37 9 95 91 74 75 73 67 67 89	10085 899 49 3 2 10 116 97 122 6 11.7 99 5.1 98 10.1 95 5.1 98 10.1 95 7.7 82 7.6 94	1990 95 55 34 23 108 117 102 123 8 107 103 58 96 104 10 84 79 88 98 98 96 96 96 96	2000 108 71 45 31 115 119 114 108 127 105 12 11 105 112 11 112 115 116 106 87 108	2005 11.3 7.6 5.1 3.8 12.7 12.1 12.2 11.6 12.8 12.4 12.2 12.3 8.4 11.4 11.6 19.9 12.2 11.4 9.4 11.1	2006 11.4 77 52 38 122 128 128 128 128 128 128 128 128 12	2007 115 78 52 39 127 129 129 129 128 129 128 129 128 129 119 115 116 101 122 125 97 113	2008 115 79 53 4 127 124 129 129 129 124 123 94 12 116 98 113	2009 11.6 8 5.4 4 12.5 12.8 12.9 12.9 12.9 12.9 12.4 12.3 9.4 12.3 11.6 11.6 11.6 11.6 11.6 11.6 11.6 12.9 12.9 12.4 12.9 12.4 12.9 12.9 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 12.9 12.4 12.5 11.6 11.6 11.6 11.7 9.9 11.7 9.9 11.7 9.9 11.7 9.9 11.7 9.9 11.7 9.9 11.7 9.9 11.7 9.9 11.4 11.5 11.7 9.9 11.4 11.5 11.7 9.9 11.4 11.5 11.7 9.9 11.4	2010 11.7 8.1 5.5 4.1 12.6 12.6 12.6 12.6 12.6 12.6 12.6 12	

5 You can find the data sorted by country

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2 Click "Education Finance"



3 Scroll the page down



④ Click "Government expenditure per student as % GDP per capita"

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6.2 Configuration example of input data

The following table illustrates variables used in the program, configuration methods, and the setting values for a Honduras case study as an example. The next section contains supplemental explanation of data that requires estimation or processing.

Paramet er name	Default value	Description	Data source
J	5	The number of income class	<fixed data=""></fixed>
L	4	The number of disaster classes (not including the no-disaster state)	<fixed data=""></fixed>
rho	0.12	Time preference rate	Recommended value
theta	2	Degree of relative risk aversion	Recommended value
cbar	0	The subsistence level of consumption	Recommended value
deltaz	0.1	Depreciation rate of physical asset	<hr/> tixed data>
deltak	0.02	Depreciation rate of production capital	<tixed data=""></tixed>
gu	0.042	Exogenous technological growth rate	These parameters are defined by the
iota	1	Compensation coefficient between the human capital investment and the years of education.	assumption. There will be no effect to the model when you use 1.
Pop0	6762426	Initial population	World Bank data (by Country)
GDP0	9120240790	Initial GDP US\$ (2004, from World bank HP, 2005US\$)	World Bank data (by Country)
alpha1	0.45	Share parameter for human capital	Social Account Matrix/Input Output Table
alpha2	0.47	Share parameter for physical capital	Social Account Matrix/Input Output Table
alpha3	0.08	Share parameter for land	Social Account Matrix/Input Output Table
cO	$93 \\ 243 \\ 448 \\ 787 \\ 2564$	Initial consumption per capita: Data of Households' survey 2004	Household Survey /JICA Poverty Profile
h0	$3.3 \\ 4.2 \\ 5.0 \\ 6.0 \\ 6.9$	Initial human capital per capita (using mean years of schooling as a proxy variable)	UNDP data (Mean years of schooling)/Household Survey /JICA Poverty Profile
z0	$ 112 \\ 293 \\ 540 \\ 949 \\ 3091 $	Initial physical asset investment per capita as flow variable	Household Survey /JICA Poverty Profile
b0	$321 \\ 842 \\ 1554 \\ 2732 \\ 8899$	Initial financial assets per capita	World Bank data (by Country)
ТО	$\begin{array}{c} 0.02 \\ 0.05 \\ 0.08 \\ 0.15 \\ 0.48 \end{array}$	Initial land per capita	World Bank data (by Country)
m0	0.33	Initial education time per capita	Household Survey /JICA Poverty Profile
deltah	0.004	Depreciation rate of human capital	World Bank data (by Country)
eta0	0	Coefficient of human investment cost function	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank
eta1	0	Coefficient of human investment cost function	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank

 Table 6-1
 Configuring variables and example case study configuration

eta2M	205.8	Coefficient of human investment cost function	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank
eta2Mv ector	$\begin{array}{c} 205.8\\ 245.3\\ 381.3\\ 1092.6\\ 1504.3\\ 1918.7\\ 5347.2\\ 20000\\ \end{array}$	0 < h <= 6 6 < h <= 9 9 < h <= 11 11 < h <= 15 15 < h <= 17 17 < h <= 20 20 < h <= 60	INSTITUTE for STATISTICS, UNESCO/World Development Indicator, World Bank

1 abie 0-2 Reference of hiput Data of Disaster Fatameters

	Description	Data source		
	Human conital damaga	Human capital damage:		
omegaV_DISASTER	roto duo to digostor hu	Desinventar / UNISDR		
(1 or 2)	rate due to disaster by	population :		
	rank	World Bank data (by Country)		
		Physical assets damage :		
THE ACTED	Physical assets damage	Desinventar / UNISDR		
$pniv_DISASIEK$	rate due to disaster by	Household:		
(1 or 2)	rank	Household Survey /JICA Poverty		
		Profile		
	Production capital	Set following the relationship		
$psiv_DISASIEK$	damage rate due to	between Capital damage rate and		
(1 or 2)	disaster by rank	Physical assets damage rate		
tauV_DISASTER	Damage rate of land	There are no dispeter in this study		
(1 or 2)	due to disaster by rank	There are no disaster in this study		
	Probability of disaster	UNICOD database Designed to		
mu	occurrence by rank	UNISDK database Desinventar		

Parameter name			Sample value			
Disaster Rank	Rank 0	Rank 1	Rank 2	Rank 3	Rank 4	
mu	0.500	0.464	0.019	0.011	0.007	
DRR		Without				
omegaV_DISASTER1	0	0.110046	0.298150	0.400638	0.475017	
phiV_DISASTER1	0	0.000191	0.000488	0.000634	0.000749	
psiV_DISASTER1	0	0.000840	0.002149	0.002789	0.003294	
tauV_DISASTER1	0	0	0	0	0	
DRR			Soft			
omegaV_DISASTER1	0	0	0	0	0	
phiV_DISASTER1	0	0.000191	0.000488	0.000634	0.000749	
psiV_DISASTER1	0	0.000840	0.002149	0.002789	0.003294	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard1			
omegaV_DISASTER1	0	0	0.078125	0.273375	0.402195	
phiV_DISASTER1	0	0	0.000153	0.000474	0.000656	
psiV_DISASTER1	0	0	0.000671	0.002084	0.002886	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard2			
omegaV_DISASTER1	0	0	0	0.099688	0.313246	
phiV_DISASTER1	0	0	0	0.000200	0.000541	
psiV_DISASTER1	0	0	0	0.000881	0.002380	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard1+soft			
omegaV_DISASTER1	0	0	0	0	0	
phiV_DISASTER1	0	0	0.000153	0.000474	0.000656	
psiV_DISASTER1	0	0	0.000671	0.002084	0.002886	
tauV_DISASTER1	0	0	0	0	0	
DRR			Hard2+soft			
omegaV_DISASTER1	0	0	0	0	0	
phiV_DISASTER1	0	0	0	0.000200	0.000541	
psiV_DISASTER1	0	0	0	0.000881	0.002380	
tauV_DISASTER1	0	0	0	0	0	

Table 6-3 Input Data List of disaster 1 on Disaster Parameters (Disaster1 =FLOOD)

Parameter name			Sample value		
Disaster Rank	Rank 0	Rank 1	Rank 2	Rank 3	Rank 4
mu	0.5	0.468048	0.015625	0.009615	0.006711
DRR					
omegaV_DISASTER2	0	0.000300	0.000928	0.001243	0.001485
phiV_DISASTER2	0	0.001339	0.003731	0.005008	0.005959
psiV_DISASTER2	0	0.005893	0.016416	0.022035	0.026222
tauV_DISASTER2	0	0	0	0	0
DRR			Soft		
omegaV_DISASTER2	0	0.000300	0.000928	0.001243	0.001485
phiV_DISASTER2	0	0.001339	0.003731	0.005008	0.005959
psiV_DISASTER2	0	0.005893	0.016416	0.022035	0.026222
tauV_DISASTER2	0	0	0	0	0
DRR			Hard1		
omegaV_DISASTER2	0	0	0.000139	0.000719	0.00116
phiV_DISASTER2	0	0	0.000914	0.003369	0.004995
$psiV_DISASTER2$	0	0	0.004019	0.014823	0.021976
tauV_DISASTER2	0	0	0	0	0
DRR			Hard2		
omegaV_DISASTER2	0	0	0	0.000175	0.000813
phiV_DISASTER2	0	0	0	0.001179	0.003873
psiV_DISASTER2	0	0	0	0.005188	0.017041
tauV_DISASTER2	0	0	0	0	0
DRR			Hard1+soft		
omegaV_DISASTER2	0	0	0.000139	0.000719	0.00116
phiV_DISASTER2	0	0	0.000914	0.003369	0.004995
psiV_DISASTER2	0	0	0.004019	0.014823	0.021976
tauV_DISASTER2	0	0	0	0	0
DRR			Hard2+soft		
omegaV_DISASTER2	0	0	0	0.000175	0.000813
phiV_DISASTER2	0	0	0	0.001179	0.003873
psiV_DISASTER2	0	0	0	0.005188	0.017041
tauV_DISASTER2	0	0	0	0	0

 Table 6-4
 Input Data List of disaster 2 on Disaster Parameters (Disaster2 = EARTHQUAKE)

6.3 Configuring input data

Input data is organized into four types of data: deep parameters, macroeconomic data, household data, and disaster data.

Data Ty	/pe	Example of Data	Details of Data
	Deep Parameters	Relative risk aversion level, rate of decrease, etc.	Fixed value
Socio Economic Parameters	Macroecono mic data	Total population, GDP, etc.	Configuration
	Household data	Consumption, savings, human investment, physical investment, etc.	method described later in this chapter.
Disaster Parameters	Disaster data	Human casualties, material damage, etc.	Configuration method described later in this chapter.

Table 6-5 Types of input data	Table 6-5	Types of input data
-------------------------------	-----------	---------------------

6.3.1 Deep Parameter

In this application, the parameter of fixed value is called Deep Parameter.

(1) Income group number J

The income group level number used in this model can accommodate up to five income groups, which was determined for consistency with usable data such as income group share data from the World Bank.

Income group number $J = 5$

(2) Disaster rank number L

There are a total of five disaster ranks available from 0-4. (Refer to Appendix D for specific information on configuring the disaster rank and other disaster damage ratios.)



(3) Time preference rate ρ

The time preference rate is an interest rate level designed to reduces current consumption and encourage saving money for the future. That is to say, it correlates current consumption with future consumption (savings). A larger time preference rate represents a more significant trend toward a preference for current consumption. The default value is 0.12.



(4) Relative risk aversion level θ

This parameter represents the level of risk acceptability for households. A larger value represents a more significant trend towards risk avoidance. This is set to a value of "2" in reference to Kraay and Raddatz (2007).



(5) Subsistence level of consumption cbar

This parameter represents the minimum level of required consumption for survival, which can be used for consideration of poverty traps. This is set to a value of "0" for simplicity.

Subsistence level of consumption cbar = 0

(6) Physical asset depreciation rate δz

This is the ratio of depreciation that physical assets experience each term. The amortization period for physical assets is set to 10 years, and so this value is set to "0.1".



(7) Production capital depreciation rate δ_k

This is the ratio of depreciation that production capital experience each term. The amortization period for production capital is set to 50 years, and so this value is set to "0.02".

Production capital depreciation rate	$\delta_k = 0.02$

(8) Exogenous rate of technological progress gb

This parameter represents the progress rate of total-factor productivity. This is set to "0.042" due to the relationship between the GDP per capita and the GDP growth rate. (Refer to Appendix B for specific information on configuring this parameter.)

Exogenous rate of technological progress	gb = 0.042
B F8	8

(9) Correction coefficient for human capital formation ι

This coefficient is used to correct the relationship between personal investment and the mean years of schooling. This is fundamentally set to a value of "1" as this parameter was incorporated to adjust parameter particulars (calibration). (No effect on the model when set to "1".)

6.3.2 Organizing and configuring socio-economic data

You can collect and organize data regarding population and GDP. Set distribution ratios such as capital input and others as well as the labor input based on input-output tables and SAM for share parameters of production functions.

(1) Population per group n

The population per income group is set to average out each group for the purpose of consistency with usable data such as income group share data from the World Bank.

1) Required data

- Use the World Bank data (by country)
- Used parameter is "population, total"

2) Configuring settings

The total population is derived by dividing by the number of income groups.



3) Configuration example

The following table summarizes the results of calculating stratified populations using the previously described expression.

Country	Honduras	Pakistan	Guatemala	Peru	Costa Rica	
Total population	6 769 496	155 151 204	19 967 900	97 409 945	1 946 996	
(people)	6,762,426	100,101,094	12,307,000	27,405,645	4,240,330	
Income group	K	L.	K	5	E.	
number	υ	Ð	υ	Ð	υ	
Population per	1 959 495	21 020 270	9 479 500	E 490 700	940 907	
group n (people)	1,302,480	51,050,279	2,473,360	0,400,769	049,207	

Table 6-6 Stratified populations (2004 values)

(2) GDP

The initial GDP value is used to calibrate the exogenous rate of technological progress coefficient B_0 . The program has been created to automatically calculate the exogenous rate of technological progress coefficient B_0 by inputting the initial GDP value.

1) Required data

- Use the World Bank data (by country)
- Used parameter is "GDP (constant 2005 US\$)"

2) Configuring settings

Use the raw data obtained from the World Bank database without any modification.

3) Configuration example

The following reference table lists the GDP for various countries.

Group	Lc	ower-middle-incom economies	Upper-middle-income economies		
Country	Honduras	duras Pakistan Guatemala		Peru	Costa Rica
GDP					
(constant	9,120,240,790	101,704,136,879	26,352,121,441	70,530,831,291	18,855,016,400
2005 US\$)					

Table 6-7 GDP (2004 values)

*Groups are classified by the standards used by the World Bank. The "Lower-middle-income economies" classification represents average income levels from \$1,046 to \$4,125. The "Upper-middle-income economies" classification represents average income levels from \$4,126 to \$12,745.

- (3) Share parameter α for production functions
 - 1) Required data
 - Social account matrix or input-output table

2) Configuring settings

The input ratio for production factors is calculated from "Wage" and "Capital" from the Social Account Matrix (SAM) or the "Wage" and "Non-wage Income" from the input-output table. This ratio is used as the share parameter for production functions.

$$\alpha_{1} = \frac{\text{WIN}}{(\text{WIN} + \text{CIN} + \text{RIN})}$$
$$\alpha_{2} = \frac{\text{CIN}}{(\text{WIN} + \text{CIN} + \text{RIN})}$$
$$\alpha_{3} = \frac{\text{RIN}}{(\text{WIN} + \text{CIN} + \text{RIN}))}$$

α_1 : Share parameter for wage
α_2 : Share parameter for capital
α_3 : Share parameter for Land
WIN: Labor income
CIN: Capital income
RIN: Land income

3) Configuration example

The following table illustrates an example share parameter configuration for production functions in the case of Honduras. The Honduras SAM data was organized by Lizardo et al. (1999).

Table 6-8 Share parameters for production functions (Honduras, 1991 values)

Production functions	Input value	Subtotal	Total	Ratio
Urban Wage Earner		5606.70	CO17 00	0.45
Rural Wage Earner	α1	1311.10	6917.80	
Capital	α 2	7084.50	7084.50	0.47
Land	α 3	Unknown	Unknown	0.08*

Production functions	Honduras	Pakistan	Guatemala	Peru	Costa Rica	Input value
Urban Wage Earner Rural Wage Earner	0.45	0.52	0.38	0.38	0.45	α 1
Capital	0.47	0.40	0.54	0.54	0.47	α 2
Land	0.08	0.08	0.08	0.08	0.08	α_3

 Table 6-9
 Share parameter for production functions

*As there is insufficient land data, the land ratio α 3 for each country was set to the same ratio as that for Pakistan (0.08 in

principle).

*Assumed values were used for Guatemala and Costa Rica as no data for these countries has been obtained.

	FACTORS			HOUSEHOLDS AND OTHER INSTITUTION			IS		
	Urblab	Rulab	Capital	hhalto	hhmedio	hhlowurb	hhlowrur	Empres	Gov
BIEN									
COMPLESTO*									
Agricultural				27 60	27.20	27.20	20.80	0.00	
exports				27.00	21.20	27.20	20.00	0.00	
(A grEnn)									
(Agricultural				26.00	16.80	44.10	52.00	0.00	
Agricultural				50.00	40.00	44.10	55.90	0.00	
grams									
(Grains)				00 70	67.70	21.00	10.40	0.00	
Livestock				80.70	07.70	54.80	18.40	0.00	
(Livestock)				126.60	101.00	107.00	104.40	0.00	
Other				130.00	191.90	187.20	194.40	0.00	
agricultural									
(OtherAgr)				222.50	710.00	070 70	1000 50	0.00	
Agroindustry				333.50	/46.60	8/2./0	1028.50	0.00	
(IndAgr)				101.20	705 10	726.00	722.00	0.00	
Other industry				481.30	/95.40	/36.00	/33.00	0.00	
(OtherInd)				0.00	0.00	0.00	0.00	0.00	
Construction				0.00	0.00	0.00	0.00	0.00	
(Constr)						100 50	115 10	0.00	
Irade (Irade)				314.20	441.40	430.60	447.10	0.00	
Mercantile				596.50	838.00	817.40	848.80	0.00	
services									
(MerSer)				2.32	5.52		5.52		12000
Public				0.00	0.00	0.00	0.00		1769.00
administration									
(PubAdmin)									
HOUSEHOLDS,									
ETC.									
High income	1513.80	354.00						1549.60	
(hhalto)									
Medium income	2192.20	512.60						2244.10	
(hhmedio)									
Urban wage	1900.70	0.00						1384.70	
Earner									
(hhlowurb)									
Rural wage	0.00	444.50						560.90	
Earner									
(hhlowrur)									
Enterprises			7084.50						
(Empres)									
Direct tax				119.70	173.40	0.00	0.00		
(Dirtax)									
SAVINGS/				1291.20	1620.50	270.80	0.00	1345.10	-1018.10
INVESTMENT	5								
(CAPACC)									
TOTAL	5606.70	1311.10	7084.50	3417.40	4948.90	3420.70	3345.00	7084.50	750.90
	-						leon	tinued on	next nage)

Social Accounting Matrix of Honduras, 1991 (continued) Millions of current Lempiras

Reference: Lizardo et al. (1999)

6.3.3 Organizing and configuring household data

Next, we will discuss collecting and organizing initial household data such as consumption amounts, physical assets, financial assets, and human capital. Data will be obtained per income group if possible.

Initial data for consumption share data is set by calculating a distribution ratio for consumption and physical assets using household survey data.

(1) Income distribution

Obtain income distribution amounts per group. This data is used to configure financial assets and other parameters described later.

1) Required data

- Use the World Bank data (by country)
- Used parameters are "GDP (constant 2005 US\$)", "Income share held by lowest 20%", "Income share held by second 20%", "Income share held by third 20%", "Income share held by fourth 20%", and "Income share held by highest 20%"

Table 6-10	World Bank Dat	a required to	o configure incon	me distributions
------------	----------------	---------------	-------------------	------------------

Name of Data
GDP (constant 2005 US\$)
Income share held by lowest 20%
Income share held by second 20%
Income share held by third 20%
Income share held by fourth 20%
Income share held by highest 20%

2) Configuring settings

First, GDP is divided by the share parameter α_i which is set by socio-economic data to obtain the labor income and capital income. Next, income share data is used to calculate data per group and distribute the labor income and capital income to each group. (Refer to "Reference: Calculation of income distribution relationships" in Appendix C for proof of concept.)

$$\beta_1 = \frac{\text{GDP} \cdot \alpha_1 \cdot a}{n}$$
$$\beta_2 = \frac{\text{GDP} \cdot \alpha_2 \cdot a}{n}$$
$$\beta_3 = \frac{\text{GDP} \cdot \alpha_3 \cdot a}{n}$$

* represents the share parameter for production functions.

3) Configuration example

Income per group can be obtained as illustrated below using Honduras as an example.

Income classification	GDP (billion \$)	Value	GDP (billion \$)×Value
Labor income	0.070	0.45	2.869
Capital income	6.376	0.47	2.997

Table 6-11 Income distribution (Honduras, 1994 values)

The calculated labor and capital income is divided by income share data into five different groups. Then the labor and capital income per capita is calculated by dividing the sorted data by the population in each group.

 Table 6-12
 Stratified labor income per capita (Honduras, 1994 values)

Income group	Labor income (total) (billion \$)	Income share	Labor income (stratified) (billion \$)	Labor income (per capita) (\$)
1st (poorest)		0.032	0.092	84.4
2nd (poor)		0.069	0.200	182.9
3rd (middle)	2.869	0.115	0.334	305.6
4th (rich)		0.192	0.556	509.0
5th (richest)		0.593	1.717	1573.3

Table 6-13 Stratified capital income per capita (Honduras, 1994 values)

Income group	Capital income (total) (billion \$)	Income share	Capital income (stratified) (billion \$)	Capital income (per capita) (\$)
1st (poorest)		0.032	0.094	86.5
2nd (poor)		0.069	0.204	187.4
3rd (middle)	2.997	0.115	0.342	313.0
4th (rich)		0.192	0.569	521.3
5th (richest)		0.593	1.758	1611.2

(2) Household expenditure share

1) Required data

• Household surveys, JICA poverty profile, or similar

2) Configuring settings

Reference household survey data form each country, poverty profiles, and similar data and then classify this data into non-durable goods expenditures (food, health, and others), durable goods expenditures (rent, housing, and durables), and education investment to obtain each share.

$$H_1 = \frac{h_1}{h}$$
$$H_2 = \frac{h_2}{h}$$

 H_1 : Share of non – durable goods expenditure H_2 : Share of durable goods expenditure h_1 : Non – durable goods expenditure h_2 : Durable goods expenditure h : Total expenditure amount

3) Configuration example

Using Honduras as an example, the breakdown of household expenditures is published by the Honduras Poverty Assessment, Document of the World Bank (2006), and so this data was used to configure the household expenditure share.

Expenditure type	Expenditure breakdown	Subtotal (Lempira)	Total (Lempira)	Expenditure ratio	
Non-durable	Food	600			
goods	Health	139	980	0.69	
(consumption)	Others	241			
Durchland	Rent	177			
(physical)	Housing	116	353	0.25	
	Durables	60			
Education investment	Education	89	89	0.06	

Table 6-14 Breakdown of expenditures per month (Honduras, 2004 values)

Table A 2 – B.4 Honduras 2004	- Monthl	y Average Per C	apita values of Consum	ption Aggregate
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		Montly PC consumption	Food	Rent	Housing	Health	Education	Durables	Others
Area	Urban	2,005	765	278	171	196	145	97	353
	Rural	881	446	84	65	87	38	26	137
Group Total		1,424	600	177	116	139	89	60	241
Regions	Tegucigalpa	2,507	846	387	207	249	207	123	489
_	San Pedro Sula	2,488	867	355	254	236	197	113	467
	Central Urban	2,034	826	247	168	216	138	101	337
	Central Rural	1,072	530	100	78	104	47	34	179
	Occident Urban	1,400	614	193	110	104	71	76	232
	Occident Rural	609	324	64	46	53	25	12	85
	Orient Urban	1,450	642	178	114	150	92	66	208
	Orient Rural	830	424	75	61	94	34	26	115
Group Total		1,424	600	177	116	139	89	60	241
Extreme Poor		358	209	44	35	18	13	3	35
Non-Extreme P	oor	735	415	81	57	49	29	12	92
Non Poor		2,314	889	294	187	247	159	114	422
Group Total		1,424	600	177	116	139	89	60	241
All Poor		558	319	63	47	35	22	8	65
Non Poor		2,314	889	294	187	247	159	114	422
Group Total		1.424	600	177	116	139	89	60	24

The values in the table are the National averages Housing includes utilities and other services, others includes transportation, transfers and personal expenditures

Reference: Honduras Poverty Assessment, Document of the World Bank (2006)

(3) Consumption c

1) Required data

- Household Survey or Poverty Profile of JICA etc.
- Household expenditure share (calculated in the formal part)

2) Configuring settings

Reference household survey data form each country, poverty profiles, and similar data and then classify this data into non-durable goods expenditures (food, health, and others), durable goods expenditures (rent, housing, and durables), and education investment to obtain each share. Data on household survey results per group is used instead of income share data when available.

Consumption c is calculated by multiplying each expenditure share as calculated in step 2 with the total expenditure amount.

$$h = GDP - Gross Domestic Saving$$

$$c = \frac{h \cdot H_1 \cdot a}{n}$$

h : Total expenditure amount						
GDP						
Gross Domestic Saving						
c : Consumption per person and per income group						
H_1 : Share of non – durable goods expenditure						
a : Income share						
n : Population per income group n						

3) Configuration example

The following table illustrates the calculation results of using the previously described expression.

Consumption c	Honduras	Pakistan	Guatemala	Peru	Costa Rica
1st (poorest)	93	208	241	295	462
2nd (poor)	243	289	545	583	1,032
3rd (middle)	448	369	889	926	1,613
4th (rich)	787	480	1,427	1,457	2,575
5th (richest)	2,564	924	3,820	3,777	6,574

Table 6-15Consumption per capita c (2004 values)

(4) Human capital h

1) Required data

- UNDP data (Mean years of schooling)
- Household surveys, JICA poverty profile, or similar

2) Configuring settings

The mean years of schooling per income group is used as the proxy variable for human capital.

3) Configuration result

The following table illustrates the result of configuring the proxy variable for human capital by using the mean years of schooling.

Personal investment h	Honduras	Pakistan	Guatemala	Peru	Costa Rica
1st (poorest)	3.3	3.2	3.5	8.4	7.9
2nd (poor)	4.2	3.9	3.5	8.4	7.9
3rd (middle)	5.0	4.2	3.5	8.4	7.9
4th (rich)	6.0	4.4	3.5	8.4	7.9
5th (richest)	6.9	5.6	3.5	8.4	7.9

Table 6-16 Human capital (mean years of schooling) configuration values (2004 values)

*Initial values for Guatemala, Peru, and Costa Rica are all the same as there is no data on the mean years of schooling per group for these countries.
(5) Physical asset z

1) Required data

- Household surveys, JICA poverty profile, or similar
- Household expenditure share (calculated as described previously)

2) Configuring settings

Reference household survey data form each country, poverty profiles, and similar data and then classify this data into non-durable goods expenditures (food, health, and others), durable goods expenditures (rent, housing, and durables), and education investment to obtain each share. Data on household survey results per group is used instead of income share data when available.

Physical asset z is calculated by multiplying each expenditure share as calculated in step 2 with the total expenditure amount. Physical asset is obtained by dividing the durable goods expenditure amount with the interest rate and converting from flow values to stock values.

h = GDP - Gross Domestic Saving

$$z = \frac{h \cdot H_2 \cdot a}{(I + \text{DEP} + \text{HDR} - \text{CDR}) \cdot n}$$



3) Configuration example

The following table illustrates the calculation results of using the previously described expression.

Physical asset z	Honduras	Pakistan	Guatemala	Peru	Costa Rica
1st (poorest)	112	186	364	306	498
2nd (poor)	293	259	825	605	1,112
3rd (middle)	540	331	1,345	962	1,738
4th (rich)	949	429	2,158	1,513	2,775
5th (richest)	3,091	827	5,779	3,923	7,084

Table 6-17Physical asset z per capita (2004 values)

(6) Financial asset b

1) Required data

- Use the World Bank data (by country)
- Used parameters are "GDP (constant 2005 US\$)", "Income share held by lowest 20%", "Income share held by second 20%", "Income share held by third 20%", "Income share held by fourth 20%", and "Income share held by highest 20%"

 Table 6-18
 World Bank data required to configure financial assets

Name of Data
GDP (constant 2005 US\$)
Rental rate (lending rate)
Income share held by lowest 20%
Income share held by second 20%
Income share held by third 20%
Income share held by fourth 20%
Income share held by highest 20%

2) Configuring settings

This parameter is expressed as follows incorporating the relationship of the income distribution calculated in step 1.

$$CI = \text{GDP} \times \alpha_2 = (I + \text{PCD}) \cdot \text{FA}$$

CI : Capital income
GDP
$$\alpha_2$$
 : Share parameter for physical capital
I : Interest rate
PCD : Depreciation rate of production capital
FA : Financial assets

Thus, the financial assets parameter is obtained by dividing the capital income by the sum of the interest rate and the production capital depreciation ratio.

$$SFA = \frac{CI \cdot a}{(I + PCD)n}$$

SFA : Financial assets parameter per person CI : Capital Income I : Interest rate PCD : Depreciation rate of production capital a : Income share n : Population per income group n

3) Configuration example

The financial assets per capita is calculated by dividing the sum of the interest rate and depreciation ratio from the capital income per capita as calculated in step 2.

Income group	Capital income (per capita) (\$)	Interest rate	Depreciation ratio	Financial assets (per capita) (\$)
1st (poorest)	70			321
2nd (poor)	184		0.02	842
3rd (middle)	340	0.199		1,554
4th (rich)	598			2,732
5th (richest)	1,947			8,899

 Table 6-19
 Financial assets per capita (Honduras, 2004 values)

Table 6-20 Financial assets per capita (2004 values)

Financial assets b	Honduras	Pakistan	Guatemala	Peru	Costa Rica
1st (poorest)	321	1297	1277	1101	1793
2nd (poor)	842	1801	2892	2176	4005
3rd (middle)	1554	2306	4713	3458	6259
4th (rich)	2732	2992	7564	5440	9993
5th (richest)	8899	5765	20256	14104	25513

(7) Land area T

1) Required data

• Use the World Bank data (by country)

Table 6-21	World Bank	data	required	to	configure	land	area
14010 0 21	n on a bann	anne	required		compare		

Name of Data
GDP (constant 2005 US\$)
Arable Land
Income share held by lowest 20%
Income share held by second 20%
Income share held by third 20%
Income share held by fourth 20%
Income share held by highest 20%

2) Configuring settings

The land area T is configured as a stratified value by using the income share data and assuming that the area is for cultivated land. Then the stratified land area per capita is calculated.

$$T = \frac{CA \cdot a}{\text{SPO}}$$

T : Land area per person CA : Cultivated land area a : Income share SPO : Population per income group

3) Configuration example

The following table illustrates the results of calculating this parameter using data for Honduras with the previously described expression.

Income group	Land area (total) (ha)	Income share	Land area (Stratified) (ha)	Land area (per capita) (ha)
1st (poorest)		0.032	$52,\!470$	0.05
2nd (poor)		0.069	113,685	0.10
3rd (middle)	1,650,000	0.115	189,915	0.17
4th (rich)		0.192	316,305	0.29
5th (richest)		0.593	977,625	0.90

Table 6-22 Stratified land area per capita (Honduras, 1994 values)

(8) Education time m

1) Required data

• Household surveys, JICA poverty profile, or similar

2) Configuring settings

The human capital investment parameter uses education time data. Note that statistics data is likely not available for developing countries.

In such cases, use the following method to configure the mean years of schooling of the representative household.

- Students attend school throughout the year. (x time \times y days)
- Workers work throughout the year. (x time \times y days)

The mean years of schooling per capita can be expresses as following with assumptions that students attend school throughout the year and workers work throughout the year.

$$m_0 \coloneqq \frac{\text{SPO}}{(\text{SPO} + \text{EPO})} = \frac{\text{TET}}{(\text{TET} + \text{TWT})}$$

m_0 : Initial value of mean years of schooling
SPO : Student population
EPO: Worker population
TET : Total education time
TWT: Total working time

*Student population: Total number of students in primary and secondary schools as published by the World Bank database.

*Worker population: Total population of those of first-year primary school age (around 5) to the retirement age (65 years) minus the student population.

3) Configuration example

The following table illustrates the calculated results for several countries using population data.

Country	Honduras	Pakistan	Guatemala	Peru	Costa Rica
Initial value of mean years of schooling m ₀	0.33	0.18	0.31	0.31	0.26

Table 6-23 $\,$ Initial value of mean years of schooling $\,m_0$

(9) Human capital depreciation ratio δh

1) Required data

• Use the World Bank data (by country)

Table 6-24 World Bank data required to configure the human capital depreciation ratio

Name of Data
Death rate, crude (per 1,000 people)
Mortality rate, infant (per 1,000 live births)
Number of infant deaths
Population, total

2) Configuring settings

The human capital depreciation ratio δ_h is obtained by dividing the number of deaths of those with human capital by the total population. The DR²AD model incorporates the obsolescence of knowledge and labor-generation turnover into the human capital depreciation ratio δ_h .

$$\delta_h \ (\equiv \text{CFR}) = \frac{\text{DT} - \text{IDT}}{\text{TPO}}$$

 $\delta_{_{\dot{h}}}$: Human capital depreciation ratio CFR : Death rate DT : Total number of deaths IDT : Nunber of infantile death TPO : Total population

3) Configuration example

The following table illustrates the calculation results using 2004 values for case study countries. The human capital depreciation ratio δ_h for all countries is within 0.4 to 0.5%.

	Honduras	Pakistan	Guatemala	Peru	Costa Rica
Death rate, crude (per 1,000 people)	5.21	7.45	5.92	5.49	4.02
Mortality rate, infant (per 1,000 live births)	26.50	81.60	34.60	23.00	9.20
Number of deaths	35,239	1,155,412	73,168	150,420	17,049
Number of infant deaths	5,160	329,382	14,941	14,105	720
Population, total	6,762,426	155,151,394	12,367,800	27,403,845	4,246,336
Depletion rate δ_k	0.004	0.005	0.005	0.005	0.004

Table 6-25 Human capital depreciation ratio δ

*Data sourced from "The World Development Indicator, World Bank"

(10) Human investment cost function η

The human investment cost functions are configured per education level group (primary, secondary, tertiary, etc.) to incorporate human investment costs in accordance with representative human capital (mean years of education) levels.

1) Required data

- ■INSTITUTE for STATISTICS, UNESCO
- Duration by level of education
- Government expenditure per student as % of GDP per capita

World Development Indicator, World Bank

- Country and Lending Groups
- GDP per capita (constant 2005 US\$)

2) Configuring settings

If data on the relationship between the cost and education time spent by household annually per education level is available, then this relationship is used to estimate the human investment cost function.

If this data is not available, a simple human investment cost function is estimated using the education expenditure ratio for each income group.

The following section describes the configuration procedure.

1. Configuring the education expenditure ratio per student

(Required data)

- Country and Lending Groups
- Government expenditure per student as % of GDP per capita

The education expenditure ratio per student (% GDP per capita) is calculated for each income group and country as published in the World Bank "Country and Lending Groups." The calculated values are used as universal values.

Table 6-26Education expenditure ratio per student (% GDP per capita, average values from 2004-2012) (Unit of
measure: %)

Income class Education Level	Low income (GNI per capita of \$1,045 or less)	Lower middle income (GNI per capita of \$1,046 to \$4,125)	upper middle income (GNI per capita of \$4,126 to \$12,745)	High income: non OECD (GNI per capita of \$12,746 or more)	High income: OECD (GNI per capita of \$12,746 or more)
Primary	12.5	13.8	17.0	15.5	20.8
Lower secondary	17.9	16.4	19.4	18.9	24.2
Upper secondary	62.7	25.7	20.5	21.2	26.7
Tertiary	215.1	74.3	36.3	28.9	29.4



2. Configuring the education expenditure amount per student (country-specific values)

(Required data)

• GDP per capita (constant 2005 US\$)

.....

The country-specific education expenditure per student (\$) is calculated by multiplying the education expenditure ratio per student (% GDP per capita) calculated in step 1 with the country-specific GDP per capita.

$USD = EOR \cdot GDP \ per \ capita(USD)$

USD : Education expenditure per student EOR : Education expenditure ratio per student (%GDP per capita)

Table 6-27	GDP ner canita	(average values	from 2004-201	12) (Unit of measure	· USD)
1 able 0-27	ODI per capita	(average values	110111 2004-201	(Onit of measure	. 03D)

Country	Honduras	Pakistan	Guatemala	Peru	Costa Rica
GDP per capita (constant 2005 US\$)	1,490	731	2,248	3,242	5,150
Income class	Lower-mid dle-income	Lower-mid dle-income	Lower-mid dle-income	Upper-mid dle-income	Upper-mid dle-income

Table 6-28 Education expenditure amount per student (Unit of measure: USD)

Country	Honduras	Pakistan Guatema		Peru	Costa Rica
Primary	205.8	100.9	310.0	555.4	880.3
Lower secondary	245.3	120.3	369.8	632.0	1001.9
Upper secondary	381.3	187.3	575.6	665.4	1056.8
Tertiary	1092.6	536.4	1653.3	1154.8	1858.0

3. Configuring the human investment cost function

The human investment cost function is configured using the education expenditure amount per student calculated in step 2. The human investment cost function is the line m for vertical axis of education expenditure amount η and horizontal axis of education time.

The "m" in line m for education time equals "1" when school is attended throughout the year and equals "0" when school is not attended at all.

The human investment cost function assumes that the education expenditure amount η multiplicatively increases as line m for education time increases. This relationship is expressed as a quadratic function. The human investment cost function could also be expressed as an exponential or logistic function, but a quadratic function improves model stability and ease of use by analytically resolving the stepped nature of line m for education time.

The following table illustrates an example human investment cost function configuration using data for Pakistan.

Pakistan	Education expenditure amount η (\$) (average values from 2004-2012)	Education time line m (years)	Human investment cost function η (m) (\$)
Primary	205.8	1	$\eta(m)=205.8 \text{ m}^2$
Lower secondary	245.3	1	$\eta(m)=245.3 m^2$
Upper secondary	381.3	1	$\eta(m)=381.3 m^2$
Tertiary	1092.6	1	$\eta(m)=1092.6 m^2$

Table 6-29 Human investment cost function configuration values (Honduras example)



Fig. 6-1 Human investment cost function configuration (Honduras example)

4. Configuring the human investment cost function per education level



The usable range of the human investment cost function per education level is established with reference to the country-specific duration by level of education.

3) Configuration example

The following table summarizes the human investment cost function after incorporating the human investment level. The range of human capital in the table is configured on the basis of the duration by education level.

Education Land						
Education Level	Honduras	Pakistan	Guatemala	Peru	Costa Rica	Duration
Primary	y = 205.8 m ²	y = 100.9 m ²	y = 310.0 m ²	y = 555.4 m ²	y = 880.3 m ²	0≦h≦6
Lower secondary	y = 245.3 m [*]	y = 120.3 m ²	y = 369.8 m ²	y = 632.0 m ²	y = 1001.9 m ²	6 <h≦9< td=""></h≦9<>
Upper secondary	y = 381.3 m ²	y = 187.3 m ²	y = 575.6 m ²	y = 665.4 m ²	y = 1056.8 m ²	9 <h≦11< td=""></h≦11<>
Tertiary (Bachelor)	y = 1092.6 m ²	y = 536.4 m ²	y = 1653.3 m [*]	y = 1164.8 m ²	y = 1858.0 m ²	11 <h≦15< td=""></h≦15<>
Tertiary (Master)	y = 1504.3 m ²	y = 651.4 m [*]	y = 2275.5 m ²	y = 1412.9 m ²	y = 2256.9 m ²	15 <h≦17< td=""></h≦17<>
Tertiary (Doctor)	y = 1918.7 m ²	y = 820.0 m ²	y = 2904.4 m ²	y = 1679.8 m ²	y = 2685.6 m ²	17 <h≦20< td=""></h≦20<>
Post-tertiary	y = 5347.2 m ²	y = 2064.6 m ²	y = 8097.9 m ²	y = 3860.1 m ²	y = 6188.3 m ²	20 <h≦60< td=""></h≦60<>

Table 6-30 Human investment cost function (stepped function)

*Tertiary (Masters), tertiary (Doctorate), and post-tertiary levels are calculated by regression analysis of data for primary through tertiary (Bachelors) levels.

6.3.4 Disaster data

(1) Configuration procedure

Use the following procedure to make configurations using disaster data.

1) Identify applicable disasters

Select a maximum of two disasters for analysis (Ex.: floods and earthquakes).

2) Type of applicable disasters

Use disaster data such as the UNISDR DesInventar for the country under analysis to configure the human damage ratio, household damage ratio, production facilities damage ratio, and the land damage ratio.

$$HSR = \frac{\sum(DT + MS + IJ + EVC + MO + AFP)}{TPO}$$
$$HDR = \frac{CHN}{THN} or \frac{AHN}{THN}$$
$$PDR = \frac{PD}{PDS}$$
$$LDR = \frac{DFL \cdot FA}{FL}$$

HSR : Human damage ratio
DT : Total number of dead
MS: Number of missing
IJ: Number of injured
EVC : Number of evacuees
MO : Number of moving people
AFP : Number of victim
TPO: Total population
HDR : Household damage ratio
CHN : Collapsed household number
AHN : Influenced household number
THN:Total household number
PDR : Production facilities damage ratio
PD : Production facilities damage
PDS : Production facilities stock amount
LDR : Land damage ratio

DFL : Damaged farmland FA : Fores area FL : Farmland area

*If data on the total number of households is not available, you can use the number of families as a replacement.

*If the production facilities stock amount cannot be determined, you can use the annual gross domestic savings published in the World Bank Indicators.

		Data availability					
Index of damage that should be input into model	Index of damage in databases	EM=DAT	DesInventar	Netcat- SERVICE	Sigma (Swiss Re)		
	Number of dead (people)	0	0	-	0		
	Number of injured (people)	0	0	0	0		
	Number of missing (people)	-	0	-	0		
Human damage	Number of evacuees (people)	-	0	-	-		
	Number of moving people (people)	-	0	-	-		
	Number of victim (people)	-	0	-	-		
Disvois al damages	Collapsed household number	-	0	_	-		
Physical damage	Influenced househole number	-	0	-	-		
Productiuon facilities damage	Amount of damage and loss (dollar)	0	0	Δ	Δ		
Land damage	Farmland and forest (ha)	-	0	-	-		

Table 6-3161 Status of damage data availability

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O: Available $\Delta:$ Available but limited -: no data

3) Estimating the damage function

The damage function can be estimated using previously generated damage data when no additional investment has been made.

Up to five occurrence probability ranks and damage ratios can be configured. Rank 0 is used for cases of no disasters or very low damage caused by disasters and ranks 1-5 are used for damage-causing disasters.

Configure damage ratios per rank by incorporating occurrence ratios (refer to Appendix C).

4) Configuring damage ratios when investment is made

You can configure damage ratios per disaster rank incorporating DRR investment.

By inputting the effect of direct and soft disaster reduction measures, the benefit of each measure, the combined benefit of measures, and the benefit as a result of differences in investment timing can be measured.

This version does not include the benefit for measures against land damage ratios (cannot be input).

Name of measure	Benefit of measure		
No policy	Configures damage ratios per probability scale.		
Soft measures	Benefit of indirect measures that only reduce human damage such as measuring the reduction of damage including death and injury caused by warning systems in place when disasters occur.		
Hard measures 1	Direct measures (two types can be configured) produce reductions in		
Hard measures 2	not only human damage, but also physical and production facilities damage due to infrastructure investment such as the establishment of dykes.		
Include hard measures 1 + soft measures	Combined benefit of previously described measures.		
Include hard measures 2 + soft measures	Combined benefit of previously described measures.		
Scenario A	Benefit when no investment is made to the first five years followed by direct measures 1 implemented after the fifth year.		
Scenario B	Benefit when no investment is made in the first five years followed by direct measures 1 implemented after the fifth year and direct measures 2 implemented after the tenth year.		

<Types of measures>

*Requires the configuration of damage ratios for overlapping portions. Refer to Appendix D - III for specific information on configuring damage ratios.

(2) Configuration example

For this case study, damage ratios were configured for floods and earthquakes as the applicable disasters.

The case study was configured so that hard measures 1 can prevent rank 1 damage and hard measures 2 can prevent rank 2 damage. Sliding the damage function in accordance with investment enables damage for ranks 2, 3, and 4 to also be reduced.

Soft measures are configured so that there is no human damage for floods but no benefit for earthquakes.

1) Floods



Red: No investment, Yellow: Hard measures 1, Blue: Hard measures 2

Fig. 6-2 Human damage function (left) and household damage function (right)

Table 6-31	Configuration results of human damage, household damage, and production facilities damage per rank
	(Example of floods occurring in Pakistan)

				Human damage				
Country (disaster)	Rank	Occuring probability	Probability	No measure	Soft measure	Hard measure 1	Hard measure 2	
Pakistan (flood)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	
	1	46.6%	1/2~1/60	0.23%	0.00%	0.00%	0.00%	
	2	1.7%	1/60~1/100	0.68%	0.00%	0.13%	0.00%	
	3	1.0%	1/100~1/146	0.92%	0.00%	0.57%	0.17%	
	4	0.7%	1/146~1/200	1.11%	0.00%	0.89%	0.65%	

				Household damage			
Country (disaster)	Rank	Occuring probability	Probability	No measure	Soft measure	Hard measure 1	Hard measure 2
Pakistan (flood)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%
	1	46.6%	1/2~1/60	0.16%	0.16%	0.00%	0.00%
	2	1.7%	1/60~1/100	0.32%	0.32%	0.21%	0.00%
	3	1.0%	1/100~1/146	0.42%	0.42%	0.38%	0.27%
	4	0.7%	1/146~1/200	0.49%	0.49%	0.47%	0.44%

				Production facilities damage			
Country (disaster)	Rank	Occuring probability	Probability	No measure	Soft measure	Hard measure 1	Hard measure 2
Pakistan (flood)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%
	1	46.6%	1/2~1/60	0.72%	0.72%	0.00%	0.00%
	2	1.7%	1/60~1/100	1.43%	1.43%	0.92%	0.00%
	3	1.0%	1/100~1/146	1.84%	1.84%	1.67%	1.17%
	4	0.7%	1/146~1/200	2.15%	2.15%	2.08%	1.93%

2) Earthquakes



Red: No investment, Yellow: Hard measures 1, Blue: Hard measures 2

Fig. 6-3 Human damage function (left) and household damage function (right)

Table 6-32	Configuration results of human damage, household damage, and production facilities damage per rank
	(Example of earthquakes occurring in Pakistan)

		Human damage						
Country (disaster)	Rank	Occuring probability	Probability	No measure	Soft measure	Hard measure 1	Hard measure 2	
	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	
	1	46.7%	1/2~1/61	0.03%	0.03%	0.00%	0.00%	
Pakistan (earthquake)	2	1.6%	1/61~1/101	0.10%	0.10%	0.02%	0.00%	
	3	1.0%	1/101~1/146	0.14%	0.14%	0.08%	0.02%	
	4	0.7%	1/146~1/200	0.16%	0.16%	0.13%	0.10%	

				Household damage					
Country (disaster)	Rank	Occuring probability	Probability	No measure	Soft measure	Hard measure 1	Hard measure 2		
	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%		
	1	46.7%	1/2~1/61	0.53%	0.53%	0.00%	0.00%		
Pakistan (earthquake)	2	1.6%	1/61~1/101	1.41%	1.41%	0.41%	0.00%		
	3	1.0%	1/101~1/146	1.87%	1.87%	1.34%	0.53%		
	4	0.7%	1/146~1/200	2.23%	2.23%	1.91%	1.53%		

				Production facilities damage						
Country (disaster)	Rank	Occuring probability	Probability	No measure	Soft measure	Hard measure 1	Hard measure 2			
	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%			
	1	46.7%	1/2~1/61	2.34%	2.34%	0.00%	0.00%			
Pakistan (earthquake)	2	1.6%	1/61~1/101	6.20%	6.20%	1.82%	0.00%			
	3	1.0%	1/101~1/146	8.24%	8.24%	5.92%	2.34%			
	4	0.7%	1/146~1/200	9.79%	9.79%	8.42%	6.75%			

Appendices

APPENDIX A: RESTRICTIONS OF THIS MODEL

The DR²AD model (Ver. 1.4) has also been developed to enable stable analysis of case studies using data from various countries. The following restrictions are in place to improve stability of the DR²AD model (Ver. 1.4).

I Simplification of method to configure coefficients of optimal value functions

The following assumptions are made regarding optimal value functions in for the DR^2AD model (Ver. 1.4).

$$V(a, h) = v_0 + v_1 \cdot a^{1-\theta} + v_2 \cdot h^{1-\theta}$$

Note that a represents total assets, h represents human capital, and θ represents the relative risk aversion level. ν is the coefficient of the optimal value function. Originally, the coefficient of the optimal value functions is determined recursively after incorporating all combinations of variables with potential to take life. This would create a significantly complex program algorithm, and so the coefficient of the optimal value function is obtained in Ver. 1.4 by calibrating the base year data (data from specific point in time). For this reason, the program is restricted to pulling long-term economic levels into base year data.

[Original Method (The following method is the result of collocation method analysis)]



II Incorporating approach periods into the model

The DR²AD model (Ver. 1.4) is configured with an approach period of 3 years.

The DR^2AD model (Ver. 1.4) produces optimal asset distribution simulation results as fully reasonable behavior of representative households is assumed. On the other hand, actual statistical data contains unreasonable behavior as well, which does not represent an optimal asset distribution. For this reason, inconsistencies in asset distribution develop between initially input statistics and initial simulation results.

As a result, some cases require two to three years for initial values of unreasonable behavior to transition to reasonable behavior. Therefore, the model is configured with a 3-year approach period to eliminate these inconsistencies that occur initially (the 3-year approach period is removed from the application output graph).



Fig. A-1 No approach period

Fig. A-2 Includes approach period

In the example including the approach period as illustrated in the right figure, the total calculation period is 23 years. The graph represents the calculation results from the 4th year until the 23rd year, with the initial 3-year period removed from the output. Examples of violent behavior do not occur after the fourth year.

APPENDIX B: HOW TO SET EXOGENIOUS TECHNOLOGICAL RATE

EXOGENIOUS TECHNOLOGICAL RATE COEFFICIENT

To better evaluate DRR investment, the technological rate coefficient B_0 , which is a variable representing exogenous technological growth, is configured to match actual GDP results during years of disaster with the model GDP results.

The technological rate coefficient B_0 is configured as a correction value used to estimate GDP on the basis of the production function. This coefficient is defined as follows.

$$B_0 = \frac{\text{GDP}_0}{H(0)^{\alpha_1} K(0)^{\alpha_2} T(0)^{\alpha_3}}$$

As a constant rate of growth that matches the rate of progress gb is assumed, the technological rate coefficient B is configured as:

$$B(t) = B_0 \cdot (1+gb)^{t-1}$$

II EXOGENIOUS TECHNOLOGICAL RATE

(1) How to estimate using production function residuals

TFP growth rate (hereinafter, gb) is typically estimated by using production function.

In this case study, the gb growth function was estimated using time series data for the Honduras gb. 2004 is used as the base year (the calculation period is from 2005 to 2011, which is the period usable for statistical data).

As a result, a declining gb and GDP growth trend is confirmed, and a negative regression analysis can be seen for the future.

Data	2004	2005	2006	2007	2008	2009	2010	2011
TFP rate gb								
t: Period	0	1	2	3	4	5	6	7
Y: GDP	9,120,240,790	9,672,095,584	10,307,270,097	10,945,102,350	11,408,284,210	11,130,848,997	11,546,149,370	11,989,031,445
N: Total population	6,762,426	6,898,825	7,037,428	7,178,436	7,322,368	7,469,844	7,621,204	7,776,669
H: Human stock (mean years of schooling)	33,812,130	32,424,478	33,779,654	35,174,336	37,344,077	38,843,189	41,154,502	42,771,680
K: Capital stock	19,405,645,752	21,612,568,226	24,684,226,554	27,383,427,502	26,635,781,164	24,160,164,907	25,758,669,483	27,146,308,804
T: Land stock	1,050,000	1,050,000	1,050,000	1,050,000	1,018,000	1,020,000	1,020,000	1,020,000
ω: Human damage rate	0.006	0.012	0.002	0.009	0.049	0.005	0.012	0.002
ψ : Capital damage rate	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
τ : Land damage rate	0.013	0.157	0.057	0.070	0.213	0.049	0.099	0.006
$\{(1-\omega)H\}^{\alpha}$ 1: Human stock share	2,636	2,579	2,640	2,681	2,703	2,809	2,875	2,939
$\{(1-\psi) K\}^{\alpha} 2$: Capital stock share	61,487	64,348	68,771	72,177	71,248	68,091	70,144	71,878
$\{(1-\tau)T\}^{\alpha}$ 3: Land stock share	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
B0: TFP coefficient	18.6	19.5	18.8	18.8	20.0	19.3	19.1	18.8
α 1: Share parameter		,						
α 2: Share parameter								
lpha 3: Share parameter								
TFP rate gb	C	0.049	0.006	0.003	0.018	0.008	0.005	0.001
TFP growth rate (log		TF	P growth ra	ate (exponer	ntial approx	ximation)		





Fig. B-1 gb estimations

(2) Configuring the rate of technological progress by the GDP line

The gb can also be configured using a simplified method of aligning the GDP growth rate and the rate of technological growth to the same value.

In this case, country-specific economic disparities are affected by the size of gb, and so countries with similar economic scales can be grouped and estimated.

For this case study, five countries are grouped and configured.

As illustrated in the following figure, the average growth rate of all countries was approximately 4%, regardless of their GDP scale. All data from 1960 to 2013 for the GDP per capita and the GDP growth rate changes for the five countries under analysis are plotted on this graph. In this case study, a gb value of 4% was used.



Fig. B-2 GDP per capita and growth rate trends for countries under analysis

APPENDIX C: DETERMINATION OF DISASTER PARAMETERS

This section serves as a reference for the method used to configure damage ratios for this case study. Procedures I, II, and III were conducted sequentially to configure the damage ratios per rank.

<Configuration flow>



- I Configure various damage ratios
 - 1. Earthquakes and floods were used as the disaster types.
 - 2. The human damage ratio (1), household damage ratio (2), and production facilities damage ratio (3) were configured for each disaster type.

*Land damage ratios are currently not supported.

3. Damage ratios per rank were configured for the following two damage ratios.

(1)
$$HSR = \frac{HS}{TPO}$$

(2) $HDR = \frac{DHN}{FN}$

HSR : Human damage ratio HS : Human damage (dead, injured), etc. TPO : Total population HDR : Household damage ratio DHN : Damaged household FN : Number of households

Demined date	• Damage data : DesInventar (UNISDR)
Required data	Population data : WDI (World Bank) etc.

3. Configure using the production facilities damage ratio and household damage ratio

3. Production facilities damage is configured as the household damage ratio times a factor of 4.4.

* A=B+C

Production facilities damage ratio = Plant damage + public facilities damage = 1+3.4+=4.4 Plant damage 1 (=1 × household damage) Public facilities damage 3.4 (= 1.7 × general asset damage (households+plants) = (1+1)×1.7=2×1.7 The general asset damage factor of 1.7 is taken from the calculation ratio published in the Japanese Flood Control Economy Survey Manual.

II Configuring damage ratios per rank

- 1. Configure the damage ratio per event on the basis of damage ratio concept A for each damage ratio per disaster type.
- 2. Perform probability statistical analysis on non-annual damage ratio data for each damage ratio per disaster type.
- 3. Graph the damage ratio distribution curve (exponential distribution) per probability scale from the results of the probability statistical analysis.
- 4. Divide the portion of the distribution curve up to a probability scale of 1/200 into four ranks and configure the damage ratio for each rank so that the expected damage ratio is equivalent to the damage ratio times the damage occurrence probability.

Damage ratio Assumed by the damage ratio Damage occurrence probability per probability scale from the results of the probability statistical analysis 1 × Probability scale Probability scale 1/2 1/4 1/8 1/30 1/60 1/100 1/200 1/2 1/4 1/8 1/30 1/60 1/100 1/200 П Divide the portion of the distribution curve up to a probability Damage ratio curve scale of 1/200 into four ranks and configure the damage ratio for each rank so that the expected damage ratio is equivalent to the damage ratio times the damage occurrence probability. Rank O=No disaster **Probability** scale 1/2 1/4 1/8 1/30 1/60 1/100 1/200

<Configuring damage ratios per rank>

III Configuring investment benefits

Investment benefit has been configured so that soft measures prevents 100% of human damage caused by floods but has no effect on earthquakes.

The configured investment benefits of the two types of hard measures are illustrated in the following figure.

<Conceptual image of investment benefits when implementing hard measures>

Damage ratio



<Configuring a benefit to reduce damage ratios when investment is made>

	Ear	thquakes	Floods				
	Soft measures	Hard measures	Soft measures	Hard measures			
Human damage ratio	No benefit	Benefit of reducing rank 1 damage to	100% reduction	Benefit of reducing			
Household damage ratio	No benefit	"0" by sliding the damage function	No benefit	by sliding the damage			
Production facilities damage ratio	No benefit	for no investment (Rank 2 damage is reduced to "0" by implementing hard measures 2).	No benefit	function for no investment (Rank 2 damage is reduced to "0" by implementing hard measures 2).			

APPENDIX D: SAMPLE DATA SET (FIVE COUNTRIES)

The following table illustrates the sample data set (five countries) included in this build of the application.

Category	Country	HONDURAS	PAKISTAN	PERU	GUATEMALA	COSTARICA
	J	5	5	5	5	5
	L	4	4	4	4	4
	rho	0.12	0.12	0.12	0.12	0.12
Deep	theta	2	2	2	2	2
Parameters	cbar	0	0	0	0	0
	deltaz	0.1	0.1	0.1	0.1	0.1
	deltak	0.02	0.02	0.02	0.02	0.02
	gb	0.042	0.042	0.042	0.042	0.042
	iota	1	1	1	1	1
	Pop0	6762426	155151394	27403845	12367800	4246336
Socio	GDP0	9120240790	$ \begin{array}{r} 10170413687 \\ 9 \end{array} $	70530831291	26352121441	18855016400
Parameters	alpha1	0.45	0.52	0.38	0.38	0.45
Tarameters	alpha2	0.47	0.4	0.54	0.54	0.47
	alpha3	0.08	0.08	0.08	0.08	0.08
	c0	93	208	295	241	462
		243	289	583	545	1032
		448	369	926	009 1497	1013
		2564	924	3777	3820	6574
	h0	3.3	3.2	8.4	3.5	7.9
		4.2	3.9	8.4	3.5	7.9
		5.0	4.2	8.4	3.5	7.9
		6.0	4.4	8.4	3.5	7.9
		6.9	5.6	8.4	3.5	7.9
	z0	112	186	306	364	498
		293	259	605	825	1112
		540	331	962	1345	1738
		949	429	1013	2158 5770	2775
	b0	391	1297	1101	1977	1703
		842	1801	2176	2892	4005
		1554	2306	3458	4713	6259
		2732	2992	5440	7564	9993
		8899	5765	14104	20256	25513
Household	TO	0.02	0.06	0.03	0.02	0.01
Parameters		0.05	0.09	0.05	0.05	0.02
		0.08	0.11	0.09	0.08	0.03
		0.15	0.15	0.14	0.15	0.05
	m0	0.33	0.18	0.31	0.31	0.15
	deltah	0.004	0.005	0.005	0.005	0.005
	eta0	0	0	0	0	0
	eta1	0	0	0	0	0
	eta2M	205.8	100.9	632	310	1001.9
	eta2Mvect	205.8	100.9	555.4	310.0	880.3
	or	245.3	120.3	632.0	369.8	1001.9
		381.3	187.3	665.4	575.6	1056.8
		1092.6	536.4	1164.8	1653.3	1858.0
		1004.3	651.4 820.0	1412.9	2275.5	2256.9
		1910.7 5347.9	2064.6	3860 1	2904.4	2000.0 6183.3
		20000	20000	20000	20000	20000

Socio-Economic Parameters

II Disaster parameters

					Damege rate of	fhuman capital			damage rate of	physical asstes			Damage rate of	financial assets	
Country(Disaster)	Rank	rate	Proba.	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2
GUATE MALA (FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	43.0%	1/2~1/23	1.44%	0.00%	0.00%	0.00%	0.89%	0.89%	0.00%	0.00%	3.93%	3.93%	0.00%	0.00%
	2	4.3%	1/23~1/56	2.82%	0.00%	1.83%	0.00%	1.62%	1.62%	1.18%	0.00%	7.13%	7.13%	5.20%	0.00%
	3	1.8%	1/56~1/112	3.61%	0.00%	3.30%	2.32%	2.09%	2.09%	1.94%	1.46%	9.20%	9.20%	8.55%	6.43%
	4	0.9%	1/112~1/200	4.26%	0.00%	4.11%	3.81%	2.51%	2.51%	2.45%	2.28%	11.05%	11.05%	10.76%	10.03%
COSTA RICA (FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.5%	1/2~1/56	0.15%	0.00%	0.00%	0.00%	0.03%	0.03%	0.00%	0.00%	0.13%	0.13%	0.00%	0.00%
	2	1.8%	1/56~1/96	0.41%	0.00%	0.09%	0.00%	0.08%	0.08%	0.02%	0.00%	0.36%	0.36%	0.08%	0.00%
	3	1.0%	1/96~1/143	0.55%	0.00%	0.37%	0.12%	0.11%	0.11%	0.07%	0.02%	0.49%	0.49%	0.32%	0.11%
	4	0.7%	1/143~1/200	0.65%	0.00%	0.55%	0.42%	0.13%	0.13%	0.11%	0.08%	0.58%	0.58%	0.48%	0.37%
PAKISTAN(FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.6%	1/2~1/60	0.23%	0.00%	0.00%	0.00%	0.16%	0.16%	0.00%	0.00%	0.72%	0.72%	0.00%	0.00%
	2	1.7%	1/60~1/100	0.68%	0.00%	0.13%	0.00%	0.32%	0.32%	0.21%	0.00%	1.43%	1.43%	0.92%	0.00%
	3	1.0%	1/100~1/146	0.92%	0.00%	0.57%	0.17%	0.42%	0.42%	0.38%	0.27%	1.84%	1.84%	1.67%	1.17%
	4	0.7%	1/146~1/200	1.11%	0.00%	0.89%	0.65%	0.49%	0.49%	0.47%	0.44%	2.15%	2.15%	2.08%	1.93%
PERU(FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.0%	1/2~1/48	0.19%	0.00%	0.00%	0.00%	0.03%	0.03%	0.00%	0.00%	0.15%	0.15%	0.00%	0.00%
	2	2.1%	1/48~1/87	0.49%	0.00%	0.16%	0.00%	0.07%	0.07%	0.04%	0.00%	0.30%	0.30%	0.19%	0.00%
	3	1.1%	1/87~1/136	0.64%	0.00%	0.48%	0.21%	0.09%	0.09%	0.08%	0.05%	0.38%	0.38%	0.35%	0.24%
	4	0.7%	1/136~1/200	0.75%	0.00%	0.66%	0.55%	0.10%	0.10%	0.10%	I 0.09%	0.46%	0.46%	0.44%	0.40%
HONDURAS (FLOOD)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	1	46.4%	1/2~1/54	11.00%	0.00%	0.00%	0.00%	0.02%	0.02%	0.00%	0.00%	0.08%	0.08%	0.00%	0.00%
	2	1.9%	1/54~1/94	29.82%	0.00%	7.81%	0.00%	0.05%	0.05%	0.02%	0.00%	0.21%	0.21%	0.07%	0.00%
	3	1.1%	1/94~1/142	40.06%	0.00%	27.34%	9.97%	0.06%	0.06%	0.05%	0.02%	0.28%	0.28%	0.21%	0.09%
	4	0.7%	1/142~1/200	47.50%	0.00%	40.22%	31.32%	0.07%	0.07%	0.07%	0.05%	0.33%	0.33%	0.29%	0.24%

Table D-1 Input Data Sample List 1

					Damege rate of	human capital			damage rate of	physical asstes		Damage rate of financial ass			sets		
Country(Disaster)	Rank	rate	Proba.	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2	without DRR	soft	hard1	hard2		
GUATE MALA (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
	1	45.7%	1/2~1/43	0.19%	0.19%	0.00%	0.00%	0.31%	0.31%	0.00%	0.00%	1.35%	1.35%	0.00%	0.00%		
	2	2.3%	1/43~1/82	0.48%	0.48%	0.18%	0.00%	0.78%	0.78%	0.25%	0.00%	3.43%	3.43%	1.09%	0.00%		
	3	1.2%	1/82~1/133	0.63%	0.63%	0.50%	0.24%	1.03%	1.03%	0.75%	0.32%	4.51%	4.51%	3.32%	1.41%		
	4	0.8%	1/133~1/200	0.75%	0.75%1	0.67%	0.57%	1.21%	1.21%	1.06%	0.87%	5.33%	5.33%	4.67%	3.82%		
COSTA RICA (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
	1	46.4%	1/2~1/54	0.46%	0.46%	0.00%	0.00%	0.44%	0.44%	0.00%	0.00%	1.95%	1.95%	0.00%	0.00%		
	2	1.9%	1/54~1/95	1.29%	1.29%	0.33%	0.00%	1.18%	1.18%	0.34%	0.00%	5.20%	5.20%	1.51%	0.00%		
	3	1.1%	1/95~1/142	1.72%	1.72%	1.18%	0.40%	1.58%	1.58%	1.13%	0.44%	6.95%	6.95%	4.96%	1.95%		
	4	0.7%	1/142~1/200	2.05%	2.05%	1.72%	1.33%	1.87%	1.87%	1.61%	1.29%	8.21%	8.21%	7.10%	5.67%		
PAKISTAN (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
	1	46.7%	1/2~1/61	0.03%	0.03%	0.00%	0.00%	0.53%	0.53%	0.00%	0.00%	2.34%	2.34%	0.00%	0.00%		
	2	1.6%	1/61~1/101	0.10%	0.10%	0.02%	0.00%	1.41%	1.41%	0.41%	0.00%	6.20%	6.20%	1.82%	0.00%		
	3	1.0%	1/101~1/146	0.14%	0.14%	0.08%	0.02%	1.87%	1.87%	1.34%	0.53%	8.24%	8.24%	5.92%	2.34%		
	4	0.7%	1/146~1/200	0.16%	0.16%	0.13%	0.10%	2.23%	2.23%	1.91%	1.53%	9.79%	9.79%	8.42%	6.75%		
PERU (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
	1	45.4%	1/2~1/39	0.54%	0.54%i	0.00%	0.00%	0.63%	0.63%	0.00%	0.00%	2.79%	2.79%	0.00%i	0.00%		
	2	2.6%	1/39~1/77	1.32%	1.32%	0.55%	0.00%	1.60%	1.60%	0.51%	0.00%	7.03%	7.03%	2.22%	0.00%		
	3	1.3%	1/77~1/128	1.75%	1.75%	1.40%	0.71%	2.06%	2.06%	1.56%	0.69%	9.04%	9.04%	6.87%	3.05%		
	4	0.8%	1/128~1/200	1.99%	1.99%	1.86%	1.64%	2.42%	2.42%	2.14%	1.80%	10.63%	10.63%	9.40%	7.90%		
HONDURAS (EARTHQUAKE)	0	50.0%	~1/2	0.00%	0.00%1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%		
	1	46.8%	1/2~1/64	0.03%	0.03%	0.00%	0.00%	0.13%	0.13%	0.00%	0.00%	0.59%	0.59%	0.00%	0.00%		
	2	1.6%	1/64~1/104	0.09%	0.09%	0.01%	0.00%	0.37%	0.37%	0.09%	0.00%	1.64%	1.64%	0.40%	0.00%		
	3	1.0%	1/104~1/149	0.12%	0.12%	0.07%	0.02%	0.50%	0.50%	0.34%	0.12%	2.20%	2.20%	1.48%	0.52%		
	4	0.7%	1/149~1/200	0.15%	0.15%	0.12%	0.08%	0.60%	0.60%	0.50%	0.39%	2.62%	2.62%	2.20%1	1.70%		

Table D-2Input Data Sample List 2

APPENDIX E: PROGRAMING ALGORITHM FLOW

The programs constructed above were performed in accordance with the following calculation algorithms.

The program algorithms are as follows.

I Overall Calculation Algorithm for the Program



II Calibration Calculation Algorithm



III Disaster Class Process Calculation Algorithm





IV Economic Growth Calculation Algorithm