

ENSIGAME: A SIMULATION GAME FOR ENVIRONMENTAL POLICY MAKING

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ABSTRACT: This paper presents a system dynamics based simulation game for environmental policy making. Due to the increasing awareness among people regarding the deterioration of environment as a result of the use of modern technology, the government has to take some action against the industry to motivate them to take pollution control measures. This leads the government and the industry into a game situation wherein they take actions, perhaps every year, by observing the other's reactions. Subsidy, tax exemption, and pollution taxes are found to be the viable options before the government. This situation is modelled here as a game in three modes, namely, both government and industry interactive mode, government only interactive mode, and industry only interactive mode. The results obtained by these three modes of the game are then compared with the model results. This game facilitates experimentation with different strategies for both the government and industry representatives. It is found improving the knowledge of the participants in decision making in such a conflicting environment.

1. INTRODUCTION

There is a world-wide concern for the degradation of the environment due to the use of modern technology in all spheres of life. This paper considers a situation wherein the government and the industry interact with each other. The government tries to induce the industry to implement pollution control measures, whereas the industry tries to avoid it and minimise its investment on pollution control. There are several alternative policies available to the government which are discussed in the following sections. In reality, government may not follow a pure policy at all times. It analyzes how the industry has responded to its previous policy and can change its policy from time to time. Similarly, the industry analyzes the implications of the government's policy and responds in a manner that is the most favourable to it. This reflects a game situation with conflicting goals for the government and the industry. This paper presents a simulation game for environmental policy making. It is based on the system dynamics model presented elsewhere by the authors (Vizayakumar and Mohapatra, 1990).

2. DESCRIPTION OF THE SYSTEM DYNAMICS MODEL

The system dynamics model of environmental impact analysis on which the present game is based, is discussed in great detail elsewhere (Vizayakumar, 1990; Vizayakumar and Mohapatra, 1990). In this section, only a bird's eye view of the model is given. Figure 1 gives an overview of the sectors and their interrelationships defined in the system dynamics model for EIA. The three sectors

of the model are Industry, Society and Environment, and Government. Technology and the pollution generated by it are obvious factors included in the model. Technology is expressed in terms of the net block, i.e., the net fixed assets of the industry using this technology. Pollution is characterized by Quality of Environment Index. Thomas (1972) considered such an index as an integrated composition of several indicators of environment. In this model, the index is represented by the ratio of a set norm (standard) for the pollution level to its actual value. Pollution is considered as an aggregate factor representing all types of pollution emanating from the use of the particular technology under consideration.

It is true that technology provides benefits to the society in the form of material goods and employment. Unfortunately, it also creates health hazards to the society. Therefore such variables as quality of life, societal benefit index, and population affected by the pollution (affected population) are included in the model.

Several studies and reports indicate the necessity and existence of pressure groups among the citizens to voice their concern against pollution-related health hazards and thus build up pressure on the government to adopt measures against pollution. The model has considered two forms of pressure on the government; one, the people's pressure on the government against pollution, called here as social pressure, and two, counterpressure from the industry against the regulations imposed regarding pollution control.

2.1 Policy Alternatives

The various policy alternatives available to the government are

- i) Improve healthcare facility by allowing more budget to healthcare,
- (ii) Insist on pollution control measures by implementing a policy of direct control through acts and legislation,
- iii) Provide subsidy on the investment on pollution control measures,
- iv) Exempt the industries from paying taxes for the investment made in acquiring/developing pollution control equipment,
- v) Impose taxes based on pollution generated, and
- vi) Restrict the use of technology, by not giving licence for additional investment using the particular technology or even by closing down the existing units.

Healthcare policy, no doubt, improves the health of the people but it is not useful as a preventive measure. Pollution control by direct regulation is a far cry and, on its own, is unlikely to be a very effective measure of pollution control, particularly in the prevailing socio-political environment of many developing countries. Restricting the growth of technology is not desirable as it restricts the material benefits to the society. Therefore the options for the government are limited to the following three

policies:

1. subsidise the investment on pollution control.
2. provide tax exemption for the investment in pollution control equipment.
3. Impose pollution tax

However, many a time, a combination of these options is implemented (Randers and Meadows, 1973).

2.2 Variables Selected for Analysis

As shown in figure 1, the three sectors involved in the environmental impact analysis are the industry employing the technology, the bio-geo-physical environment and the society at large, and the government. The following variables defined in the model are chosen to represent the state of affairs in the above-mentioned sectors:

- Profit margin for the industry (PMGN),
- Quality of environment index (QEI),
- Quality of life index (QOL), and
- Government net income from this industry (GII).

Profit margin is the ratio of annual profit rate to the sales revenue. Government income from this industry mainly consists of taxes on profit and taxes on pollution. But this income is reduced by subsidy paid by the government, tax exemption granted to the industry for its investment in pollution control measures, and investment in building up healthcare facility to combat pollution generated health hazards. The time-varying behaviour of the four variables, PMGN, QEI, QOL, and GII are plotted later for various policy runs for the purpose of analysis and comparison among the policy tests.

3. FORMULATION OF THE GAME

The model described above has been converted here into a game. The principles, suggested by Mohapatra and Saha (1989) are generally followed to carry out this conversion. The present game, however, has the following novelties:

- i) The game can be played interactively and in a user-friendly manner. Thus it does not require the services of a computer operator. The program is written in Fortran 77 for HP-1000 system but it can be used on any other system with a few system-oriented modifications.
- ii) The game can be played in the following three modes:
 - a) both government and industry interactive mode (BGIM).
 - both the government and the industry representatives play simultaneously,
 - b) government only interactive mode (GOIM).
 - the role of the industry is played by the computer, and

- c) industry only interactive mode (IOIM).
 - the role of the government is played by the computer.
- iii) In BGIM mode, when one team enters its decision, the computer also reads other team's decision given by that team in a separate program and runs the game.
- iv) This game is both interactive (team responding to computer queries) and interacting (among the teams in BGIM mode).
- v) The game verifies whether the other team's decision for the current plan period is available or not and gives prompt accordingly.

4. BOTH GOVERNMENT AND INDUSTRY INTERACTIVE MODE (BGIM)

In this mode of the game, the team representing the government and the one representing the industry directly interact with each other. The participants key in their decisions directly whenever prompts appear on the monitor. Two different computer programs are used one each for the government team and the industry team. Both the programs contain the same main program but they differ in so far as the input files, the output files, and the report structure are concerned.

The report to the government contains information regarding pollution level, industry profit and its investment in pollution control, decisions of the government during the previous plan period, and government receipts from and payments to this industry, etc. The report to the industry contains the industry financial statements, government decisions during the previous plan period, its decision on pollution control investment during the previous plan period, pollution level, etc.

The values of the variables, namely, sales revenue, annual profit rate, expenditure on pollution taxes, government income due to this industry, subsidy amount offered, and amount gained by industry due to tax exemption, auxiliary variables in the system dynamics model, are provided in the report along with their during-the-period accumulated values. Therefore additional equations are added to the program to calculate their accumulated values during each period. A new level variable is also defined for health care facility to provide its during-the-period value. All these new level variables are initialized to zero before every simulation run.

Apart from giving the end-of-the-period and during-the-period information on the screen and on the printer, the program also writes these values to a file by appending it everytime so that they can be looked into and analysed at any time later.

4.1 Mode of Interaction Between the Teams

Two programs were developed for the two teams separately. The programs read the decision variables of both the teams. When the group representing the government enters its decisions on the monitor, the program reads them and writes them onto a file. Then

it reads the values of the industry decisions from a similar file of the industry and compares the plan periods of both the groups. If there is a mismatch in the plan periods, it aborts the program and asks to wait till the industry takes its decision. If the plan periods match, it runs the program and prints the report on request. It acts in a similar way when the industry enters its decisions.

4.2 Mode of Playing the Game

In order to play the game, the players have to run their own program. The program puts several queries to the players regarding plan period, decision variables and the mode of output.

To start the game, the teams do not have to give their decisions. They merely have to set the value of the plan period as zero. Thereupon, the program, automatically, runs for a period equivalent to ten plan periods and gives the output at the end of the tenth plan period. This initial run for ten plan periods allows pollution to accumulate in the environment and to deteriorate its quality. Social awareness is considerable and the government is under pressure to intervene.

The output of the initial run is the first information the participants obtain after they respond to the plan period prompt with a value of zero. With this information they analyse the situation and take decisions for the next plan period. One year constitutes one plan period in this game.

After a team takes its decisions, it runs the program again and responds with '1' to the prompt for the plan period. The team is then prompted to key in the decision variable values. These values are written onto an input file by the program. The other team similarly keys in the plan period value of '1' and its decisions. Until both the teams enter their decisions, the program does not run; an attempt to run the program gets aborted and a message appears on the screen to wait until the other team keys in its decisions.

The teams repeat the above mentioned steps for a number of periods, fifteen in this case, by increasing everytime the value of the plan period by one and by providing the decisions for the corresponding plan period. Tables 1 and 2 depict the prompts from the computer and responses of the two groups respectively.

5. GOVERNMENT ONLY INTERACTIVE MODE (GOIM)

This mode allows the government representatives to play the game in their work environment. They can experiment with different strategies, by playing the game again and again. Here, however, the strategy of the industry remains automated and, therefore, unchanged.

When a team starts the game, the computer simulates the model for its initial run with a length equal to ten plan periods as in BGIM and provides the first output. When the team wishes to play

the game for another round, the computer increases the plan period by one and prompts to input the values of the decision variables. After the team keys in his decisions, the model is run for a plan period, i.e., one year in this case and provides the output. This process is repeated till the player decides to stop the game.

Table 1
Government Team Interaction - BGIM Mode

Prompt	Response
Write plan period - Give 0 for initial run	0
Is Plan Period Correct ? - Write Yes or No	Yes
Do You Need Printout of Initial Run ? Write Yes or No	Yes
Write plan period - Give 0 for initial run	1
Is Plan Period Correct ? - Write Yes or No	Yes
Give Values of Pollution Taxes, Subsidy, Tax Exemption and Additional Health Care	0.1,0,0,0
Are the Values Correct ? Write Yes or No	Yes

Please Wait. Industry has yet to take Decision	
Write plan period - Give 0 for initial run	1
Is Plan Period Correct ? - Write Yes or No	Yes

Do You Need Printout ? Write Yes or No	Yes

Table 2
Industry Team Interaction - BGIM Mode

Prompt	Response
Write plan period - Give 0 for initial run	0
Is Plan Period Correct ? - Write Yes or No	Yes
Do You Need Printout of Initial Run ? Write Yes or No	Yes
Write plan period - Give 0 for initial run	1
Is Plan Period Correct ? - Write Yes or No	Yes
Give Value of Investment in Pollution Control	0.0
Is the Value Correct ? Write Yes or No	Yes

Please Wait. Government has to take Decision	
Write plan period - Give 0 for initial run	1
Is Plan Period Correct ? - Write Yes or No	Yes

Do You Need Printout ? Write Yes or No	Yes

6. INDUSTRY ONLY INTERACTIVE MODE (IOIM)

This mode is very similar to GOIM. But, in contrast to GOIM, the decisions of the government are taken by the pre-defined rules incorporated in the program, and the team has to take decisions on behalf of the industry. Here, the team (industry representatives who are responsible to take budget allocation decisions) repeats

the game with different strategies for a given strategy of the government.

7. PLAYING THE GAME

The game has been designed in three modes as explained earlier. BGIM mode has to be played by two teams, whereas the other two modes, GOIM and IOIM, have to be played by only one team. A team may consist of one or more players. During the trial runs of the game, several teams played all the three versions. A write-up was given to them, explaining the model in brief, the decisions to be taken, bases for taking decisions, the way they should interact with computer etc.

The team representing the government was asked to take the following decisions:

- i) pollution taxes as a fraction of sales revenue,
- ii) subsidy to be offered as a fraction or multiple of the industry's investment on pollution control,
- iii) amount exempted from taxes as a fraction or multiple of industry's investment on pollution control, and
- iv) rate of increase in healthcare facility.

The team representing the industry was asked to take only one decision, i.e., the amount to be invested on pollution control as a fraction of the maximum amount required to control pollution completely.

8. RESULTS OF THE GAME

The game was played in all the three modes. The results are presented here and are compared with the model run presented elsewhere by Vizayakumar and Mohapatra (1989). Here, in all the modes of game, the game starts from eleventh year. For the first ten years, the model runs by assuming that the industry does not invest in pollution control and the government also does not take any policy decisions. Therefore, the model results are modified accordingly by assuming that during the first ten years pollution control investment as well as the values of government decision variables are zero.

Figures 6 (a), (b), (c), and (d) depict the behaviour of the variables, Quality of Environment Index (QEI), Quality of Life (QOL), Government Income due to this Industry (GII), and Profit margin to the industry (PMGN) respectively, for the following:

- 1) Both Government and Industry interactive Mode (BGIM),
- 2) Government Only Interactive Mode (GOIM),
- 3) Industry Only Interactive Mode (IOIM), and
- 4) The model run.

The same number is given in the figures to indicate the version of the game and the model run. The figures show that the players of BGIM and IOIM achieved better results in respect of quality of

environment index and quality of life compared to the model run. But in respect of government income due to this industry and Profit margin, the model results are better than the game results excepting for the GOIM mode which shows more profit margin throughout than that for the model run.

A system dynamics model normally does not permit frequent policy shifts. But system dynamics based game allows such policy shifts to occur from period to period, reflecting a real world situation. A game participant therefore faces a very realistic situation and, more importantly, learns from his experiments with different strategies.

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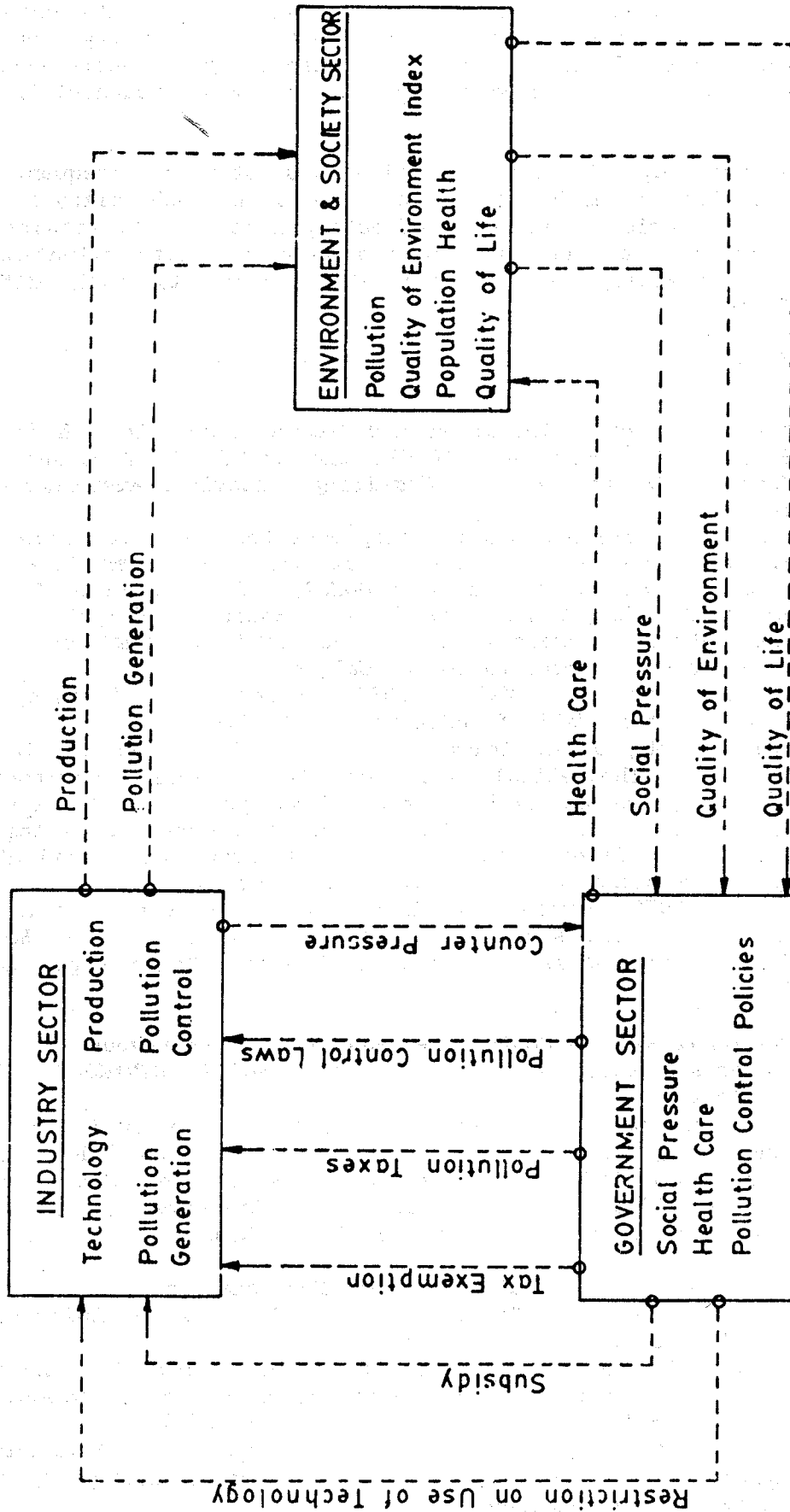


FIG. SECTORAL OVERVIEW DIAGRAM.

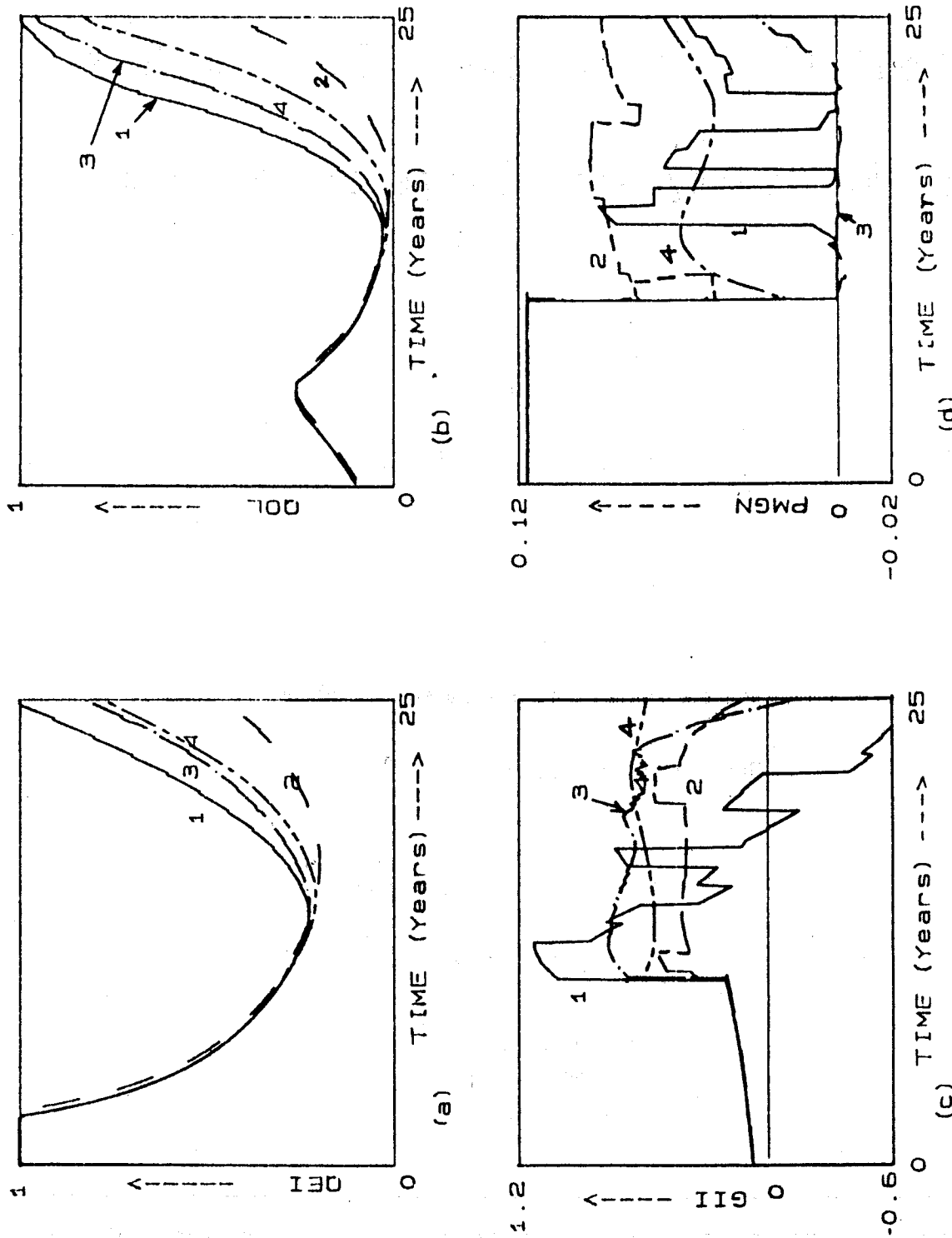


FIG. COMPARISON OF GAME RESULTS WITH MODEL RESULTS