Optimizing Simulation Model on Forest Policy

Development of mathematical model for forest policy formation and its optimizing simulation

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This paper designs an Economy-Welfare-Environment Adjustment System model (EWEAS model or EWE model in short) which consists of the circular flow of the economic, the welfare, and the environment system of forestry. That is, this model builds the relationship between the systems for material wealth and that for mental wealth.

The EWE model is designed as a complete open system model which describes the economy-welfare-environment circular system in forestry by linking up the internal system of forestry with the surrounding external systems.

The EWE model can be manipulated as a policy formation or a policy decision model, and it is available for policy evaluation in the economic, the welfare, and the environmental phase of forestry.

The EWE model is a basic simulation system model which is reliable in its reproductivity or fitness, stability, and universality. Thus, this model ought to be useful in any country in the world as well as in Japan.

Development of an economy-welfare-environment optimal adjustment system model of forestry (EWE model)

The EWE theoretical model of forestry, namely the theoretical Economy-Welfare-Environment Optimal Adjustment System model of forestry is developed, and two major characteristics are clarified: one is that this EWE theoretical model designs an economy-welfare-environment system of forestry which is composed of a circular flow of an economic system of forestry, a welfare system of forest owners' household, and an environmental system of forestry; the other is that this model treats an open system which links the internal economy-welfare-environmental system of forestry with the external national economy system and market system of the production factors.

The cause and effect relationship among the internal and external systems is as follows: once certain changes occur in the national economy system as an external system,

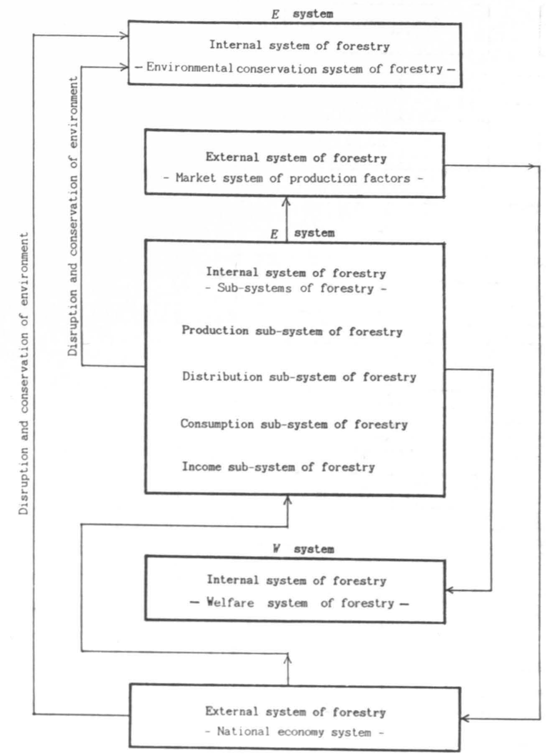


Figure 1. Formation of EWE model.

some changes are brought about in the economy-welfare-environment system of forestry as an internal system through business cycle; then the changes in the economy-welfare-environment system of forestry cause some changes in the market system of production factors as the other external system through the demand of the production factors of forestry; and finally, the changes in the market system of the production factors stimulate some changes in the national economy. See Figure 1.

To put it more concretely, the cause and effect relationship among the internal system (i.e., the economy-welfare-environmental system of forestry) and the external systems (i.e., the market system of production factors and the national economy system) is clarified as shown in Figure 2. In other words, the total system of EWE model is designed as in the flow diagram of Figure 2.

Cause and effect relationship between the forestry economy system and the national economy system

Once certain changes occur in the national economy (Y), some changes are brought about in the residential construction area(H). As the result, the lumber demand($\tilde{D}$) is influenced by both the changes in the residential construction area of the present term(H) and that with one year's lag(H_{-1}). Naturally, the residential construction area(H) is also varied by the policy manipulation of the housing treasury investment, loan, and subsidy(F).

Cause and effect relationship among internal sub-systems in forestry economy

Since the changes in the lumber demand($\tilde{D}$) effected by the changes in external national economy system (Y) cause fluctuation in the total log demand(D) at the same time, the total log supply(S) is determined so as to meet it. In this model, the log import is assumed, so that the total log supply(S) which corresponds with the total log demand(D) is the sum of the domestic log supply (S^*) and the domestic supply of imported log(M). That is $S=S^*+M$.

A new equilibrium price of total log(P) is determined when the total log demand(D) and the total log supply(S) which are determined as above coincide with each other in the whole log market, and the equilibrium-total log price(P) decides, as an original price, the new lumber price ($\tilde{P}$), the new domestic log price(P^*), and the new domestic price of imported logs(P^{**}). Thus, the new lumber demand($\tilde{D}$), the new domestic log supply(S^*), and the new domestic supply of imported logs(M) vary according to those new prices ($\tilde{P}$, P^*, P^{**}) respectively. Moreover, the domestic supply of imported logs(M) is also influenced by the changes in the lumber demand with one year's lag($\tilde{D}_{-1}$) and the international balance of payments(X), in addition to the change in the domestic price of imported logs(P^{**}). The domestic log supply(S^*), on the other hand, is influenced by the changes in the labor wage rate of forestry (ω) and the subsidy for im-

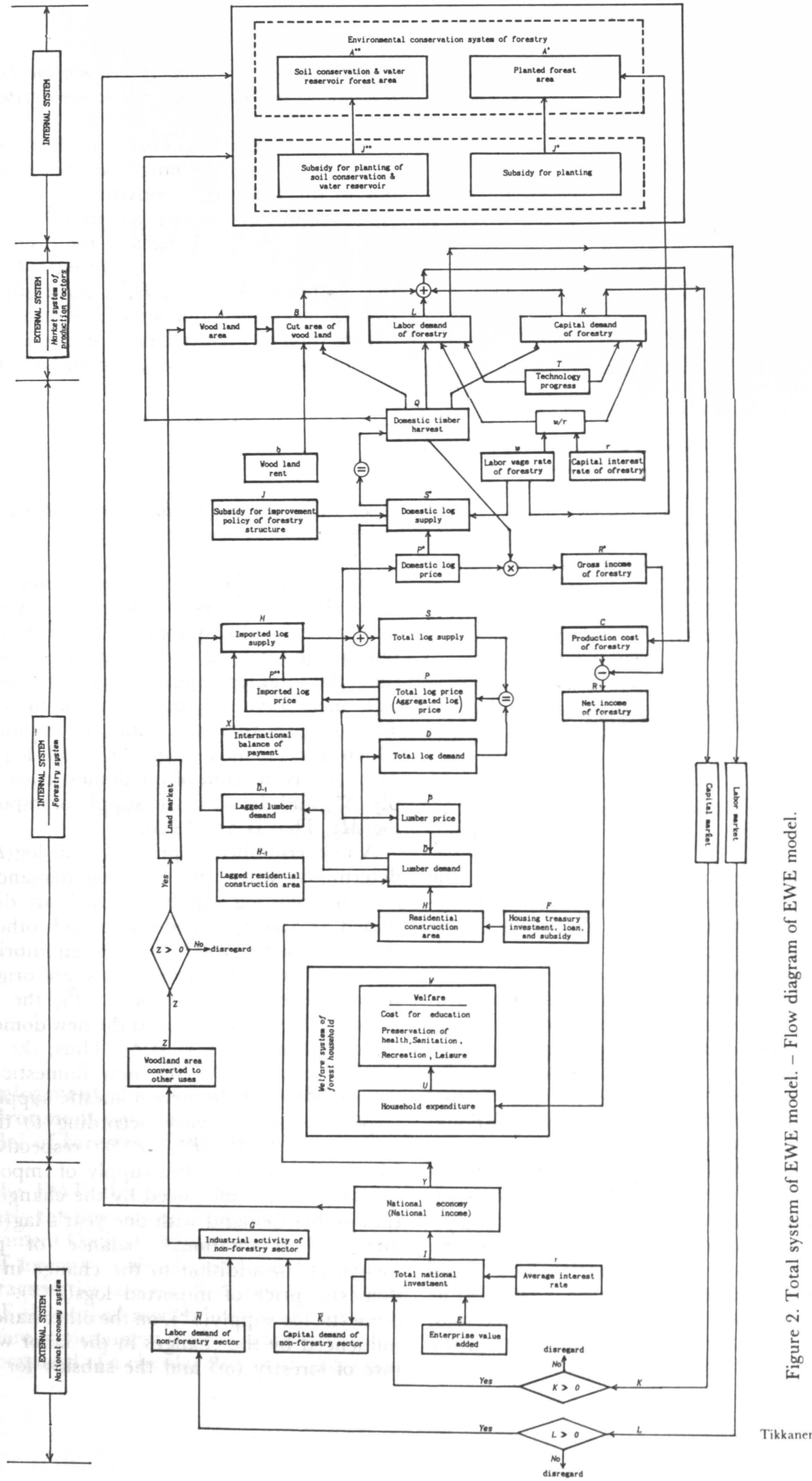


Figure 2. Total system of EWE model. – Flow diagram of EWE model.

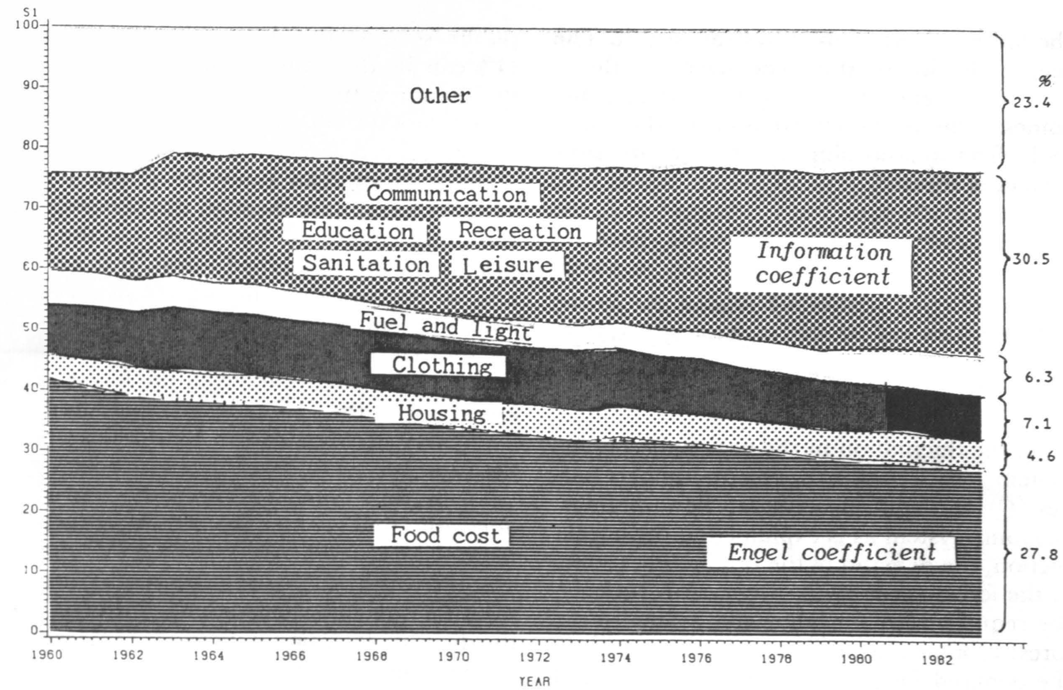


Figure 3. Composition of household expenditure. – Information coefficient.

provement policy of forestry structure(J), besides the change in the domestic log price(P^*). Then the domestic timber harvest(Q) is determined so as to be in accord with the domestic log supply(S^*). This is the explanation of the cause and effect relationship in the economic sub-system of forestry.

Meanwhile, the gross income of forestry (R^*) is obtained by multiplying the domestic timber harvest(Q) by the domestic log price(P^*), when the domestic timber harvest(Q) is determined as above. That is, $R^*=P^*\times Q$. On the other hand, production cost(C) for the domestic timber harvest(Q) is obtained by multiplying the production factors of woodland area(B), labor demand(L), and capital demand(K) by each price; woodland rent (b), labor wage (w), capital interest (r) respectively, and summing up those products. That is, $C=bB+wL+rK$. Thus, the net income of forestry (R) is derived by subtracting the production cost of forestry (C) from the gross income of forestry (R^*). That is, $R=R^*-C$. If the ratio of added value (a) of forestry is researched, however, the net income of forestry (R) is also derived by multiplying the gross income of forestry (R^*) by the ratio of added value(a), i.e. $R=a\times R^*$. In this paper, the net income of forestry (R) is decided by the latter method. Finally, the forest owners' household expenditure(U) is obtained by multiplying the net income of forestry (R) by propensity to consume (e). That is, $U=e\times R$.

Thus, the welfare(W) of forest owners' household is decided by multiplying the forest owners' household expenditure(U) by information coefficient(i). That is, $W=i\times U$. Here, in my opinion, the information coefficient(i) is the ratio of the household expenditure which is concerned with the level of mental satisfaction to the whole household expenditure(U). In other words, the information coefficient(i) is the ratio of the costs of education, preservation of health, sanitation, recreation, and leisure to the whole household expenditure(U). See Figure 3. Accordingly, the information coefficient(i) corresponds to Engel Coefficient which is the ratio of the food cost to the whole household expenditure(U). Thus, we recognize the former as a measure to indicate the mental wealth, while the latter is that of the physical wealth. The bigger the information coefficient(i), therefore, the higher the household welfare becomes. This is the explanation of the cause and effect relationship in the welfare subsystem of forestry.

Cause and effect relationship between the forestry economy system and the market system of production factors

As the fluctuation in the national economy system changes the domestic timber harvest(Q) through the circular flow of forest economy system as is explained in the former section, the demand of the production factors of the forest economy is also varied. Namely, the requirements for labor and capital in the forest economy system fluctuate according to the demand functions of forest labor(L) and forest capital(K), while the domestic timber harvest (Q) varies. Those changes in labor demand(L) and capital demand(K) in the forestry sector stimulate the labor demand ($\bar{N}$) and the capital demand ($\bar{K}$) in the non-forestry sector respectively, through the labor market and the capital market. Furthermore, the variation in the total national investment (I) stimulates the national income(Y), while the average interest rate(r^*) and the enterprise value added (E) vary.

Thus the changes in the capital($\bar{K}$) and the labor($\bar{N}$) in the non-forestry sector influence the industrial activity in the non-forestry sector(G), at the same time. As the result, this change in the non-forestry sector(G) influences the woodland area through the forest land converted to other uses(Z) in the land market. Now, the second great cycle is repeated. These cycles are of indefinite duration.

The environmental conservation of forest and the public compensation

By the harvest of domestic timber, the functions of the forest as a public service i.e. the non-timber products of the concerned forest are lost in a moment. The evaluated value of these lost forest functions as the public service, i.e. the public service value (V) can be determined through multiplying the domestic timber harvest (Q) by the unit public service value (v) of the Q. Therefore $V = v \times Q$.

Since society can enjoy the public service value of forest only through the planting and the maintenance of the forest by the proprietors of the concerned forest, it is reasonable to suppose that the "V" should be paid back to them as the indispensable social cost for the reforestation and the maintenance of that forest, at the time when the forest is cut away. Thus, the "V" is to be repaid as a tax by society itself instead of by the forest proprietors.

From this point of view, the more the domestic timber harvest (Q) increase, the more the lost public service value (V) rises in absolute value, so that the tax which compensates for the "V" increases accordingly, and the disposable national income (Y) decreases on the same scale (V).

On the other hand, this tax, equivalent to the "V" should, from the political point of view, be repaid as the subsidy for reforestation (J^*) and the subsidy for planting of soil conservation and water reservoir (J^{**}) to the forest proprietor.

Here, the unit public service value, i.e. the average public service price (v) which is necessary to estimate the "V" is determined through dividing the whole public service value of the forests in Japan (estimated by benefit-cost analysis, see Table 1) by its whole forest growing stock.

Table 1. Forest function as public service and its evaluation.

Forest function as public service	Evaluated public service value billion yen/year (1970)	(1983)
1. Water reservoir	1 600.0	3 238.4
2. Soil loss prevention	2 270.8	4 596.1
3. Soil conservation	50.4	102.0
4. Health-recreation	480.6	972.7
5. Wildlife protection	1 770.0	3 582.5
6. Oxygen supply-air cleaning	4 873.8	9 864.6
Total	11 045.6	22 356.3

cf. Japanese Forestry Agency (Investigation in 1970)

Incidentally, the total volume of standing timber in Japan in 1983 is 2 100 million cubic meters and its total public service value is 22 356.3 billion yen (conversion of the public service value of 1970 into that of 1983 by price index number). Therefore, the "v" is 10 645.9 yen per cubic meter.

The EWE mathematical model of forestry

The above clarifies the mutual relation among E-W-E, i.e. "economy", "welfare", and "environment" of forestry through the cause-and-effect relationship between internal system and external system of forestry. If we are to get the optimal balance among them, it is indispensable to adopt the following EWE mathematical model which describes the above relation in terms of formulas. That is, using this EWE mathematical model, i.e. the EWE theoretical model, we can control the "forest economy", "forest owner's welfare", and "environmental conservation of forestry" to the expected balance.

Estimation of the EWE theoretical model and its reproductivity test simulation

Estimation of the EWE theoretical model

This EWE theoretical model i.e. the EWE mathematical model is estimated by two methods; the 2-stage least squares method and the limited information maximum likelihood method. The results of both estimations are almost the same. In this paper, however, the result of the estimation by the 2-stage least squares method only is shown for the space is limited. See Table 2.

Reproductivity test simulation of the EWE theoretical model – Partial test simulation–

The partial test simulation to examine the reproductivity of the above estimated theoretical model, or the structural model is practiced as in Figure 4. The fitness of the model is extremely good. However, a few diagrams are shown to save pages.

Examination of the cause and effect relationship of the EWE theoretical model

In this paragraph, the cause and effect relationship between the dependent and the independent variables of the estimated EWE theoretical model is examined. That is, the elasticity coefficients between those variables are estimated as in Table 3, and shown by using the diagrams as in Figure 5. However, a few of them are presented.

The diagrams in this figure make the relationship between the dependent and independent variables very clear. Namely, in each diagram, the height of the histogram of each independent variable on the horizontal axis indicates the degree of the influence to the dependent variable on the vertical axis.

Estimation of the EWE policy formation model and its reproductivity test simulation

The EWE models for policy making

In this paragraph, before the estimation, it will be important to make sure the relationships of the "relation between the theoretical model and policy formation model" and the "relation between the theoretical model and policy decision model" and the "relation between policy decision model and policy manipulation model", which are necessary in the following paragraphs. These are shown in Figure 6 modelwise.

Table 2. Estimated EWE mathematical model of forestry.

I External system of forestry
– Market system of production factors –

(1) Labor demand of forestry

$$L = 1.4256 + 0.0172\,Q - 0.0004\,w/r - 0.9397\,\mathrm{Dum1} + 0.3709\,\mathrm{Dum2}$$

(0.0290) (0.0004) (0.1397) (0.2178)

[0.4972] [–0.1587]

$<< R^2 = 0.9408 >>$

(2) Capital demand of forestry

$$K = -8.8079 + 0.2206\,Q + 0.0071\,w/r + 2.4262\,\mathrm{Dum1} - 1.3132\,\mathrm{Dum3}$$

(0.1201) (0.0023) (0.4576) (0.6625)

[1.5612] [0.6899]

$<< R^2 = 0.9242 >>$

(3) Cut area of woodland

$$B = -169.1148 + 14.7329\,Q$$

(1.0738)

[1.3797]

$<< R^2 = 0.8996 >>$

II Internal system of forestry
– Sub-systems of forestry –

II · 1 Economy system of forestry – E system –

1) Production sub-system of forestry

(1) Domestic timber harvest

$$Q = S^*$$

2) Distribution sub-system of forestry

(1) Domestic log supply

$$S^* = 51.6008 + 0.1024\,P^* - 0.3489\,w + 0.1327\,J$$

(0.0332) (0.0332) (0.1117)

[0.2167] [–0.4910] [0.0372]

$<< R^2 = 0.9671 >>$

(2) Domestic log price

$$P^* = 1.0610 + 1.0694\,P - 6.8848\,\mathrm{Dum3}$$

(0.0702) (2.0734)

[1.0016]

$<< R^2 = 0.9211 >>$

(3) Imported log supply

$$M = -59.9594 + 0.2712\,P^{**} + 1.7877\,\hat{D}_{-1} + 0.4503\,X + 7.9472\,\mathrm{Dum2} - 3.3507\,\mathrm{Dum3}$$

(0.1077) (0.1904) (0.1171)

[0.6273] [1.9369] [0.0322]

(1.6910) (2.4992)

$<< R^2 = 0.9562 >>$

(4) Imported log price

$$P^{**} = 7.5192 + 0.8448\,P + 5.8180\,\mathrm{Dum3}$$

(0.0751) (2.2163)

[0.8911]

$<< R^2 = 0.8782 >>$

(5) Total log supply

$$S = S^* + M$$

(6) Total log demand

$$D = -0.2083 + 2.0689\,\hat{D}$$

(0.0760)

[1.0027]

$<< R^2 = 0.9724 >>$

(7) Market equilibrium of demand and supply

$$D = S \rightarrow P$$

3) Consumption sub-system of forestry

(1) Lumber demand

$$\hat{D} = 30.7339 - 0.0813\,\hat{P} + 0.0776\,H + 0.1179\,H_{-1} - 8.6713\,\mathrm{Dum2} - 4.8958\,\mathrm{Dum3}$$

(0.0752) (0.0375) (0.0419)

[–0.1921] [0.1960] [0.2874]

(1.7356) (1.1494)

$<<R^2 = 0.9109>>$

(2) Lumber price

$$\hat{P} = 2.4340 + 1.0377\,P - 6.5230\,\mathrm{Dum3}$$

(0.1119) (3.3008)

[0.9851]

$<<R^2 = 0.8124>>$

4) Income sub-system of forestry

(1) Gross income of forestry

$$R^* = P^* \times Q$$

(2) Net income of forestry

$$R = a \times R^*$$

II · 2 Welfare sub-system of forestry – W system –

(1) Forest owners' household expenditure

$$U = e \times R$$

(2) Forest owners' household welfare

$$W = i \times U$$

II · 3 Environmental conservation sub-system of forestry – E system –

(1) Lost total evaluated value of environmental conservation functions of forest

$$V = v \times Q$$

(2) Planted forest area

$$A^* = 493.8685 - 4.9754\,w + 2.0658\,J^* + 62.0029\,\mathrm{Dum1} - 50.8458\,\mathrm{Dum3}$$

(0.8525) (1.5527) (21.2088) (17.0472)

[–1.0179] [0.1777]

$<<R^2 = 0.9504>>$

(3) Soil conservation and water reservoir forest area

$$A^{**} = 24.3749 + 0.3130\,J^{**}$$

(0.0220)

[0.5450]

$<<R^2 = 0.9058>>$

III External system of forestry
– National economy system –

(1) National income

$$Y = 29.6579 + 1.6318\,I + 16.1566\,\mathrm{Dum2} + 29.4410\,\mathrm{Dum3}$$

(0.0614) (2.9608) (2.8479)

[0.6735]

$<<R^2 = 0.9939>>$

(2) National investment

$$I = 0.3509 - 0.8068\,r^* + 1.0864\,E + 10.7907\,\mathrm{Dum2} + 4.3676\,\mathrm{Dum3}$$

(0.8438) (0.0429) (1.5293) (1.5629)

[–0.1167] [1.0069]

$<<R^2 = 0.9915>>$

(3) Labor demand of non-forestry sector

$$\hat{N} = N - L$$

(4) Capital demand of non-forestry sector

$$\hat{K} = I - K$$

(5) Industrial activity of non-forestry sector

$$G = -167.1213 + 39.4734\,\hat{N} + 0.5895\,\hat{K}$$

(4.9116) (0.0732)

[3.0431] [0.4681]

$<<R^2 = 0.9933>>$

(6) Residential construction area

$$H = -24.7447 + 1.0894\,Y - 26.2549\,\mathrm{Dum2} - 58.9664\,\mathrm{Dum3}$$

(0.0732) (6.6614) (6.2759)

[1.4988]

$<<R^2 = 0.9519>>$

Notes:

1) Numbers in parenthes are standard errors.

2) Numbers in brackets are elasticity coefficients.

3) R^2 is a determination coefficient.

4) *Dum1* is a dummy variable representing the structural change of Japanese forestry (1961～67: *Dum1*=0, 1968～83: *Dum1*=1).

Dum2 is a dummy variable representing the structural change of Japanese economy by the first oil crisis (1961～73: *Dum2*=0, 1974～83: *Dum2*=1).

Dum3 is a dummy variable representing the structural change of Japanese economy by the second oil crisis (1961～79: *Dum3*=0, 1980～83: *Dum3*=1).

5) Sample period is 1961～83.

Explanation of letters

A	: Woodland area
A*	: Planted forest area (i.e., reforestation area)
A**	: Soil conservation and water reservoir forest area
a	: Ratio of added value of forestry
B	: Cut area of woodland
C	: Production cost of forestry
D	: Total log demand
$\hat{D}$	: Lumber demand
$\hat{D}_{-1}$	: Lumber demand with one year's lag
e	: Propensity to consume
E	: Enterprise value added
G	: Industrial activity of non-forestry sector
H	: Residential construction area
H_{-1}	: Residential construction area with one year's lag
I	: National investment
i	: Information coefficient
J	: Subsidy for improvement policy of forestry structure
J*	: Subsidy for planting (i.e., Subsidy for reforestation)
J**	: Subsidy for planting of soil conservation and water reservoir
K	: Capital demand of forestry
$\hat{K}$	: Capital demand of non-forestry sector (i.e., Investment of non-forestry sector)
L	: Labor demand of forestry
M	: Domestic supply of imported log (i.e., Imported log supply)
N	: Total labor demand (i.e., Total work force)
$\hat{N}$	: Labor demand of non-forestry sector
P	: Total log price (i.e., Aggregated log price)
P*	: Domestic log price
P**	: Domestic price of imported log (i.e., Imported log price)
$\hat{P}$	: Lumber price
Q	: Domestic timber harvest
R	: Net income of forestry
R*	: Gross income of forestry
r	: Capital interest of forestry
r*	: Average interest rate (i.e., National interest rate)
S	: Total log supply
S*	: Domestic log supply
U	: Forest owners' household expenditure
V	: Lost total evaluated value of environmental conservation function of forest (i.e., Total compensation in accordance with the public service value of forest)
v	: Average evaluated value of environmental conservation function of forest (i.e., Unit public service value of forest)
W	: Forest owners' household welfare
w	: Labor wage rate of forestry
w/r	: Relative price of labor wage and capital interest of forestry (i.e., Ratio of labor wage rate to capital interest rate of forestry)
X	: International balance of payment
Y	: National income

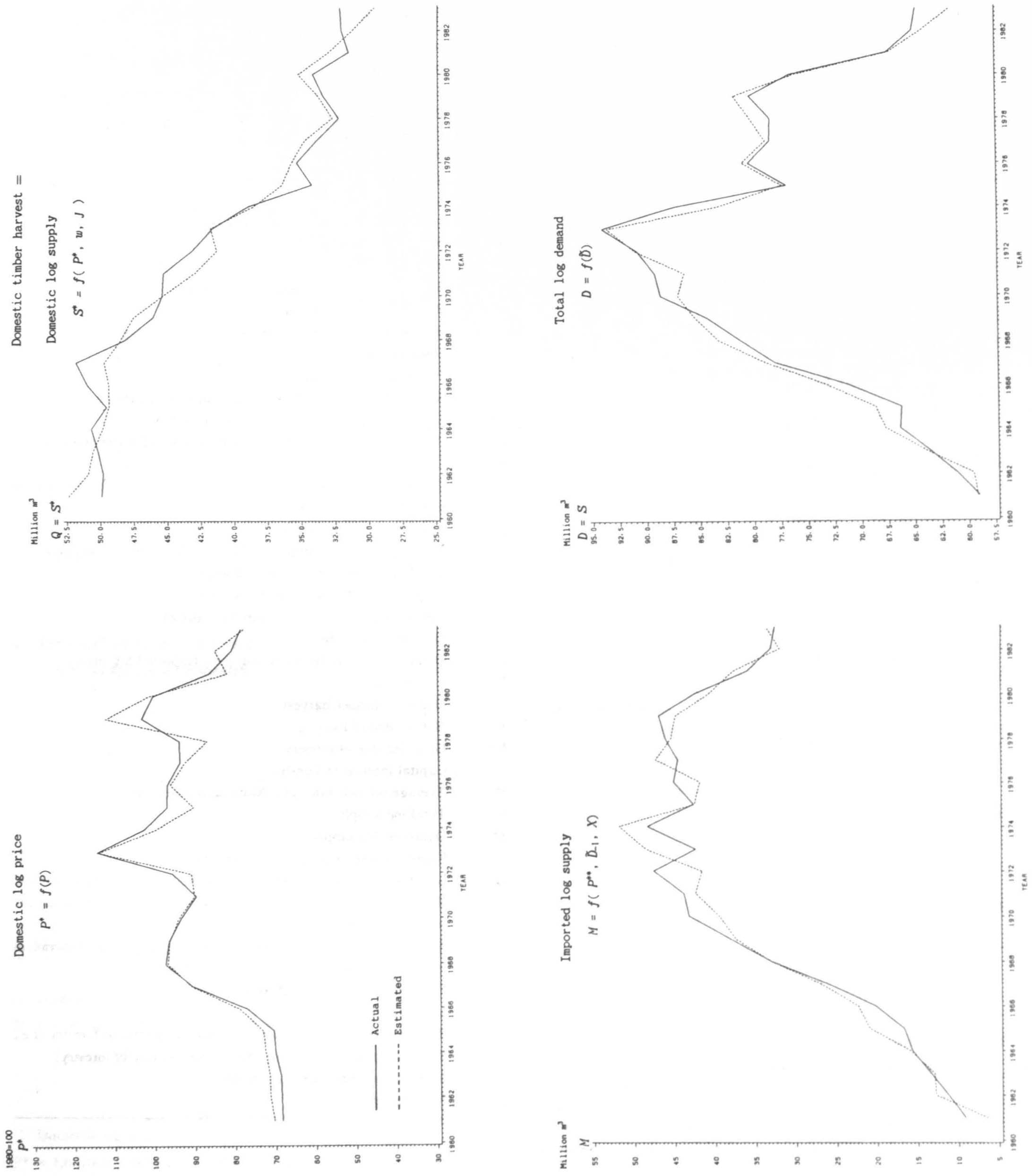


Figure 4. Reproductivity test simulation of EWE theoretical model. – Partial test simulation.

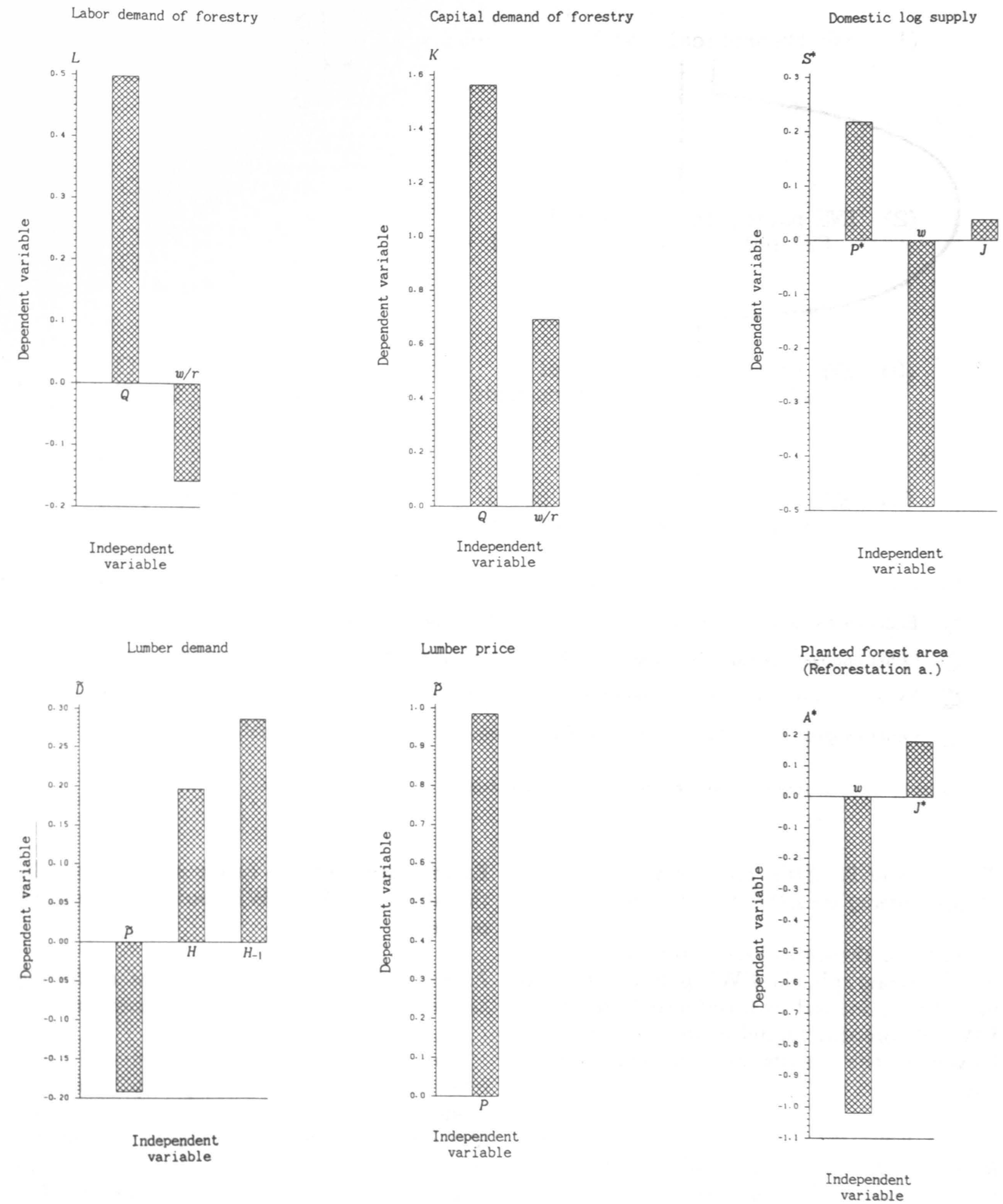
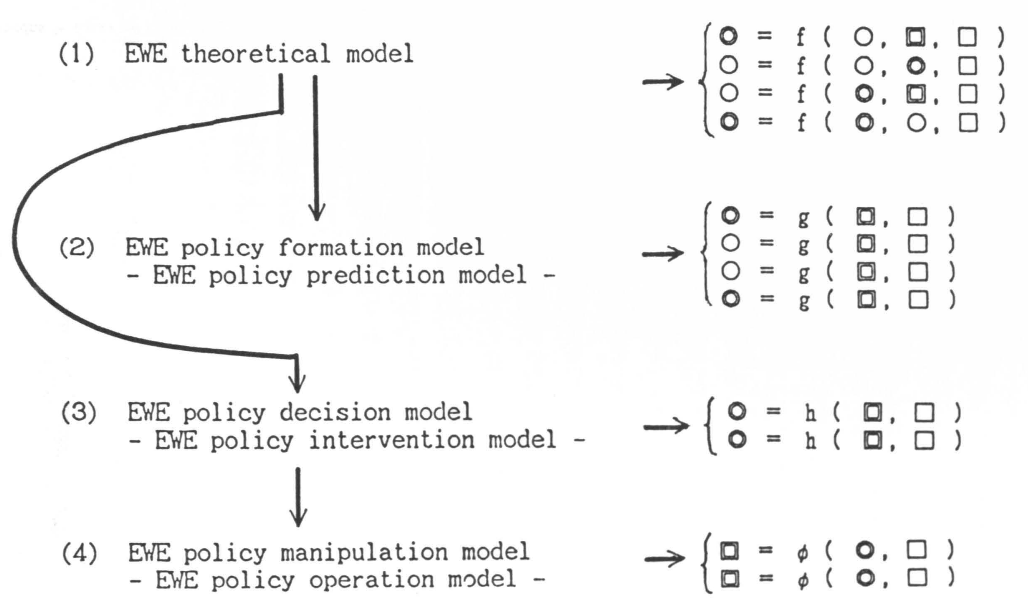


Figure 5. Examination of the cause and effect relationship of EWE theoretical model.



Explanatory notes

◎ Endogenous variable selected as policy target: Policy target variable

○ Other endogenous variable except for policy target variable: Non-policy target variable

▣ Exogenous variable selected as policy instrument: Policy instrumental variable

□ Other exogenous variable except for policy instrumental variable: Given variable

Figure 6. Various types of EWE model for policy operating.

Estimation of the EWE policy formation model – Reduced form of the EWE theoretical model –

With the theoretical background as above, in this paragraph, the EWE policy formation model is estimated as a reduced form of the EWE theoretical model estimated formerly. However, the results are omitted to save pages.

Reproductivity test simulation of the EWE policy formation model – Final test simulation –

The reproductivity of the EWE policy formation model estimated as above is examined by both total test simulation and final one, but here, only the result of the latter is shown to save pages. See Figure 7. The fitness of the EWE policy formation model is extremely good. In this paper, however, a few of them are shown.

Examination of the cause and effect relationship of the EWE policy formation model

Examination of the cause and effect relationship between the endogenous and the exogenous variables

The examination of the cause and effect relationship of the EWE policy formation model means that of the cause and effect relationship between the endogenous and the exogenous variables and so between the target and the instrumental variables. The results are shown in the following Table 4.

This table can be illustrated otherwise using diagrams as in Figure 8. However, a few of them are shown to save pages.

Table 3. Examination of the cause and effect relationship of EWE theoretical model. – Examination of the elasticity coefficient between dependent and independent variables–

Dependent variable	L	K	B	Q=S*	P*	M	P**	D	$\dot{D}_{-1}$	$\dot{P}$	A*	A**	Y	I	G	H	P	$\dot{N}$	$\dot{K}$
L				0.4972															
K				1.5612															
B				1.3797															
S*=Q					0.2167														
P*																	1.0016		
M							0.6273												
P**																	0.8911		
D									1.0027										
$\dot{D}$										−0.1921						0.1960			
$\dot{P}$																	0.9851		
A*																			
A**																			
Y														0.6735					
I																			
G																		3.0431	0.4681
H													1.4988						
$\dot{N}$																			
$\dot{K}$																			

Dependent variable	X	J	J*	J**	r*	w	w/r	E	$\dot{D}_{-1}$	H_{-1}
L							−0.1587			
K							0.6899			
B										
S*=Q		0.0372				−0.4910				
P*										
M	0.0322								1.9369	
P**										
D										
$\dot{D}$										0.2874
$\dot{P}$										
A*			0.1777			−1.0179				
A**				0.5450						
Y										
I					−0.1167			1.0069		
G										
H										
$\dot{N}$										
$\dot{K}$										

Effect of the exogenous variables on the household welfare and the environmental conservation

In consideration of the every elasticity coefficients between the endogenous and the exogenous variables, the effects of these eight exogenous variables mentioned above on those endogenous variables of the forest owners' household welfare and the environmental conservation of forest which are the most important target variables for the EWE model are made clear.

Effects of the exogenous variables on the household welfare

The forest owners' household welfare (W) depends on the forest owners' household expenditure (U), the (U) depends on the net income of forestry (R), and the (R) also depends on the domestic log supply (S^*) and the domestic log price (P^*) as mentioned in Figure 2. As a result, the endogenous variables which effect on the forest owners' household welfare at the end are only the domestic log

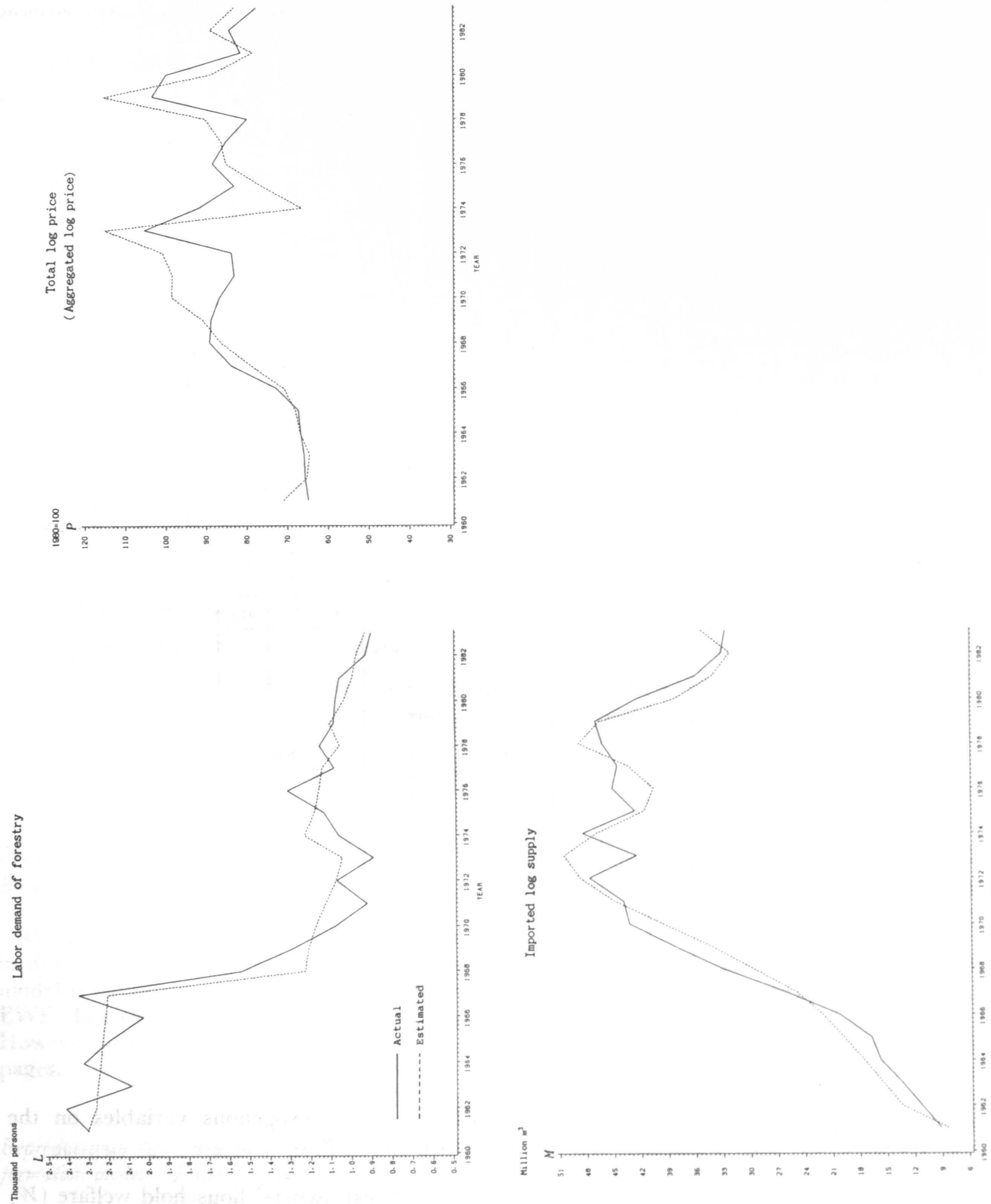


Figure 7. Reproductivity test simulation of EWE policy formation model. – Final test simulation.

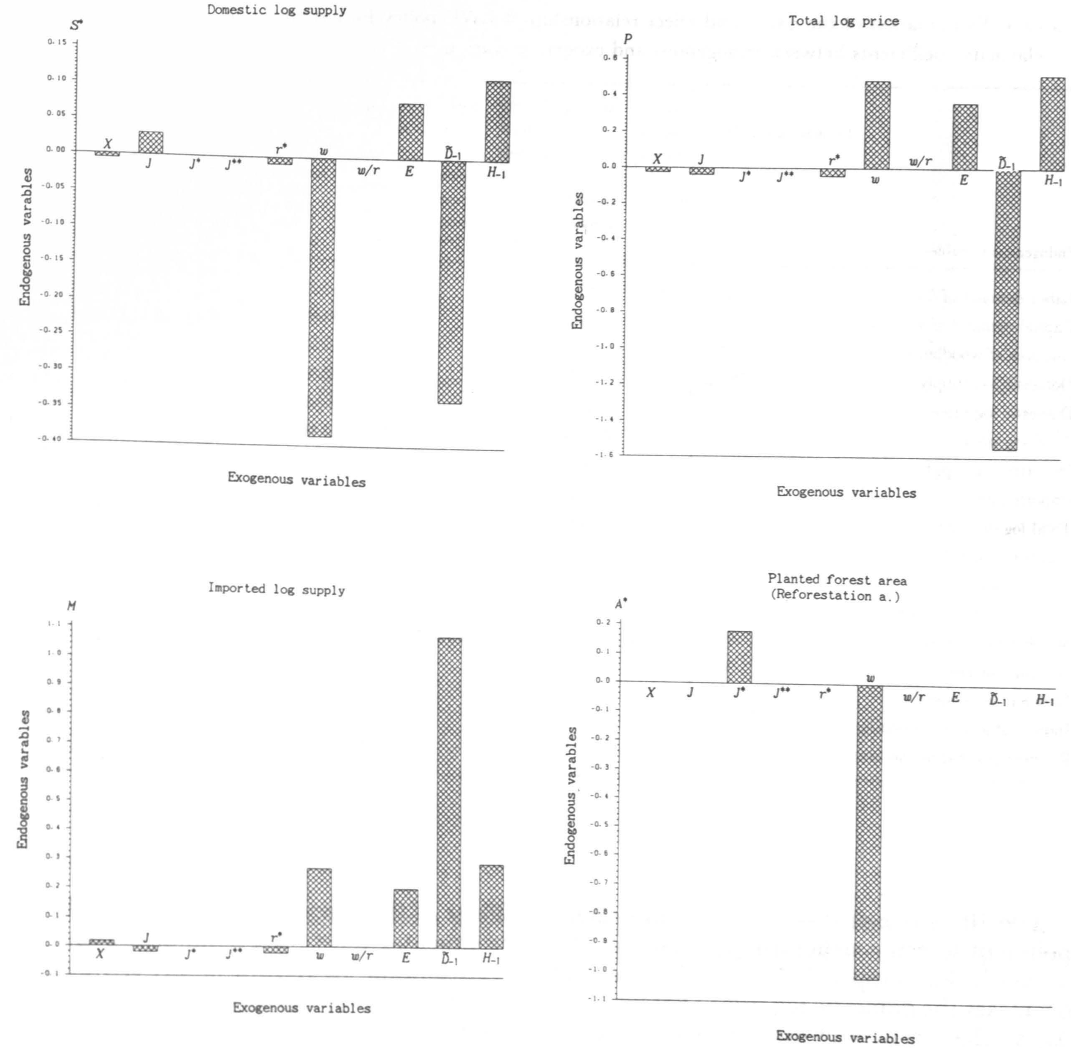


Figure 8. Examination of the cause and effect relationship of EWE policy formation model.

supply (S^*) and the domestic log price (P^*).

Therefore, the effects of these eight exogenous variables (X, J, J^*, J^{**}, r^*, w, w/r, E) on the forest owners' household welfare (W) are made clear, when the elasticity coefficients among those two endogenous variables (S^*, P^*) and the above mentioned eight exogenous variables are examined (See Table 4 or Figure 9). That is, the policy formations among the endogenous variable of the forest owners' household welfare and the above eight exogenous variables are made clear as followed. In this paper, however, only the effect of subsidy for improvement policy of forestry structure (J) as an exogenous variable on the forest owners' household welfare is made clear as an example for the space is limited.

The effect of subsidy for improvement policy of forestry structure (J):

Table 4. Examination of the cause and effect relationship of EWE policy formation model. – Examination of the elasticity coefficients between endogenous and exogenous variables –

Endogenous variables \ Exogenous variables		International balance of payment X	Subsidy for improvement of forestry structure J	Subsidy for reforestation J*	Subsidy for soil & water conservation J**	Average interest rate r*	Forest labor wage rate w	Relative price of wages & interest w/r	Enterprise value added E	Lagged labor demand $\hat{D}_{-1}$	Lagged residential construction area H_{-1}
Labor demand of forestry	L	-0.0029	0.0146			-0.0042	-0.1913	-0.1587	0.0373	-0.1679	0.5540
Capital demand of forestry	K	-0.0087	0.0456			-0.0140	-0.6028	0.6899	0.1213	-0.5244	0.1753
Cut area of woodland	B	-0.0077	0.0404			-0.0124	-0.5329		0.1072	-0.4632	0.1547
Domestic log supply	S*=Q	-0.0056	0.0293			-0.0090	-0.3863		0.0777	-0.3357	0.1120
Domestic log price	P*	-0.0258	-0.0366			-0.0416	0.4837		0.3585	-1.5496	0.5173
Total log price	P	-0.0257	-0.0366			-0.0415	0.4829		0.3580	-1.5472	0.5165
Imported log supply	M	0.0178	-0.0205			-0.0232	0.2700		0.2001	1.0720	0.2887
Imported log price	P**	-0.0229	-0.0326			-0.0370	0.4303		0.3191	-1.3788	0.4603
Total log demand	D	0.0049	0.0069			-0.0153	-0.0916		0.1318	0.2935	0.1902
Lumber demand	$\hat{D}$	0.0049	0.0669			-0.0152	-0.0913		0.1315	0.2927	0.1897
Lumber price	$\hat{P}$	-0.0254	-0.0360			-0.0409	0.4757		0.3527	-1.5241	0.5089
Planted forest area (Reforestation a.)	A*			0.1777			-1.0179				
Soil & water conservation forest area	A**				0.5450						
National income	Y					-0.0786			0.6782		
National investment	I					-0.1167			1.0069		
Industrial activity in non-forestry	G					-0.0547			0.4714		
Residential construction area	H					-0.1178			1.0164		

The 10 % rise of subsidy for improvement policy of forestry structure *(J)* increases the domestic log supply *(S*)* by 0.293 % and decreases the domestic log price *(P*)* by 0.366 %, so that in case of other exogenous variables are fixed, the 10 % increase of subsidy for improvement policy of forestry structure *(J)* decreases the household welfare by –0.073 % (= 0.293 % – 0.366 %) as the result.

What this fact means is that the increase of the subsidy for improvement policy of forestry structure *(J)*, the biggest and the most important exogenous variable as utterly controllable policy instrument of the above eight exogenous variables, does not increase the welfare of forest owners; to the contrary, this policy decreases the household welfare of forest owners and therefore clarified is a serious fact (or reality of selfcontradictory policy) that this policy brings about countermarching affection against the expected aim of the government.

Effects of the exogenous variables on the environmental conservation compensation

In the EWE policy formation model, the public compensation in accordance with the value of environmental conservation of forest depends on the quantity of the domestic timber harvest *(Q)* or that of the domestic log supply *(S*)* only. Therefore, the effects of the exogenous variables on the environmental conservation of forest are clarified by examining the elasticity coefficient among the domestic log supply *(S*)* as the endogenous variable and the above eight variables *(X, J, J*, J**, r*, w, w/r, E)* as the exogenous ones. See Table 4 or Figure 9. From these table and figure, the following facts are made clear. Here, only the effect of the *(J)* on the environmental conservation compensation is explained as an example.

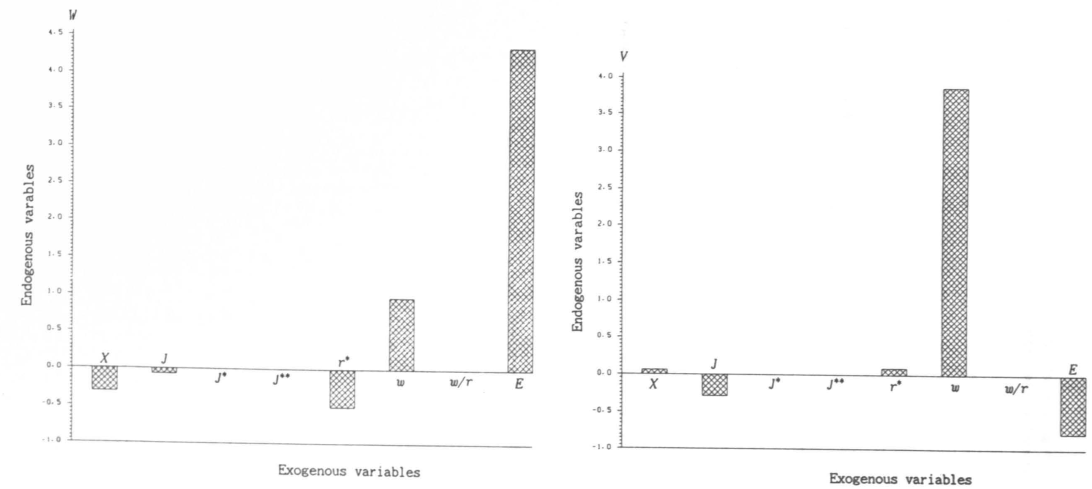


Figure 9. Effects of the exogeneous variables on the forest owners' household welfare and the environmental conservation of forest.

The effect of subsidy for improvement policy of forestry structure *(J)*:

The 10 % rise in subsidy for improvement policy of forestry structure *(J)* increases the domestic log supply *(S*)* by 0.293 %. So that, in case of other exogenous variables are fixed, the 10 % increase of subsidy for improvement policy of forestry structure *(J)* decreases the public service value *(V)* corresponding to the environmental conservation of forest by 0.293 %. Therefore, the public compensation for the environmental conservation of forest increases the corresponding amount.

In this way, the effects of the exogenous variables on the household welfare and the environmental conservation of forest are made clear, these effects can be illustrated otherwise using diagrams as in Figure 9.

Policy forming simulation by the EWE policy formation model – Policy prediction –

Since the EWE policy formation model is a model to observe the variation of endogenous variables (including policy target variables) influenced by the changes of exogenous variables (including policy instrumental variables), it is possible to predict experimentally the variations of endogenous variables according to that of exogenous variables predicted beforehand. Therefore the situation of policy forming is simulated by the EWE policy formation model. In this sense, a simulation of this kind is named here as "policy forming simulation" or "policy prediction".

In the practical prediction, a trend curve is extrapolated to each exogenous variable for a standard policy prediction, and at the same time, certain conscious variations are to be assumed for upper or lower policy predictions. A few of them are shown in Figure 10.

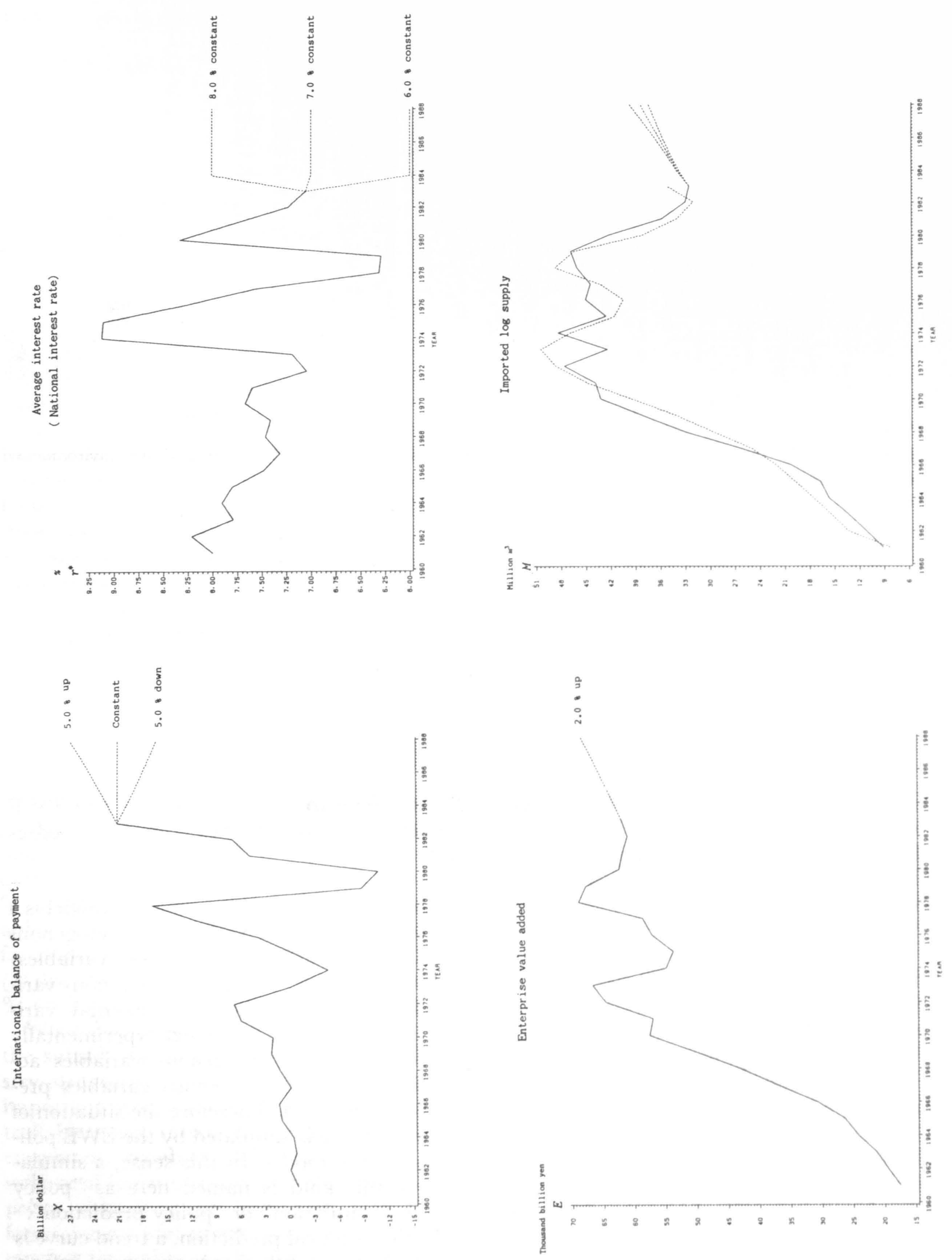
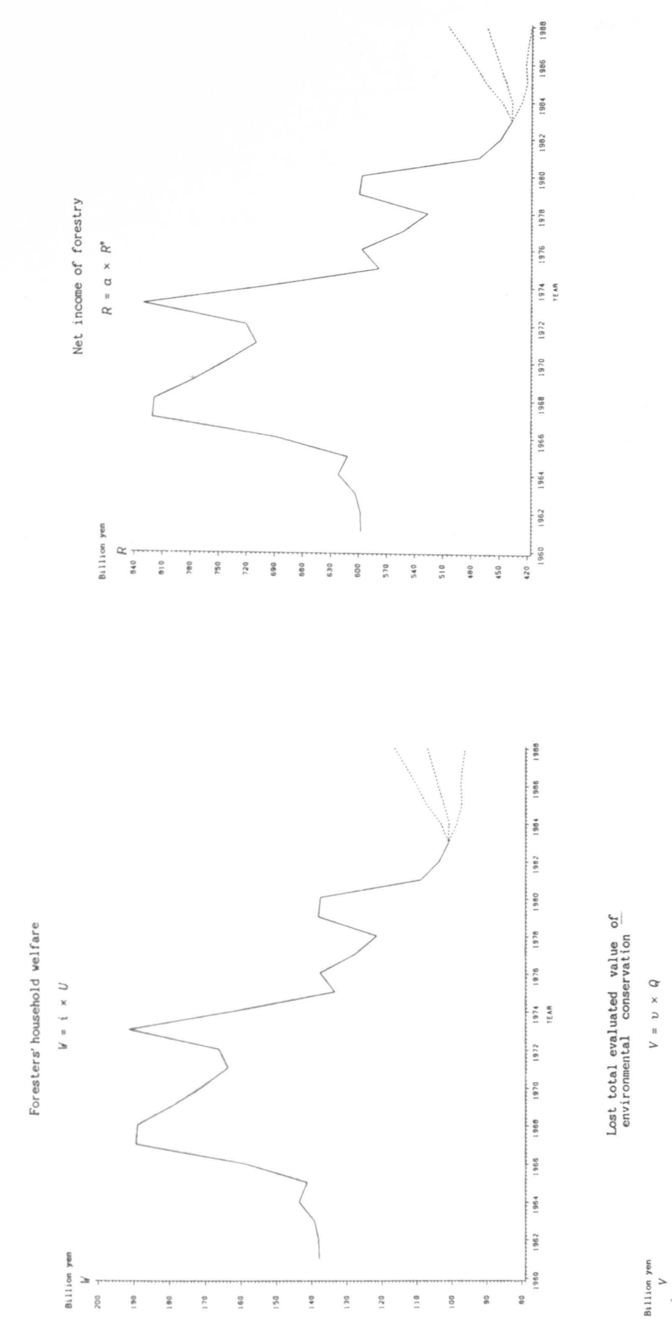


Figure 10. Policy forming simulation by EWE policy formation model. – Policy prediction.



Estimation of the EWE policy decision model

Theory of the estimation of the EWE policy decision model

As the EWE policy decision model, namely the EWE policy intervention model is the one to measure the policy effect on the target variable when the positive policy intervention is given on the instrumental variable, in such a policy decision model, the marginal condition has to be satisfied so that the number of target variables can coincide with that of instrumental variables. In order to get such a policy decision model of the EWE model, let us suppose the general form of the EWE mathematical model as follows.

$$(1) \quad AY_A+BY_B+CZ_C+DZ_D=u$$

$$A = \begin{bmatrix} a_{11} \cdots\cdots a_{1k} \\ \vdots \quad\quad \vdots \\ a_{k1} \cdots\cdots a_{kk} \\ a_{k+1,1} \cdots\cdots a_{k+1,k} \\ \vdots \quad\quad \vdots \\ a_{k+l,1} \cdots\cdots a_{k+l,k} \end{bmatrix} \quad B = \begin{bmatrix} b_{11} \cdots\cdots b_{1l} \\ \vdots \quad\quad \vdots \\ b_{k1} \cdots\cdots b_{kl} \\ b_{k+1,1} \cdots\cdots b_{k+1,l} \\ \vdots \quad\quad \vdots \\ b_{k+l,1} \cdots\cdots b_{k+l,l} \end{bmatrix} \quad C = \begin{bmatrix} c_{11} \cdots\cdots c_{1k} \\ \vdots \quad\quad \vdots \\ c_{k1} \cdots\cdots c_{kk} \\ c_{k+1,1} \cdots\cdots c_{k+1,k} \\ \vdots \quad\quad \vdots \\ c_{k+l,1} \cdots\cdots c_{k+l,k} \end{bmatrix}$$

$$D = \begin{bmatrix} d_{11} \cdots\cdots d_{1m} \\ \vdots \quad\quad \vdots \\ d_{k1} \cdots\cdots d_{km} \\ d_{k+l,1} \cdots\cdots d_{k+1,m} \\ \vdots \quad\quad \vdots \\ d_{k+l,1} \cdots\cdots d_{k+l,m} \end{bmatrix} \quad \begin{matrix} Y_A = [Y_{A1} \cdots\cdots Y_{Ak}]' & Y_B = [Y_{B1} \cdots\cdots Y_{Bl}]' \\ Z_C = [Z_{C1} \cdots\cdots Z_{Ck}]' & Z_D = [Z_{D1} \cdots\cdots Z_{Dm}]' \\ u \; = [u_1 \cdots\cdots u_{k+l}]' & \end{matrix}$$

Here, Y_A, Y_B, Z_C, Z_D, and u are policy target variables, non-policy target variables, policy instrumental variables, given variables (in this case, it is constant), and error term, respectively.

After eliminating Y_B, Z_D, and u from formula (1), and solving it with respect to Y_A, we obtain the EWE policy decision model in general form, as below.

$$(2) \quad Y_A = C^{**}Z_c+E^*$$

$$C^{**} = \begin{bmatrix} c^{**}_{11} \cdots\cdots c^{**}_{1k} \\ \vdots \quad\quad \vdots \\ c^{**}_{k1} \cdots\cdots c^{**}_{kk} \end{bmatrix} = - \begin{bmatrix} a^*_{11} \cdots\cdots a^*_{1k} \\ \vdots \quad\quad \vdots \\ a^*_{k1} \cdots\cdots a^*_{kk} \end{bmatrix}^{-1} \begin{bmatrix} c^*_{11} \cdots\cdots c^*_{1k} \\ \vdots \quad\quad \vdots \\ c^*_{k1} \cdots\cdots c^*_{kk} \end{bmatrix}$$

$$E^* = \begin{bmatrix} E^*_1 \\ \vdots \\ E^*_k \end{bmatrix} = - \begin{bmatrix} a^*_{11} \cdots\cdots a^*_{1k} \\ \vdots \quad\quad \vdots \\ a^*_{k1} \cdots\cdots a^*_{kk} \end{bmatrix}^{-1} \begin{bmatrix} d^*_{11} \cdots\cdots d^*_{1m} \\ \vdots \quad\quad \vdots \\ d^*_{k1} \cdots\cdots d^*_{km} \end{bmatrix} \begin{bmatrix} Z_{D1} \\ \vdots \\ Z_{Dm} \end{bmatrix}$$

Based on this formula (2), the effects of the various kinds of policy decisions are simulated.

Estimation of the EWE policy decision model

With the theoretical background as above, the next step is to deduce the EWE policy decision model from the EWE theoretical model. For this purpose, it is necessary to determine beforehand which ones are policy target variables and which ones are policy instrumental variables of the whole variables of this model.

Seeing that this EWE theoretical model is designed so as to these three elements of forestry economy, welfare, and environment stand in a trio, i.e. in the optimal harmony of E-W-E, the required policy target variables for the optimal harmony of these three elements of "E,W,E" should have their own objects as follows respectively: firstly, as to the economic policy target "E", it is necessary to have its objects in the net income of forestry (R) which represents the ultimate results in forest economy and the imported log supply (M) which is the strongest economic outside pressure in the forest economy respectively: secondly, as to the welfare policy target "W", the forest owners' household welfare (W) is required as its object; and lastly, as to the environmental policy target "E", the reforestation area (A^*) and the soil conservation and water reservoir forest area (A^{**}) which represent the conservation of national land and water resources are required as its objects.

Of these targets, however, the net income of forestry (R) and the forest owners' household welfare (W) are, in this EWE theoretical model, expressed as the function of domestic log price (P^*) and domestic log supply (S^*) like $R = a(P^* \times S^*)$ and $W = i\{e(P^* \times S^*)\}$ respectively (here, "a" is ratio of added value of forestry, "e" is propensity to consume, and "i" is information coefficient). Therefore the (R) as the economic policy target and the (W) as the welfare policy target are determined basically by the (P^*) and the (S^*).

Next, the policy instrumental variables to attain the above policy targets are regarded as follows. As to the economic policy target of forestry, in the case to test its effect, national average interest rate (r^*) which controls the forest economy is, while in the another case to test the effect of the outside pressure on forestry economy, international balance of payment (X) which controls the imported log is required respectively.

As to the welfare policy target of forestry, to test the effects on the household welfare of forest owner, the subsidy for improvement policy of forestry structure (J) is especially needed as the policy instrumental variables.

Finally, for the environmental policy target of forestry, in order to examine its effectiveness on the environmental conservation, the subsidies for reforestation (J^*) and for planting of soil conservation and water reservoir (J^{**}) are outstandingly required.

In conclusion, the whole variables included in the EWE theoretical model are classified and rearranged from the standpoint of making the EWE policy decision model as listed in Table 5.

With the theoreticaal background above, the EWE policy decision model is deduced from the EWE theoretical models shown in Table 6. Only by this policy decision model, we can judge the effectiveness of the active policy intervention in policy instrumental variables on the policy target variables precisely.

Policy decision simulation by the EWE policy decision model

In the Table 7 shown are the simulations for the policy effectiveness of domestic log supply (S^*), domestic log price (P^*), imported log supply (M), reforestation area (A^*), and soil conservation and water reservoir forest area (A^{**}) as the policy target variables in the case of the changes of international balance of payment (X), subsidy for improvement policy of forestry structure (J), subsidy for reforestation (J^*), subsidy for planting of soil conservation and water reservoir (J^{**}), and average interest rate (r^*) as the policy instrumental variables of this model by ± 10 %, ± 20 %, ± 30 %, ± 40 %, or ± 50 % uniformly.

Estimation of the EWE policy manipulation model

Theory of the estimation of the EWE policy manipulation model

A policy manipulation model is the one to determine the ranges of the various policy instruments which attains the various policy targets. Then the EWE policy manipulation model in general form is obtained by solving the above mentioned formula (2) with respect to Z_C as follows.

$$(3) \quad Z_C = A^{**}Y_A+E^{**}$$

$$A^{**} = \begin{bmatrix} a^{**}_{11} \cdots\cdots a^{**}_{1k} \\ \vdots \quad\quad \vdots \\ a^{**}_{k1} \cdots\cdots a^{**}_{kk} \end{bmatrix} = - \begin{bmatrix} c^*_{11} \cdots\cdots c^*_{1k} \\ \vdots \quad\quad \vdots \\ c^*_{k1} \cdots\cdots c^*_{kk} \end{bmatrix}^{-1} \begin{bmatrix} a^*_{11} \cdots\cdots a^*_{1k} \\ \vdots \quad\quad \vdots \\ a^*_{k1} \cdots\cdots a^*_{kk} \end{bmatrix}$$

$$E^{**} = \begin{bmatrix} E^{**}_1 \\ \vdots \\ E^{**}_k \end{bmatrix} = - \begin{bmatrix} c^*_{11} \cdots\cdots c^*_{1k} \\ \vdots \quad\quad \vdots \\ c^*_{k1} \cdots\cdots c^*_{kk} \end{bmatrix}^{-1} \begin{bmatrix} d^*_{11} \cdots\cdots d^*_{1m} \\ \vdots \quad\quad \vdots \\ d^*_{k1} \cdots\cdots d^*_{km} \end{bmatrix} \begin{bmatrix} Z_{D1} \\ \vdots \\ Z_{Dm} \end{bmatrix}$$

On the ground of this formula (3), simulated are the ranges of the various policy instruments or the degree of the various policy interventions to realize the various policy targets.

Estimation of the EWE policy manipulation model

With the theoretical background mentioned above, the EWE policy manipulation model is deduced from the EWE policy decision model, as shown in Table 8. Only by this policy manipulation model, we can judge what degree we should manipulate the policy instrumental variables so as to attain the expected values of policy target variables. That is, with this model, we can optimize the social system of forestry with "visible hand" steadily and scientifically.

Literature

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Total of 4 references

Table 5. Classification and rearrangement of the whole variables of EWE policy decision model.

Endogenous variable				
	Name of variable	Letter	Target variable	Non-target variable
Endogenous variables estimated simultaneously	Labor demand of forestry	L		⊕
	Capital demand of forestry	K		⊕
	Cut area of woodland	B		⊕
	Domestic log supply	S^*	⊗	
	Domestic log price	P^*	⊗	
	Total log price	P		⊕
	Imported log supply	M	⊗	
	Imported log price	P^{**}		⊕
	Total log demand	D		⊕
	Lumber demand	$\tilde{D}$		⊕
	Lumber price	$\tilde{P}$		⊕
	Planted forest area	A^*	⊗	
	Soil & water conservation forest area	A^{**}	⊗	
	National income	Y		⊕
	National investment	I		⊕
	Industrial activity in non-forestry	G		⊕
	Residential construction area	H		⊕
Endogenous variables estimated accordingly	Domestic timber harvest	Q	$Q = S^*$	
	Total log supply	S	$S = S^* + M$	
	Gross income of forestry	R^*	$R^* = P^* \times S^*$	
	Net income of forestry	R	$R = a \times R^*$	
	Forest owners' household expenditure	U	$U = e \times R$	
	Forest owners' household welfare	W	$W = i \times U$	
	Lost total evaluated value of environmental conservation	V	$V = v \times Q$	
	Labor demand of non-forestry sector	$\tilde{N}$	$\tilde{N} = N - L$	
	Capital demand of non-forestry sector	$\tilde{K}$	$\tilde{K} = I - K$	

Table 5. cont.

Exogenous variable			
Name of variable	Letter	Instrumental variable	Given variable
International balance of payment	X	△	
Subsidy for improvement of forestry structure	J	△	
Subsidy for reforestation	J^*	△	
Subsidy for soil & water conservation	J^{**}	△	
Average interest rate	r^*	△	
Labor wage rate of forestry	w		□
Relative price of wage and interest	w/r		□
Enterprise value added	E		□
Lagged lumber demand	$\tilde{D}_{-1}$		□
Lagged residential construction area	H_{-1}		□
Dummy variable 1	*Dum 1*		□
Dummy variable 2	*Dum 2*		□
Dummy variable 3	*Dum 3*		□

Note

Dum 1 represents the structural change of Japanese forestry.
(1961–67: Dum1 = 0, 1968–83: Dum1 = 1)

Dum 2 represents the structural change of Japanese economy by the first oil crisis.
(1961–73: Dum2 = 0, 1974–83: Dum2 = 1)

Dum 3 represents the structural change of Japanese economy by the second oil crisis.
(1961–80: Dum3 = 0, 1981–83: Dum3 = 1)

Table 6. Estimated EWE policy decision model.

$$Y_A = C^{**} Z_C + E^*$$

$$\underbrace{\begin{bmatrix} S^* \\ P^* \\ M \\ A^* \\ A^{**} \end{bmatrix}}_{Y_A} = \underbrace{\begin{bmatrix} -0.0961 & 0.1044 & 0 & 0 & -0.0491 \\ -0.9384 & -0.2766 & 0 & 0 & -0.4798 \\ 0.2492 & -0.0593 & 0 & 0 & -0.1028 \\ 0 & 0 & 2.0658 & 0 & 0 \\ 0 & 0 & 0 & 0.3130 & 0 \end{bmatrix}}_{C^{**}} \underbrace{\begin{bmatrix} X \\ J \\ J^* \\ J^{**} \\ r^* \end{bmatrix}}_{Z_C}$$

$$+ \underbrace{\begin{bmatrix} -0.2744 & 0.0662 & -0.3815 & 0.0520 & 0 & -5.1640 & 2.7591 & 66.1132 \\ 0.7270 & 0.6461 & -3.7259 & 0.5083 & 0 & -50.4319 & -26.9462 & 141.7290 \\ 0.1558 & 0.1384 & 0.9894 & 0.1089 & 0 & -2.8583 & 6.0711 & -24.7806 \\ -4.9754 & 0 & 0 & 0 & 62.0029 & 0 & -50.8458 & 493.8680 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 24.3749 \end{bmatrix} \begin{bmatrix} w \\ E \\ \tilde{D}_{-1} \\ H_{-1} \\ Dum1 \\ Dum2 \\ Dum3 \\ 1 \end{bmatrix}}_{E^*}$$

Table 7. Policy decision simulation by EWE policy decision model. – Policy effect simulation –

Degree of attainment of policy target	↘	Domestic log supply S^*					Domestic log price P^*				
Degree of policy intervention	→	±10 %	±20 %	±30 %	±40 %	±50 %	±10 %	±20 %	±30 %	±40 %	±50 %
International balance of payment	X	∓0.056	∓0.112	∓0.168	∓0.224	∓0.280	∓0.258	∓0.516	∓0.774	∓1.032	∓1.290
Subsidy for improvement of forestry structure	J	±0.293	±0.586	±0.879	±1.172	±1.465	∓0.366	∓0.732	∓1.098	∓1.464	∓1.830
Subsidy for reforestation	J^*										
Subsidy for soil & water conservation	J^{**}										
Average interest rate	r^*	∓0.090	∓0.180	∓0.270	∓0.360	∓0.450	∓0.416	∓0.832	∓1.248	∓1.664	∓2.080
Total	Σ	±0.147	±0.294	±0.441	±0.588	±0.735	∓1.040	∓2.080	∓3.120	∓4.160	∓5.200

Degree of attainment of policy target	↘	Imported log supply M					Planted forest area A^*				
Degree of policy intervention	→	±10 %	±20 %	±30%	±40 %	±50 %	±10 %	±20 %	±30 %	±40 %	±50 %
International balance of payment	X	±0.178	±0.356	±0.534	±0.712	±0.890					
Subsidy for improvement of forestry structure	J	∓0.205	∓0.410	∓0.615	∓0.820	∓1.025					
Subsidy for reforestation	J^*						±1.777	±3.554	±5.331	±7.108	±8.885
Subsidy for soil & water conservation	J^{**}	∓0.232	∓0.464	∓0.696	∓0.928	∓1.160					
Average interest rate	r^*	∓0.259	∓0.518	∓0.777	∓1.036	∓1.295	±1.777	±3.554	±5.331	±7.108	±8.885
Total	Σ	∓0.518	∓1.036	∓1.554	∓2.072	∓2.590	±3.554	±7.108	±10.662	±14.216	±17.770

Degree of attainment of policy target	↘	Soil & water conservation forest area A^{**}				
Degree of policy intervention	→	±10 %	±20 %	±30 %	±40 %	±50 %
International balance of payment	X					
Subsidy for improvement of forestry structure	J					
Subsidy for reforestation	J^*					
Subsidy for soil & water conservation	J^{**}	±5.450	±10.900	±16.350	±21.800	±27.250
Average interest rate	r^*	±5.450	±10.900	±16.350	±21.800	±27.250
Total	Σ	±10.900	±21.800	±32.700	±43.600	±54.500

Table 8. Estimated EWE policy manipulation model.

$$Z_C = A^{**}\, Y_A + E^{**}$$

$$\underbrace{\begin{bmatrix} X \\ J \\ J^* \\ J^{**} \\ r^* \end{bmatrix}}_{Z_C} = \underbrace{\begin{bmatrix} 0.0006 & -0.4759 & 2.2210 & 0 & 0 \\ 7.5355 & -0.7714 & 0.0012 & 0 & 0 \\ 0 & 0 & 0 & 0.4841 & 0 \\ {} & 0 & 0 & 0 & 3.1949 \\ -4.3453 & -0.7087 & -4.3444 & 0 & 0 \end{bmatrix}}_{A^{**}} \underbrace{\begin{bmatrix} S^* \\ P^* \\ M \\ A^* \\ A^{**} \end{bmatrix}}_{Y_A}$$

$$+ \underbrace{\begin{bmatrix} 0.0001 & 0 & -3.9704 & 0 & 0 & -17.6500 & 0.6578 & 122.4470 \\ 2.6284 & -0.0006 & 0 & 0.0001 & 0 & 0.0140 & -41.5700 & -388.8400 \\ 2.4085 & 0 & 0 & 0 & -30.0140 & 0 & 24.6131 & -239.0700 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -77.8750 \\ -0.0004 & 1.3468 & 0 & 1.0590 & 0 & -70.5980 & -33.4830 & 280.0700 \end{bmatrix}}_{E^{**}} \begin{bmatrix} w \\ E \\ \bar{D}_{-1} \\ H_{-1} \\ Dum1 \\ Dum2 \\ Dum3 \\ 1 \end{bmatrix}$$