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A PROTOTYPE SYSTEM DYNAMICS MODEL FOR ASSESSING THE SUSTAINABILITY OF CONSTRUCTION PROJECTS

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Abstract: There is a worldwide demand for an increasingly sustainable built environment. This has resulted in the need for a more accurate evaluation of the level of sustainability of construction projects. To do this involves the development of better measurement and benchmarking methods. One approach is to use a theoretical model to assess construction projects in terms of their sustainable development value (SDV) and sustainable development ability (SDA) for implementation in the project life cycle, where SDA measures the contribution of a project to development sustainability and as a major criterion for assessing its feasibility.

This paper develops an improved SDA prototype model that incorporates the effects of dynamical factors on project sustainability. This involves the introduction of two major factors concerning technological advancement and changes in people's perceptions. A case study is used to demonstrate the procedures involved in simulation and modeling, one outcome of which is to demonstrate the greater influence of technological advancement on project sustainability than changes in perception.

Key words: Construction project management; Sustainable development ability (SDA); System dynamics

1 INTRODUCTION

The construction industry provides the basic living conditions for the sustainability and development of human life on the Earth. In order to cope with an ever-increasing population, pressure on land, and growing economic activity, construction projects are in increasing demand and activity is booming in many countries, particularly in developing countries such as China. At the same time, sustainable development and globalization is the new 'Zeitgeist' of the 21st century. This is particularly important for the construction industry, as construction activity generally has a greater impact on the environment than other industries. There is therefore an urgent need to apply sustainable development principles to construction industry practices.

The origin or promotion of sustainable development is described in the Brundland Report as 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). This definition has since been extended to include government missions to achieve sustainable development in individual industries. The current sustainable development agenda now forms the cornerstone of built environment activities generally, with the environmental dimension being a key aspect over the past two decades (Edum-Fotwe and Price, 2009). As Prasad and Hall (2004) comment, "the built environment provides a synthesis of environmental, economic and social issues. It provides shelter for the individual, physical infrastructure for communities and is a significant part of the economy and its design sets the pattern for resource consumption over its relatively long lifetime”.

The current global economic downturn provides a unique opportunity to re-assess the sustainability of construction projects and develop more innovative practices. Of especial importance is the inherently nature of the sector, where changing external circumstances subject the construction business is to increased uncertainties and dynamic changes (Love *et al*, 2002; Baloi and Price, 2003). These dynamic changes occur in multiple dimensions, including those relating to policy, technology, economy and management. For example, new construction technologies, such as Building Information Models (BIM), have had a significant impact on industry practices (Huang *et al*, 2008; Chan *et al*, 2009). The ubiquitous nature of such changes and uncertainties make the construction business a continually turbulent environment. Sustainable construction development in this environment depends on two major drivers: the rapid advancement of scientific and technological progress; and people’s perception of project sustainability. Consideration of these drivers opens new pathways for modeling various methods of sustainable development.

Several studies have already investigated sustainable development in the construction industry. Spence and Mulligan (1995), for example, identify and quantify the principal causes and effects of construction activity on environmental stress. Hill and Bowen (1997), on the other hand, introduce a framework of key principles for enabling construction activity to contribute to sustainable development. These comprise: project environmental assessment; environmental policy; organizational structure; environmental management programs; and the external/internal audit of environmental performance. In addition, CIB (1999) propose a paradigm for assessing the feasibility of construction projects that extends the traditional feasibility study approach (mainly focusing on cost, time and quality) to integrating resource consumption and environmental impact within a global contour, while Zimmermann *et al* (2005) provide a set of benchmarks for sustainable construction and therefore enable the requirements of buildings and structures in contributing to a sustainable society to be defined.

Revealed in these studies, is a major concern of construction professionals for the sustainability of projects (Crawley and Aho, 1999; Ding, 2008; Shen *et al*, 2010), with environmental performance assessment during the construction process being a particularly important emerging issue since 1990s (Cole, 1999; Thoresen, 1999; Cooper, 1999; Holmes and Hudson, 2000). For example, Life Cycle Assessment (LCA) is a well-known effective and analytical tool for assessing the environmental impact of a construction product from a cradle-to-grave perspective (Bengtsson, 2000). Other studies have proposed a variety of methods for promoting environmental management and obtaining more sustainable construction projects over their life cycle (Brochner and Fredriksson, 1999; Heerwagen, 2000; Tam *et al*, 2002).

In terms of sustainability *assessment*, one of the most significant contributions is Shen *et al*'s theoretical model for assessing the sustainability of a construction project (Shen *et al*, 2002). By using this model, the sustainable development *value* (SDV) and sustainable development *ability* (SDA) of a construction project can be obtained. SDA is used to measure the contribution of a project to the attainment of general sustainable development, and is recommended as a major criterion for examining its feasibility. This was later extended by Shen *et al* (2005) into an SDA model involving the various additional dynamic factors needed to assess the sustainability of a project over its whole life cycle. Their theoretical model is

$$\begin{cases} SDA(t)=\int_0^t W_E(t)I_E(t)dt+\int_0^t W_S(t)I_S(t)dt+\int_0^t W_{En}(t)I_{En}(t)dt \\ W_E(t)+W_S(t)+W_{En}(t)=1 \\ I_E, I_S, I_{En} \in [-100,100] \end{cases} \quad (1)$$

where $I_E(t)$, $I_S(t)$ and $I_{En}(t)$ denote the dynamic functions of a project's economic impact, social impact and environmental impact respectively. The values of the variables I_E, I_S and I_{En} are defined as relative measures within the interval [-100,100], while the variables $W_E(t)$, $W_S(t)$ and $W_{En}(t)$ denote the weight of economic impact, social impact and environmental impact to SDA respectively. Obviously, I_E, I_S, I_{En}, W_E, W_S, W_{En} *in Model* (1) changes when time changes.

In order to simulate and establish *Model (1)*, Shen *et al* (2005) proposed the simplified model, however, all the three weighting factors (W_E, W_S and W_{En}) are considered to be constant. As a matter of fact, as commented earlier, the construction business takes place in a dynamic and changeable environment and the construction procurement is therefore equally dynamic. This implies that the model's three weighting variables (W_E, W_S and W_{En}) for addressing the significance of the economic, social and environmental horizons cannot be constant.

$$\begin{cases} SDA(t)=W_E\int_0^t I_E(t)dt+W_S\int_0^t I_S(t)dt+W_{En}\int_0^t I_{En}(t)dt \\ W_E+W_S+W_{En}=1 \\ I_E, I_S, I_{En} \in [-100,100] \end{cases} \quad (2)$$

in which the SDA values and the weighting values interact during the whole course of the project life cycle. In other words, the SDA changes when the weighting values between the three attributes change, and *vice versa*. Furthermore, as mentioned earlier, contemporary construction businesses operate with two major types of drivers: technology advancement and people's perceptions of sustainable construction. Of these, technology related variables are denoted by $I_E(t)$, $I_S(t)$ and $I_{En}(t)$, the evaluation of which is needed for a full SDA assessment. The aim of this paper, therefore, is to extend the current SDA model to incorporate these effects.

2 RESEARCH METHOD

System dynamics (SD) is a proven effective method for modelling and analysing complex, dynamic and nonlinearly interacting variables and is adopted in this study as the tool to simulate the assessment process of sustainable performance. The method was introduced in the form of a computer simulation model by Forrester in 1971. Using SD, Forrester (1971) further proposed a "world model" - comprising five modules for world population, industrialization, pollution, food production and resource depletion - to forecast the exhaustion of the world's resources. SD modelling is effective for conducting simulation processes and has two major characteristics in allowing for: (1) changes in variables over time, and (2) feedback: the transmission and receipt of information (Richardson and Pugh, 1981).

The SD method has been used in several research studies relating to the construction industry. Chritamara and Ogunlana (2002), for instance, developed a model using SD principles for evaluating project management procedures, with the application of the model aiming to assist decision making in mitigating time and cost overruns. Love *et al* (2002), on the other hand, presented a framework using SD for dealing with dynamic feedbacks in managing complex projects, while Dolol and Jaafarl (2002) adopt the SD approach as a simulation tool to establish the baseline value of a construction project.

Together, these studies suggest that the SD method is appropriate in modelling the sustainability of construction projects.

In using the SD method, four elements need to be defined, including state variables (Stock), flow function (Flow), auxiliary variables (Convertor), and streamline (Connector), with decision-making feedback loops. The four elements are connected as a system, as shown in Figure 1 (HPS, 1997; Shen *et al*, 2005; Yao *et al,* 2011).

<Insert Figure 1 here>

In Figure 1, the volume of stock changes at different time points (as both in-flows and out-flows) are generated over time. For example, the sustainability of a construction project can be considered to be a stock, which can be increased or reduced when different practices are employed. The relationship between the stock and flow need to be established for conducting a simulation, as follows:

$$Stock(t) = Stock(t - dt) + (Flow)dt \quad (3)$$

or

$$Stock = \int (Flow)dt \quad (4)$$

In line with the simplified *model (2)*, by using the SD approach, Shen *et al* (2005) introduced a SDA simplified prototype model, as shown in Figure 2, where *E*, *S* and *En* denote the effect of a construction project on the three sustainable development contributors of economic, social and environmental performance respectively. However, in discussing the application of the prototype, they defined these three parameters as deterministic functions of time by assuming that the relationship between the values of the parameters and time can be determined over a project's life cycle. This application is challenged in this study by arguing that all variables and parameters in the SDA model are affected by many dynamics in the course of project life cycle and that the effect of these dynamics on the three weighting variables needs to be taken into account. This challenge leads to the introduction of an improved model for assessing project sustainability, as discussed in the next section.

<Insert Figure 2 here>

3 IMPROVED SD MODEL FOR ASSESSING SUSTAINABILITY

The application of the SDA model was demonstrated in a case study by Shen *et al* (2005). As assumed in their study, the weighting factors W_E, W_S and W_{En} are constants, and their values are provided by the decision makers. The validity of this assumption has been addressed earlier in this paper. Different decision makers allocate different weighting values by considering the characteristics of different types of projects. In particular, the global financial crisis produces more fluctuations and potential risks. For example, there may be a lack of funds available. This lack of funds may therefore cause projects to be interrupted or even terminated. As observed by Wu and Olson (2010), risks may come from technology advancement and people's perception changes and therefore comprise two major groups of dynamics. For example, when green technology measures are adopted to improve the sustainability of construction projects, the weighting values of the economic, social and environment variables change accordingly. On the other hand, if perceptions of sustainable development change, the weighting values of the three variables also change.

Decision makers in different circumstances give different priority values to the economic, social and environmental dimensions. For example, in developing countries, people tend to pay more attention to economic development, thus the economic system is prioritized with a higher weighting value. For developed countries, a green environment is more important, and thus the environmental subsystem in the SDA evaluation model is prioritized with a higher weighting value.

To take this into account, the model in Figure 2 may be further developed and extended as shown in Figure 3. In the model shown in Figure 3, V_E, V_S and V_{En} denote SDV from the perspective of the economic, social and environmental subsystems respectively. V_E, V_S and V_{En} determines the value of the flow (I_E, I_S and I_{En}) and the final SDV value of the project as a whole. Two adjustment subsystems ("◇" in Figure 3) are introduced to incorporate the influence of the two dynamic drivers on the evaluation of sustainability. In Figure 3, there are three adjustment factors, *A4V2E*, *A4V2S, and A4V2En* (where "A4" denotes for "adjustment for") which are built into three Value Adjustment Decision Making Processes (VADMP). In the three VADMPs, the V_E, V_S and V_{En} values are determined both by their initial values (V_{E0}, V_{S0} and V_{En0}) and their adjustment factor ($A4V_E$, $A4V_S$ and $A4V_{En}$).

The following discussion demonstrates how the adjustment decision is made when incorporating the effects of the dynamics of changing technology and perceptions.

<Insert Figure 3 here>

3.1 The value adjustment decision process to incorporate the influence of technology advancement

The SD model in Figure 3 introduces the value adjustment decision subsystem (VADS) to take into account the influence of technology measures on project SDA. The dynamic process of making adjustments due to changes in technology measures is shown in Figure 4, where '*LA*' is introduced to denote the changes of technical measures in the economic, social and environmental aspects involved. The adjustment factor '*outLA*' is used to show the extent to which LA affects the economic, social, and environmental subsystems simultaneously. The function of the VADS is triggered by a change in the *SDA* value of the stock. When the *SDA* falls below a certain limit (*L4SDA*), a need for improvement will be signaled. A technology measure (*LA*) is therefore recommended to improve the SDA value. This dynamic interaction affects the adjustment values $A4V_E$, $A4V_S$ and $A4V_{En}$ respectively. Following Shen *et al* (2005), the process of generating the values of $A4V_E$, $A4V_S$ and $A4V_{En}$ is simulated by SD software iThink.

<Insert Figure 4 here>

3.2 The weight value adjustment decision process for incorporating the influence of perceptions

People's perception of project sustainability is reflected by the weighting values of W_E, W_S and W_{En}. As mentioned earlier, the global financial crisis has induced a significant impact on society, including people's confidence. In this context, the global crisis may negatively influence perceptions of sustainability. Therefore, the weighting values of W_E, W_S and W_{En} are altered accordingly due to the external environment. The dynamic interactions between the weighting variables (W_E, W_S and W_{En}), dimensional sustainable development values (V_E, V_S and V_{En}) and the total sustainable development value (*SDA*) are demonstrated in Figure 5. This shows that when the level of SDA changes, the corresponding weighting values of W_E, W_S and W_{En} change accordingly. If *SDA* rises and reaches the expected value (*U4SDA*), it is likely that people will perceive a higher level of sustainability, therefore, the value UA (Upper limit adjustment) needs to be adjusted. For example, if decision-makers decide to raise project sustainability in response to new regulations, the weighing values of W_E, W_S and W_{En} are adjusted, and the SDA value therefore changes accordingly. The process of adjusting the values of SDA due to the changes in the perception of project sustainability is carried out by IThink, and the results are shown in the Appendix.

<Insert Figure 5 here>

4 CASE STUDY

A real-life case is used to illustrate the application of the improved model illustrated in Figure 3. The case is the FD NaCN Innovation Project, located in Chongqing, China, which is the reconstruction of a previous nitrogenous fertilizer plant that was demolished due to the Three Gorges Project. The data are related to the project feasibility study's economic, social, environmental, and technical assessment results. In order to collect the initial values of the parameters (V_E, V_S and V_{En}), interviews with the project managers and client were conducted, and the results are presented in the following step-functions (5), (6) and (7).

$$V_E(t)=\begin{cases}-10 & t\in(0,1]\\ -100 & t\in(1,5]\\ 0 & t\in(5,6]\\ 60 & t\in(6,46]\\ 10 & t\in(46,47]\end{cases} \quad (5)$$

$$V_S(t)=\begin{cases}-60 & t\in(0,1]\\ 50 & t\in(1,5]\\ -20 & t\in(5,6]\\ 30 & t\in(6,46]\\ -50 & t\in(46,47]\end{cases} \quad (6)$$

$$V_{En}(t)=\begin{cases}-50 & t\in(0,1]\\ -80 & t\in(1,5]\\ 0 & t\in(5,6]\\ -70 & t\in(6,46]\\ -100 & t\in(46,47]\end{cases} \quad (7)$$

4.1 Data input

The FD NaCN Innovation Project life cycle comprises (I) the inception stage (1/4 year); (II) the construction stage (1 year); (III) the commission stage (1/4 year); (IV) the operation stage (10 years); and (V) the demolition stage (1/4 year). The values presented in (5), (6) and (7) are input into the software IThink. This then allows the graphical representation of the value distributions. The initial SDV values of the performance factors for FD NaCN Innovation Project are shown in Figure 6.

<Insert Figure 6 here>

4.2 Scenarios

Based on the above discussion, three typical scenarios are used to analyze the application of the model (Figure 3). For scenario (1) the assumption is that the lower limit of *SDA* is -100 (that is *L4SDA* =-100). When the *SDA* value is lower than this, additional technological measures are adopted to increase the SDA value by 50%, i.e. the LA (Lower limit adjustment) is set to 50%. Similarly, if the *SDA* is higher than the assumed upper limit of 100, people perceive a higher level of project sustainability and the values of weighting variables are adjusted by, for example, 1/8 (*UA* =1/8). For scenario (2), assume the lower limit of *SDA* is again -100 (*L4SDA* =-100) and *LA* (Lower limit adjustment)=50%. Here, the perception of project sustainability does not change, and therefore the weighting values are not adjusted, i.e. *UA* =0. Finally, for scenario (3) assume both LA and UA are “0”, indicating no changes to both lower and upper adjustments. The assumptions involved in these scenarios are summarized in Table 1.

<Insert Table 1 here>

4.3 Simulation result

Inputting the data described in (3)-(5) and the scenario values in Table 1 to *Ithink 9.0* enables the simulation results to be obtained. The core procedures involved in applying the SD model are provided in the Appendix, while the simulation results of the SDA values for the case project are given in Table 2 and presented graphically in Figure 7.

<Insert Table 2 here>

5 DISCUSSION

The following observations are based on the simulation results summarized in Table 2 and Figure 7.

5.1 Scenario 1

Curve 1 in Figure 7 represents the simulation results of the SDA value of the FD NaCN Innovation project for Scenario 1. This shows that when the SD model involves changes in both technological measures and perceptions of project sustainability, the SDA value of the project is relatively high. According to Table 2, the life-cycle value of SDA of the project is 85.31. It is also interesting to note that the SDA value starts to decline when the project enters the final stage. This is because people have a higher expectation of the sustainable development value of the project at this time. Perceptions of project sustainability are therefore above the upper limit and the weighing value changes accordingly, with a corresponding effect on SDV value.

5.2 Scenario 2

Curve 2 in Figure 7 represents the simulation results for Scenario 2. This indicates that, when the SD model involves technological advancement only without considering changes in perceptions, the SDA of the project is also relatively high. However, the SDA value in scenario 2 is higher than that in

Scenario 1 for the demolition stage of the project. According to Table 2, the value of SDA is 130.00 at the end of the project life cycle, indicating that sustainable development capability can reach a very high level with technological advancement. It also suggests that perceptions of sustainable performance can influence the project's sustainable development capability both positively and negatively.

5.3 Scenario 3

Curve 3 in Figure 7 represents the simulation results for Scenario 3 and shows that, when the model involves neither technological advancement nor changes in perception, the SDA of the project is very poor - the lowest level of all the three scenarios. According to Table 2, the value of SDA for Scenario 3 is 44.17 at the end of the project life cycle. The results imply that the technological measures help improve the sustainable development capability of the project across its life cycle, while perceptions of its sustainability cause fluctuations in SDA values. Therefore, as both technological and perception changes occur in practice, it is therefore necessary for decision makers to identify the technological advancements needed and promote improvements in perceptions of sustainability levels.

It should also be noted that the values of the parameters in the model, including W_E, W_S, W_{En}, LA, L4SDA, U4SDA, and UA vary according to project conditions, project nature, client requirements, technology and perception changes of project sustainability.

<Insert Figure 7 here>

6 SUMMARY

The simulation results indicate quite clearly that the sustainable development of construction projects is mainly determined by the technological measures and perceptions of project sustainability. Also, comparing Scenario 1 with Scenario 3 indicates that the changes in technology are more direct, which can affect project sustainability. In other words, the economic/social/environmental performance of construction projects can be improved by applying new technological measures. Of course, the measures to use depend on the particular economic/social/environmental issues involved. For example, some technologies may be aimed at reducing economic cost, while others may focus on providing local job opportunities or in the direct reduction of carbon emissions.

By comparing Scenario 1 with Scenario 2 on the other hand, it can be concluded that perceptions are less important than technology. It is known that perceptions depend on the level of understanding of the observer of what is being perceived. However, people's perceptions are also affected by the priority of national development involved. For example, economic development is usually the first priority for developing countries. As the economy grows, attention then turns to the issue of social fairness. After social problems have been addressed, environmental issues start to become of concern. One example is the public perception of nuclear power plant. Before 1979, nuclear power was thought to be very safe. However, the Three Mile Island accident in Pennsylvania heightened anxiety worldwide over the safety of nuclear power, greatly changing public perceptions. This was followed by the 1986 Chernobyl disaster, which intensified public concerns over possible catastrophic reactor accidents. With the Fukushima nuclear power plant disaster caused by a 9.0 magnitude earthquake and following tsunami on 11 March 2011, public perceptions of nuclear power finally changed from generally very positive to generally very negative.

The procedures involved in using the SD model are listed in the Appendix. For Figures 4 and 5, the SD simulation software *IThink* was used to generate the values for $A4V_E$, $A4V_S$ and $A4V_{En}$ also shown in the Appendix[1].

7 CONCLUSIONS

This paper introduced an alternative SD model as a possible means of improvement in the assessment of construction project sustainability. The model emphasizes the incorporation of technological advancement and changes in the public perceptions. A case study was employed to illustrate the model's application and demonstrates that a project's sustainability capability can change due to the impact of various dynamic variables, particularly those relating to, technical measures and people's perception. This provides a reference for decision makers wishing to increase project sustainability. The simulation process involved indicates that the improved SDA model supported by the SD method is appropriate for assessing the dynamic impact of external changes on sustainability. Simulation results can provide a further useful reference to help decision makers when considering the feasibility of a construction project in terms of its sustainability.

The case study results further reveal that technological advancement is more influential on project sustainability than people's perceptions. The study provides an alternative approach to improving sustainability, making a useful contribution to the promotion of sustainable development principles.

Note: [1]It's worth highlighting that the proposed model is in the form of a prototype, the source code of the program developed being reproduced in the Appendix. This has been made to be as flexible as possible, so that users or industry peers can adjust parameter values according to the individual project characteristics and contexts involved.

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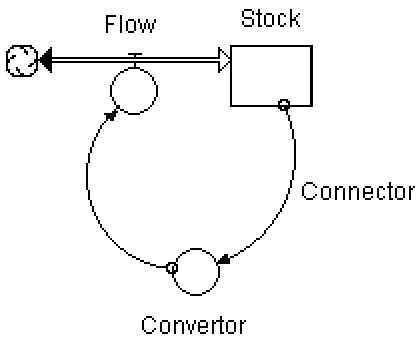

Figure 1 An example model of four elements involved in using the system dynamics approach (Shen *et al* 2005)

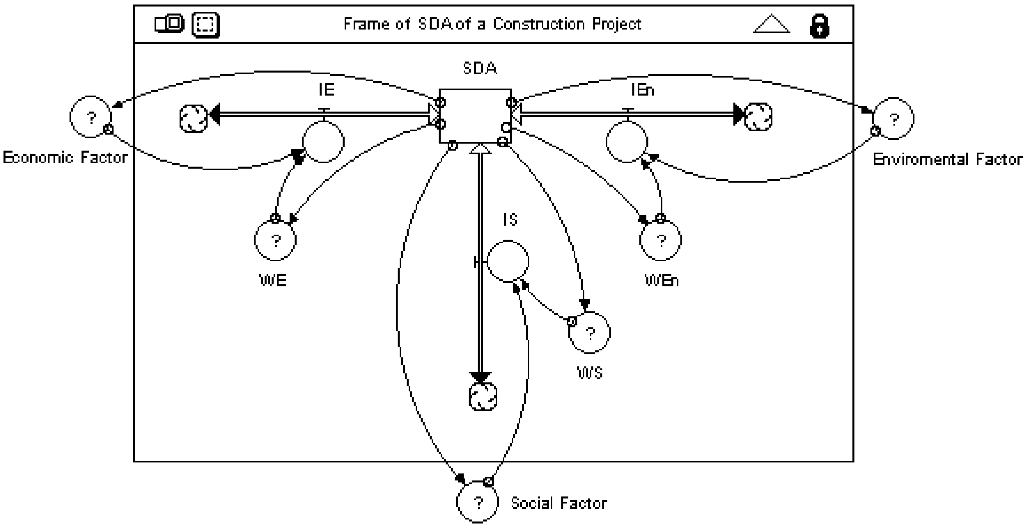

Figure 2 SDA prototype model using system dynamics (Shen *et al*, 2005)

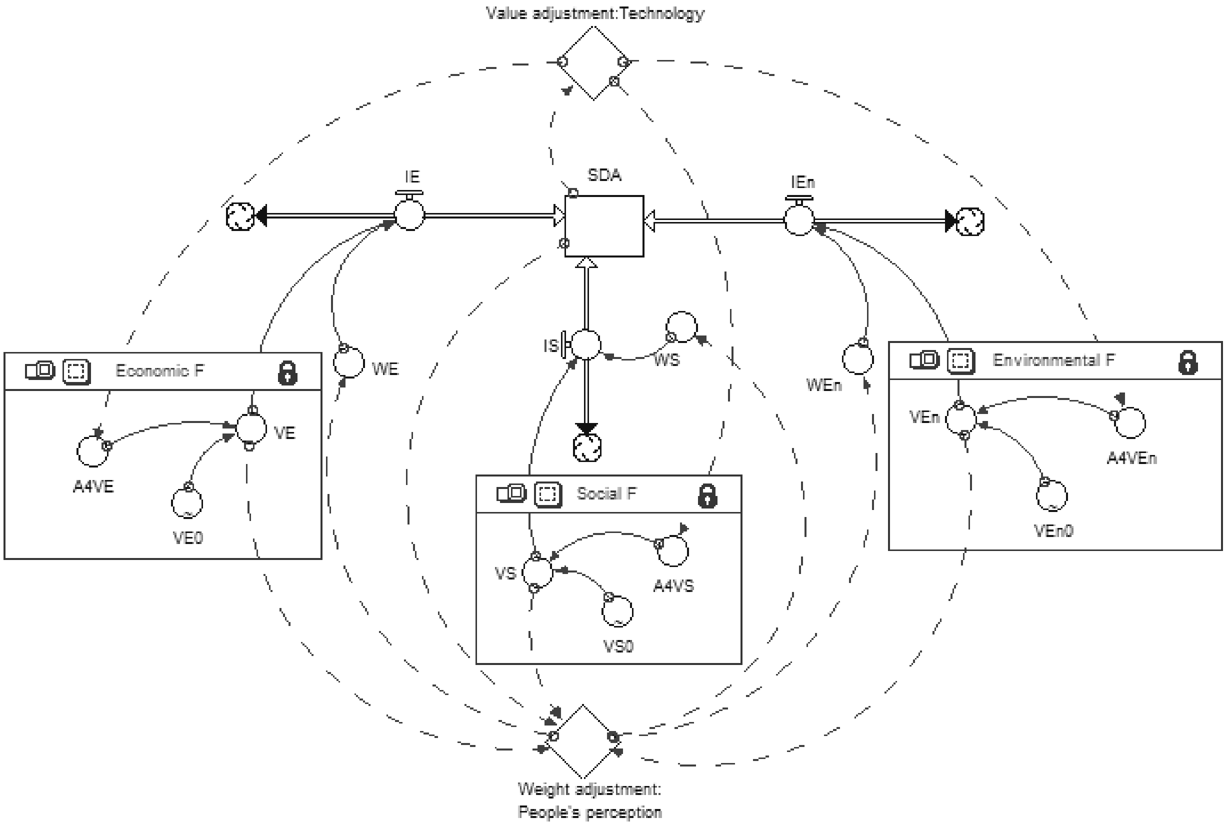

Figure 3 The innovative and dynamic SDA model

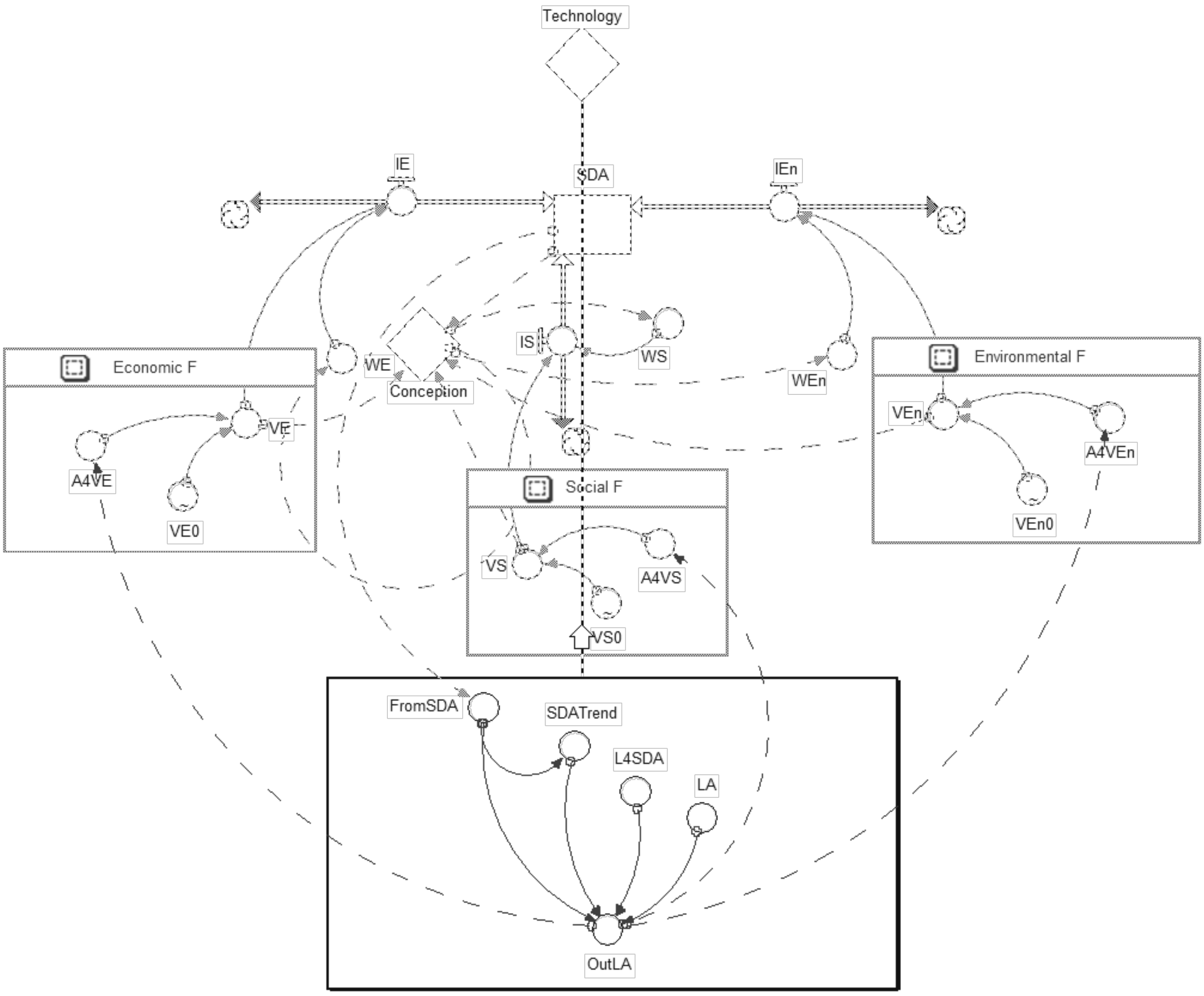

Figure 4 Effects of technology advancement on the decision making process

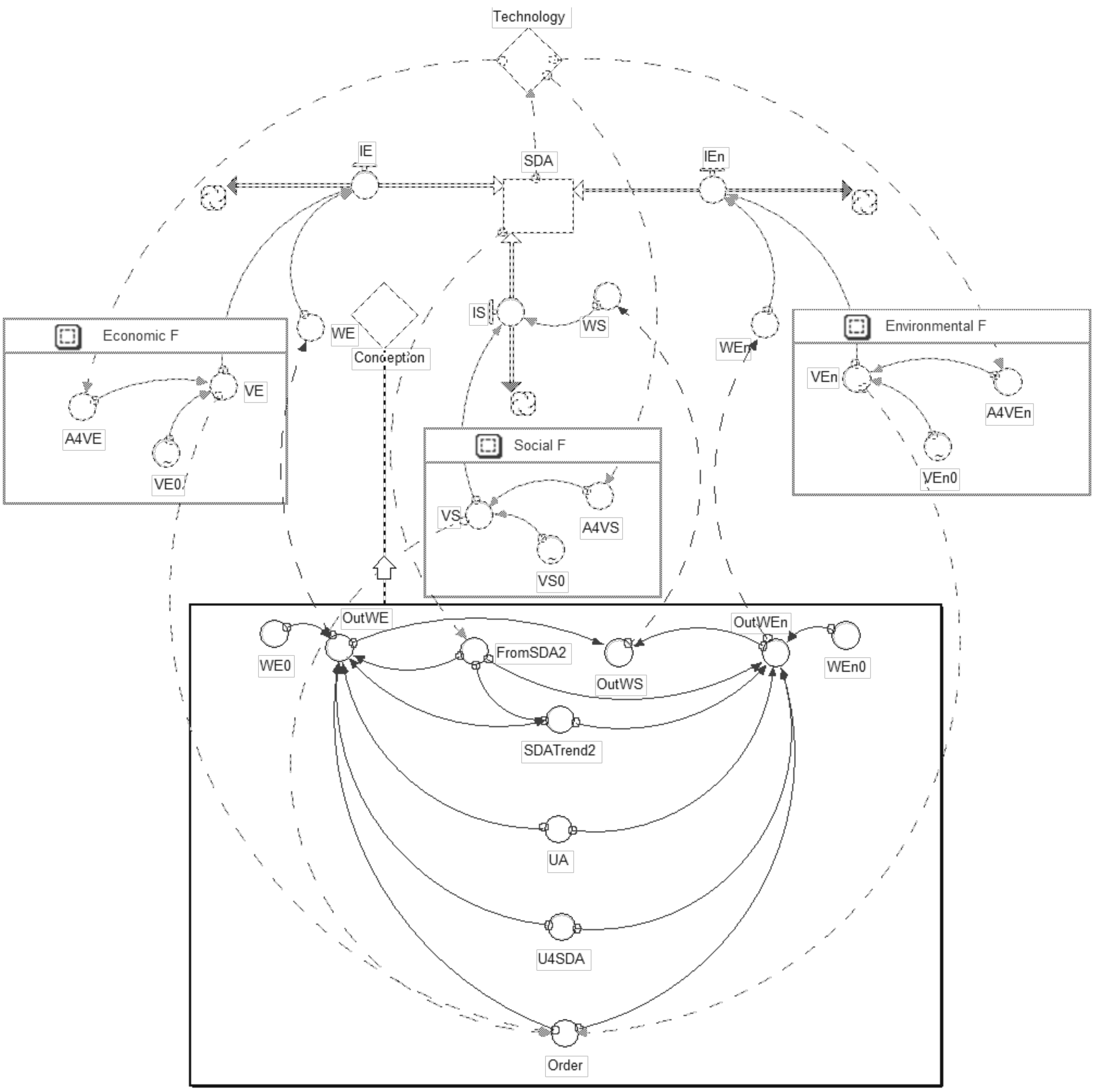

Figure 5 People's perception decision process in the SDA model

(Note: LA: Lower limit adjustment; L4SDA: Lower limit for SDA; UA: Upper limit adjustment; U4SDA: Upper limit for SDA)

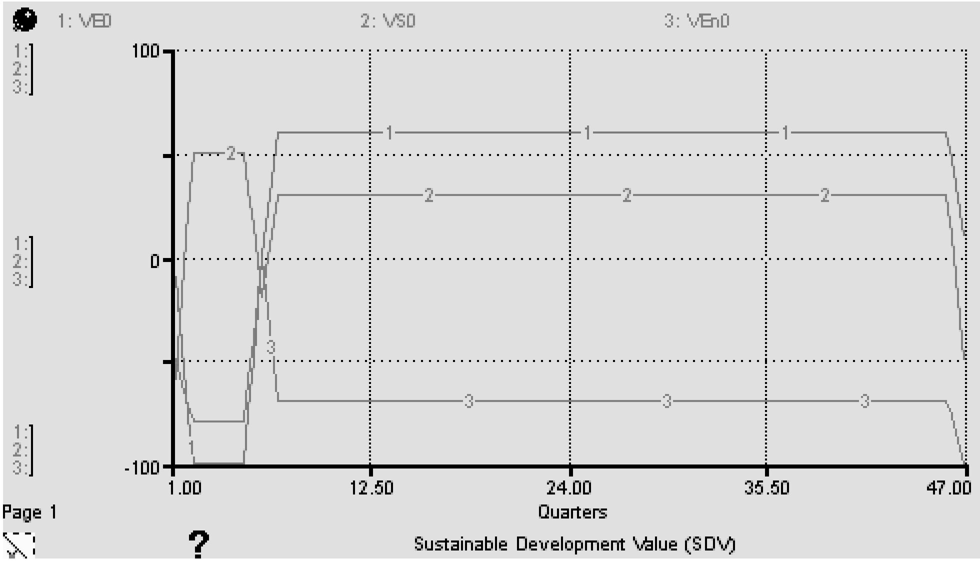

Figure 6 The initial SDV value for Economic, Social and Environmental performance

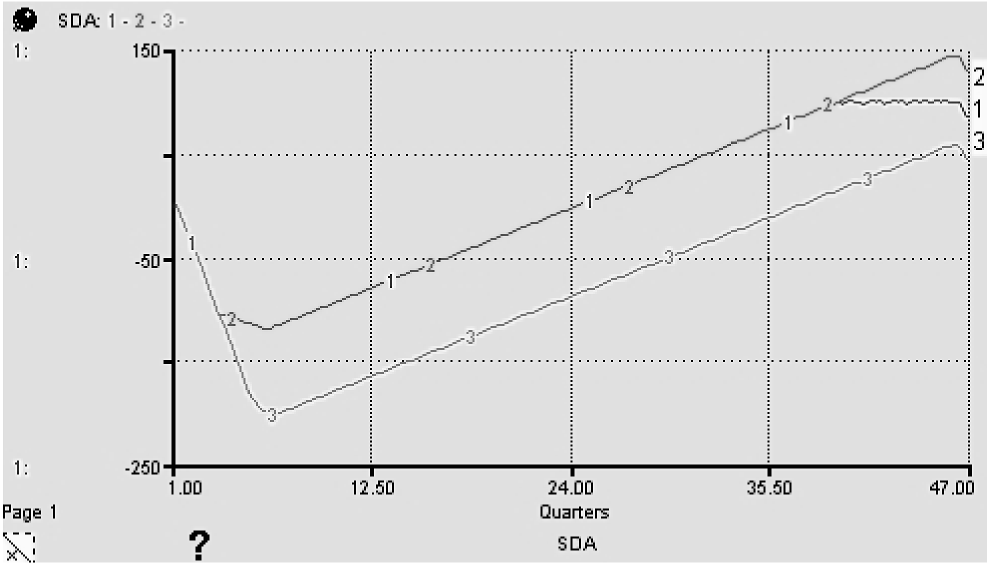

Figure 7 Simulation results of SDA for the FD NaCN Innovation Project

Table 1 Scenario parameters for the FD NaCN Innovation Project

Scenario	Parameters	Note
Scenario 1	*LA*=0.5,*UA*=1/8	When the *SDA* is lower than the lower limit, technological measures are adopted. If it is higher than the upper limit, the peoples' perception of sustainable performance changes.
Scenario 2	*LA*=0.5,*UA*=0	When the SDA is lower than the lower limit, technological measures are adopted but there are no changes in people's perception of project sustainability performance.
Scenario 3	*LA*=0,*UA*=0	No feedback occurs due to the lack of application of technological measures and lack of changes in people's perception of project sustainability performance.

Table 2 Simulation results of SDA for the FD NaCN Innovation Project

Quarters	Scenario 1	Scenario 2	Scenario 3
1	-41.25	-41.25	-41.25
2	-84.58	-84.58	-84.58
3	-108.75	-108.75	-127.92
4	-113.75	-113.75	-171.25
5	-120.42	-120.42	-200.83
6	-116.67	-116.67	-202.50
7	-110.00	-110.00	-195.83
8	-103.33	-103.33	-189.17
9	-96.67	-96.67	-182.50
10	-90.00	-90.00	-175.83
11	-83.33	-83.33	-169.17
12	-76.67	-76.67	-162.50
13	-70.00	-70.00	-155.83
14	-63.33	-63.33	-149.17
15	-56.67	-56.67	-142.50
16	-50.00	-50.00	-135.83
17	-43.33	-43.33	-129.17
18	-36.67	-36.67	-122.50
19	-30.00	-30.00	-115.83
20	-23.33	-23.33	-109.17
21	-16.67	-16.67	-102.50
22	-10.00	-10.00	-95.83
23	-3.33	-3.33	-89.17
24	3.33	3.33	-82.50
25	10.00	10.00	-75.83
26	16.67	16.67	-69.17
27	23.33	23.33	-62.50
28	30.00	30.00	-55.83
29	36.67	36.67	-49.17
30	43.33	43.33	-42.50
31	50.00	50.00	-35.83
32	56.67	56.67	-29.17
33	63.33	63.33	-22.50
34	70.00	70.00	-15.83
35	76.67	76.67	-9.17
36	83.33	83.33	-2.50
37	90.00	90.00	4.17
38	96.67	96.67	10.83
39	99.27	103.33	17.50
40	97.81	110.00	24.17
41	100.42	116.67	30.83
42	98.96	123.33	37.50
43	101.56	130.00	44.17

44	100.10	136.67	50.83
45	98.65	143.33	57.50
46	85.31	130.00	44.17