

# Sustainable Equilibrium Evaluation of Outsize Engineering Project

Hong Kai-rong

The School of Business, Central South University, P.R.China, 410083

Email: hongkair@mail.csu.edu.cn

**Abstract:** This paper proposes a project evaluation approach known as sustainable equilibrium evaluation (SEE) which can reveal the social and ecological value of outsize engineering project more adequately, by setting up an equilibrium analytical framework of project value based on the equilibrium of option game, reciprocal fairness and risk aversion, and combining the thought of sustainable development with project evaluation. The SEE approach sufficiently reflects the complexity of belief changes of connected subjects and the significance of analyzing the value of outsize engineering project, and is characterized by simple procedure and rational logic, which are necessary to the judgment of project feasibility.

**Key words:** Sustainable Equilibrium Evaluation; Option Game Equilibrium; Reciprocal Fairness Equilibrium; Risk Aversion Equilibrium; Outsize Engineering Project

## 1. Introduction

Contrast to the normal engineering project, the development of outsize engineering project has a complex and profound influence on a particular region as well as the whole society with its huge scale and long cycle of investment. Moreover, the economic, social and ecologic value of outsize engineering project is closely and intricately interacted. Therefore, any approach chosen to evaluate the value and feasibility of outsize engineering project must solve two problems : consistency of the basis of project value analysis model and effective integration of sustainable development and project evaluation .

In order to solve these problems, the author proposed and defined the concept of sustainable equilibrium evaluation (SEE) of project. The SEE can be treated as a combining thoughts of sustainable development with agent game equilibrium analysis in outsize engineering project evaluation, namely assessing the economic, social and ecologic value of outsize engineering project with portfolio equilibrium analysis framework based on the equilibrium of option game ,reciprocal fairness and risk aversion. By utilizing sustainable equilibrium evaluation model, the NPV analysis of economic value and the overall evaluating indicator of social and ecologic value of project can be cross-referenced, and the feasibility discrimination of the corresponding project will also lay a more reasonable foundation of agent rational behavior.

Although the social and ecologic value have been taken into account from different perspectives, the outsize engineering projects, including "Three Gorges Project", " Pipeline Project of the Western Gas Transported to East "and" South-North Water Diversion Project", usually see some negative effects(for example, increased cost in migration and additional fee in ecologic protection)and positive effects(such as acceleration of economic and social development in region) which cannot be predicted in feasibility analysis ,after the projects start.

Not only the combining intellection concerning the evaluation of outsize projects and the concept of sustainable development can be commenced from the integrated evaluation methods, but also the evaluation indexes can be determined based on the connotation of sustainable development concepts and the property of outsize project. Traditional research focuses on the analysis of environmental and ecological consequences of outsize project, or directly explores the

multiple values of engineering project. Unlike Traditional research, we propose the thoughts of sustainable equilibrium evaluation by combining the option game equilibrium, reciprocal fairness equilibrium and risk aversion, seeking to ensure the rationality and correctness of the value analysis of outsize engineering project under a more realistic environment with uncertainty of agent strategies interaction.

Considered in terms of game equilibrium, project evaluation is actually a kind of value of project strategy under agent interaction environment. Accordingly, the economical, social and ecological value of the project can also be considers as a strategy value arising from the belief of different agents and various equilibrium consequences resulting from strategy interaction of associated agents. In other words, the economic, social and ecological value of the outsize project, which are closely related, can be reflected in a kind of framework of strategy interaction based on the reciprocal equilibrium analysis of option game, interactive fairness and risk aversion. Therefore, the author puts forward an evaluation approach of sustainable equilibrium ,which can not only realize the effective integration of sustainable development and environmental and ecological protection concepts as well as the project evaluation thoughts, but also lay a foundation for unifying analysis of the economic and socio-ecological evaluation of project, thus ensuring the quality of outsize project evaluation which has complex value content and significant socio-ecological impacts.

## **2. Literature Review**

The author proposes the thought of sustainable equilibrium evaluation with purpose of realizing the effective combination of project evaluation thoughts with sustainable development concepts under equilibrium analysis framework. This research treats sustainable development as a stability preference of benefits chasing of the agents (Chichilnisky,1997), or unites the sustainable development concepts and project evaluation thoughts in agent inter-generational game (Haurie,2005), or explores an common approach of inter-generational public project evaluation (Liu,2004), or considers the measure of project value from the aspects of use-value and non-use-value (Sharp,2001). Aiming to break through the theory limitation of traditional NPV used in urban land development project evaluation, the author (2002,2003) brought forth and defined the evaluation of project strategy value and project interaction apply to the environment of agent game. Then the author (2004) further explored a sustainable development model of urban land based on reciprocal fairness equilibrium. This conceptual model can hold water only when the sustainable development concept becomes a common belief consistent with the rationality of all the development agents.

Another purpose is to improve traditional approach of project evaluation. The author (2007) defined and analyzed option game evaluation theory, which is a natural extension of option game equilibrium analysis in the area of project evaluation. Generally speaking, the main ideological references which enrich the option game evaluation thoughts include continuous option game model created by Smets (1991), Dixit and Pindyck (1994).In the other hand, Smit and Ankum (1993) and Trigeorgis(1997) built the first discrete model of option game through the strategic analysis of enterprises under uncertainty. Imai and Watanabe (2004,2006) presented binomial option game model which the united characteristic of combining continuous-time model with discrete-time model. In addition, Huisman and Kort (1999) developed the standard duopoly model of R&D investment and Grenadier (2002) set up a standard model of symmetric oligopoly under

uncertainty. All of these achievements have highlighted the inherent meaning of project evaluation in option game equilibrium analysis based on a certain project.

Moreover, the meaningful results of research regarding sustainable equilibrium evaluation model also include the random game equilibrium method represented by Fudenberg and Tirole (1985), which is often used to resolve continuous option game model, the reciprocal fairness equilibrium put forward and defined by Rabin (1993) and risk aversion equilibrium proposed by Shalev (1997,1998) in the framework of behavior game theory. In addition, the sequential reciprocal equilibrium model created by Dufwenberg and Kirchsteiger (1998), the inequity aversion model built by Fehr and Schmidt (1999) and Bolton and Ockenfels (2000) and those research papers which integrate reciprocity, intention and social preference effectively are recognized as very representative references, all of these have made a grate contribution to the reciprocal fairness equilibrium theory. Inferring from the research results of the reciprocal fairness theory, given the project agents is a kind of reciprocal fairness belief, the project value won't solely depend on material benefits brought by project development any longer, it also rests with psychological utility contained in reciprocal fairness equilibrium. Thus, we can set up a related thought with uniting reciprocal fairness equilibrium analysis and project evaluation.

Risk aversion equilibrium is another theory to support sustainable equilibrium evaluation model. Its ideological roots can be traced back to Fudenberg and Tirole's viewpoint (1991) about substituting the loss minimization for the profit maximization, as well as Tversky and Kahneman's understanding (1992) concerning the dependent relationship between agent preference and reference level. Shalev firstly proposed and defined risk aversion equilibrium ,he believed we could predict the behavior of agent more accurately when we use the risk aversion equilibrium analysis based on reference dependent utility function, because it incorporated the factor of risk aversion into agent utility. Furthermore, the author's study also indicated although Shalev (1997, 1998) especially defined that the loss aversion function took the payoff in different phrases as a reference point of the risk aversion behavior, the character of outsize project could provide a certain meeting point for the application of risk aversion equilibrium evaluation method. Additionally, we can learn from the analysis thoughts represented by Palmini (1999), mainly expatiated on risk aversion and minimum safety standards in the framework of game equilibrium. Palmini regarded the risk aversion equilibrium between associated agents as a specific performance of ecological value of project, according to this associated thoughts, he established an ecological value equilibrium analysis model of project, which combined agent risk aversion motive and environmental and ecological protection concepts.

To sum up, we can construct a kind of project evaluation approach— sustainable equilibrium evaluation which can reveal the social and ecological value of outsize engineering project more adequately, and meanwhile maintains simple procedure and logical rationality by setting up a kind of equilibrium analysis framework of project value based on the equilibrium of option game, reciprocal fairness and risk aversion, aiming to realize an effective combination of sustainable development concept and project evaluation thoughts. Compared to traditional NVP evaluation approach or narrow real option evaluation, this paper puts forward a sustainable equilibrium evaluation method reflects the complex worth content and the essential social and ecologic factors more accurately, provides the various belief changes and its value meaning of outsize engineering project more completely.

### 3. The technical route and application model of sustainable equilibrium evaluation

The author proposes sustainable equilibrium evaluation with the purpose of making up for deficiencies of the traditional evaluation methods and applying to the particularity required by outside engineering project evaluation. Different from ordinary project evaluation, it is required to measure social and ecological value of project more accurately, because for outside engineering project, some social and ecological factors which can be ignored by NVP evaluation would bring about unacceptable and enormous social-ecological costs, thus becoming determinants of the success of project. In addition, the non-use values or existence values which construct the important connotations of social and ecological value can not be measured precisely in traditional evaluation model. Owing to this, the author bring forth this sustainable equilibrium evaluation to reveal the social and ecological value of outside engineering project more adequately in the feasibility judgment of outside engineering project with setting up a kind of equilibrium analysis framework of project value.

#### 3.1 The technical route of sustainable equilibrium evaluation

SEE is a project evaluation approach combining the concept of sustainable development with using the equilibrium of option game, reciprocal fairness and risk aversion, metering the economic, social and ecological value of projects, and thus is a project value analysis approach determining the feasibility of the outside engineering project.

As shown in Figure 1, the technical route of SEE includes the following four steps:

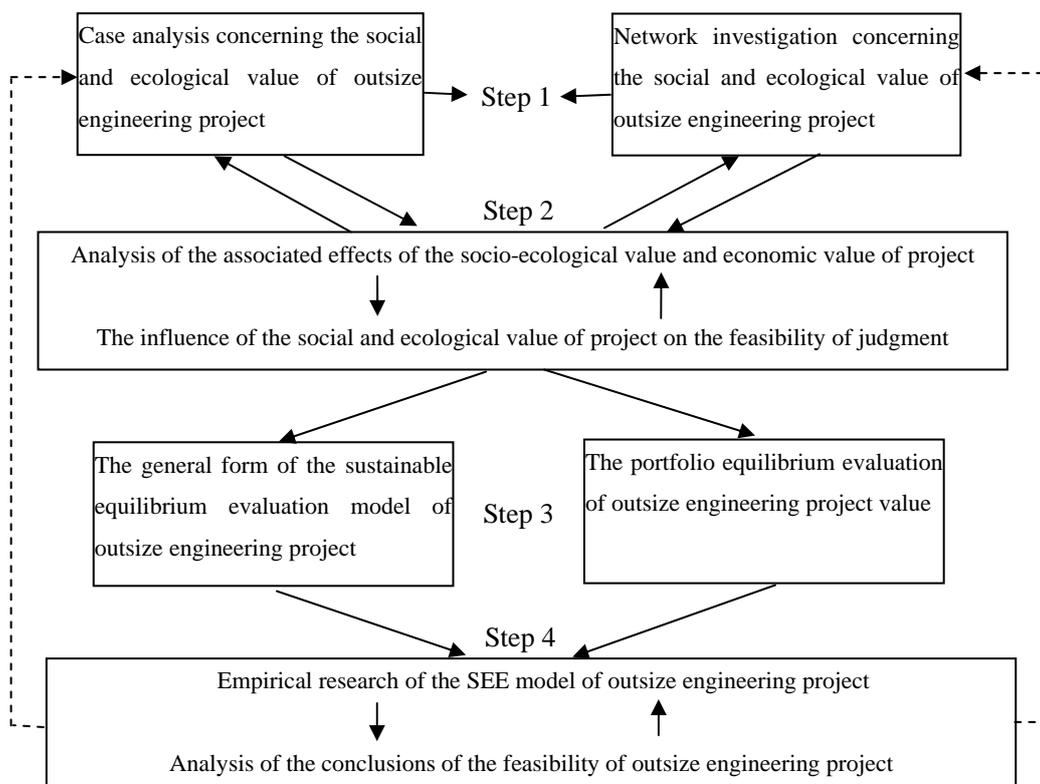


Figure 1 The basic steps of the evaluation of sustainable equilibrium

#### 3.1.1 The case analysis and network investigation of the social and ecological value of outside

engineering project

The first step of project value analysis involves the use of traditional evaluation method for outsize engineering project feasibility analysis of the case, the analysis of how the realistic project subject keeps balance between economic, social and ecological value of project as well as how this balance strategy impact the connotation of the project value. The case analysis and network investigation also provide the necessary data for the comparative analysis of project economic value and social ecological value as well as the analysis of case and internet simulation experiment of the sustainable equilibrium evaluation model.

### 3.1.2 The Analysis of the associated effects of the socio-ecological value and economic value of project

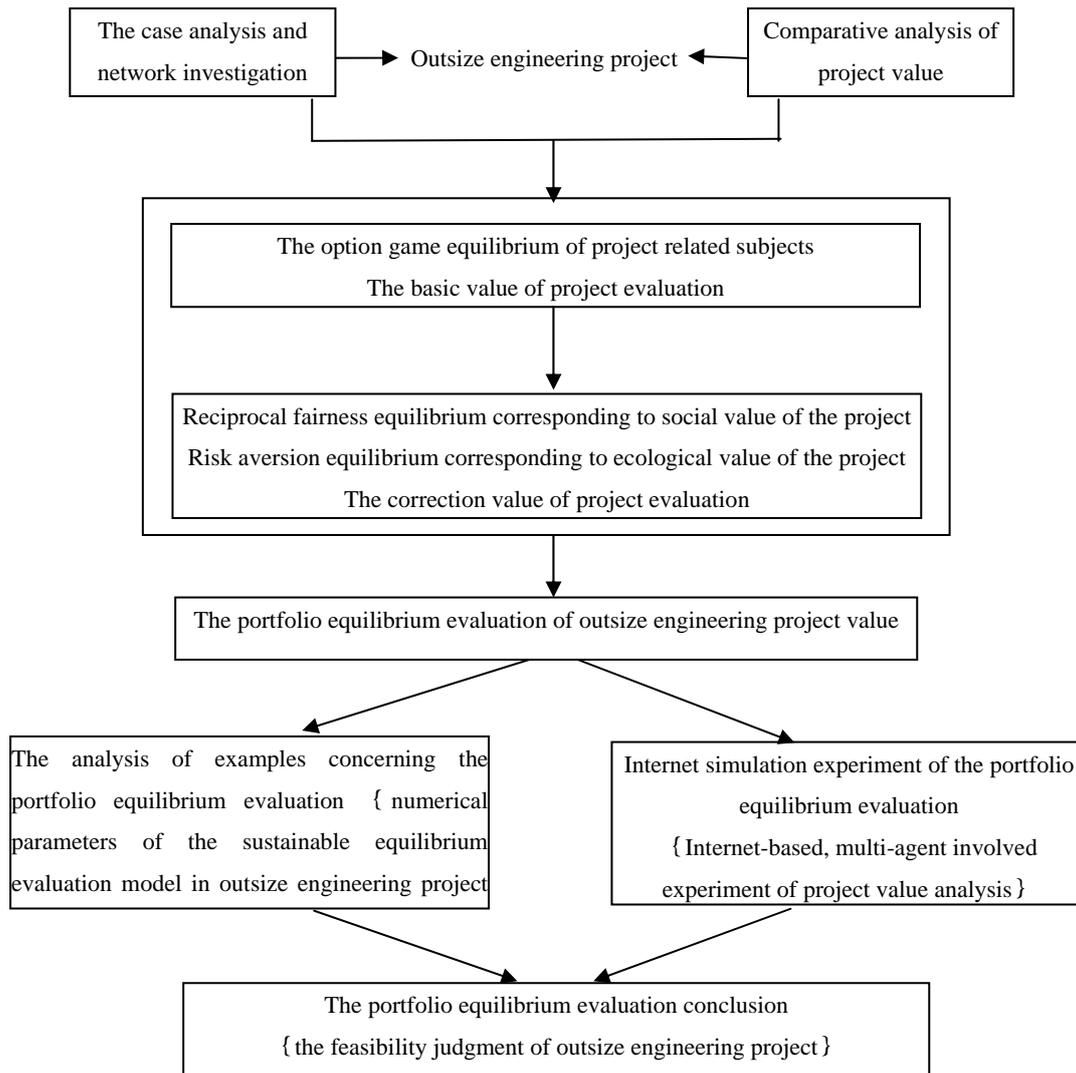
According to the game equilibrium thinking of project evaluation, social evaluation of project can be interpreted as a specific form of the reciprocal fairness equilibrium, because those strategic choices which can not achieve the reciprocal fairness equilibrium of subject can not be the consistent prediction of the project related subject. In addition, subject strategic choices beyond risk aversion equilibrium which may result in significant future losses (ecological disaster) also can not raise the level of the overall value of the project the balance of risk aversion of those options may result in significant future losses (ecological disaster) is the main strategy of choice, even though there are enormous economic benefits to compensate for the current period. Therefore, in SEE thinking, the project related subject strategy reciprocal equilibrium and its changes, in fact, reflected in the value connotation of outsize engineering project and its changes.

### 3.1.3 The portfolio equilibrium evaluation and model construction concerning the value of outsize engineering project

Similarly, according to the game equilibrium thinking of project evaluation, the project subject equilibrium of option game, reciprocal fairness and risk aversion, in fact, can be understood as the different forms concerning the value connotation of project and belief structure of related subject. In view of this, we can combine the beliefs of reciprocal fairness and risk aversion into subject belief construction of the option game evaluation model in order to establish a sustainable equilibrium evaluation approach concerning the value analysis of outsize engineering project based on the strategy equilibrium profile of project related subject with the characteristics of stability.

### 3.1.4 The empirical analysis of the sustainable equilibrium evaluation model of outsize engineering project

In order to prove the rationality and validity of the sustainable equilibrium evaluation model, the author designs two cross-referencing ideas of empirical analysis: Firstly, contrast to outsize engineering project case analysis by means of the traditional evaluation method, we employ analysis of examples concerning the sustainable equilibrium evaluation model; Secondly, in outsize engineering project case analysis , we conduct experiments to analyze project value which can control evaluation variables on the internet. These two Empirical Analysis methods not only lead to the numerical representation of the parameters in the sustainable equilibrium evaluation model, but also extend the application of this evaluation model.



**Figure 2 The application model of the sustainable equilibrium evaluation**

### 3.2 The application model of sustainable equilibrium evaluation

The sustainable equilibrium evaluation model has more complex external form compared with the general model of evaluation due to its multiple equilibrium characters and the complexion of outsize engineering projects value of the project evaluation equilibrium. In order to simplify this method, the application of model based on the option game equilibrium of the connect subjects of project、 the reciprocal fairness and risk aversion constructs the up or down amended value in the basis value.

Just as shown in Figure 2, firstly, we can determine the basic value corresponding to the option game equilibrium and reflecting the economic value of project based on case analysis and network survey. This basic value can contain in the model of option game of such as “two subjects but one project” or “two subjects and two projects” or “more subjects and more projects” according to different situations of projects (Hong, 2007). Then, we consider reciprocal fairness and risk aversion as its up(the ideal equilibrium) or down(the non ideal equilibrium) amended value; next, we make case analysis and simulate experiment of internet based on the numerical examples analysis of combinational model of the equilibrium evaluation; Finally, we draw a conclusion

about the feasibility of the outside engineering under a comprehensive analytical framework. According to this application model, we can draw a conclusion that the standard of project feasibility is the combination of portfolio strategies of option game equilibrium; reciprocal fairness and risk aversion. Or we can say the conclusion of the sustainable equilibrium evaluation of project feasibility just exists in the intersection of option game equilibrium, reciprocal fairness and risk aversion.

Why do we conduct internet simulated experiments of the sustainable equilibrium evaluation model? Firstly, in the case of unceasing changes of the subjects' cognitive conception and ceaseless evolutions of every nation's or even humankind's cognitive notions of environment ecological value, we can only depend on Group decision-making function of internet and experiment economics method which control the variable of evaluation, and integrate the public as many as possible into the project value analysis experience of a multiple subjects and angles. By doing so, we can accurately understand the common beliefs determining the value of social ecology of those special projects. Secondly, considering the particularity of the outsize engineering project, this so-called the sustainable equilibrium evaluation (SEE) can not truly reflect the idea of sustainable development of the whole society if we can not sufficiently describe various subjects' cognition and judgment of project value in the outsize engineering evaluation. Thus, through this experiment, we not only show the project social ecology value according to the significant changes caused by the evolution of social belief, but also can we realize numerical value of the model variable of the sustainable equilibrium evaluation through case analysis, thus can maintain real value of the approach of the sustainable equilibrium evaluation.

#### **4. Conclusion**

Based on the accurate grasp of the specificity of outsize projects evaluation, this paper demonstrates a kind of project evaluation approach which can reveal the social and ecological value of outsize engineering project more adequately by setting up an equilibrium analysis framework of project value based on the equilibrium of option game, reciprocal fairness and risk aversion, and uniting the thought of sustainable development and project evaluation. The innovation of Sustainable Equilibrium Evaluation (SEE) can be concluded as follows: first, SEE can measure the economical, social and ecological value of outsize engineering project under a unified framework of equilibrium analysis by defining the project social value of Reciprocal Fairness Equilibrium and the project ecological value of Risk Aversion Equilibrium, which can provide an analysis framework for project evaluation to realize the unification of project economic evaluation and project socio-ecological evaluation. Second, SEE can reflect the changes of socio-ecological evaluation of outsize engineering project and the evolution and change of the corresponding social common belief by carefully-designed example analysis and Internet simulation application models, which guarantees the logical rationality and practical implications of this evaluation approach.

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