Decision-making model of the urban regeneration construction project based on environment improvement

Shilong Li[1,2*], Hongyan Tian[3]

[1] *Faculty of Construction Management and Real Estate Chongqing University, Chongqing City, China, 400045*

[2] *Centre for Construction Economics and Management Chongqing University, Chongqing City, China, 400045*

[3] *Department of Building Economy Chongqing Vocational College of Architectural Engineering, Chongqing City, China, 400070*

Received 6 October 2013, www.tsi.lv

Abstract

Urban regeneration is regarded as a more deliberate and harmonious progress of development, which takes a series of more sensible and multiple regeneration ways to achieve the goals, such as protection, repair, reuse and redevelopment. It is suggested that urban regeneration has positive effects on urban development and social economic system. Improvements in urban systems mainly originate from the environmental improvement, including ecological environment, social environment and the neighbourhood environment. Urban regeneration construction project and its decision-making model become the important research contents of urban regeneration. This paper discusses the urban regeneration from angle of project, and suggests a mathematical decision-making model of the urban regeneration construction project, which considers the risk, cost and environment constraints. Meanwhile, it is suggested that the joint exploitation is an important selection criterion. A case simulation is suggested in this paper in order to test the strategy model.

Keywords: Urban Regeneration, Decision-making Model, Project

1 Introduction

It is considered that urban regeneration originates from large-scale torn down and reconstructed renewal projects, which is regarded as the sustainable construction tasks in the development of urban construction. The old urban tissue may inevitably appear to physical form decline during the process of urban development and expansion. The urban pattern, public facilities and buildings are faced with the transformation of physical and economic performance or may be reconstructed considering the overall environment requirements. Due to the various constant impacts and challenges during the vicissitude of the social economy and political structure, some of the old urban areas are increasingly at the disadvantageous positions [1]. It have been pointed out that urban regeneration is the inevitable product in the process of urban development by different field researchers, which is also an intuitive performance of development and changes of the urban economy, society, environment and spatial morphology [2].

Urban regeneration is implemented by different construction projects, which could improve the urban function, ameliorate the living environment and promote the comprehensive quality of the city. The element diversifications of the space, quantity and quality are brought about by the urban regeneration, which will affect all urban systems and individuals with the implementation of new URCP (urban regeneration construction project). Whitehead, T researched the link between urban quality improvements and economic activity, and pointed out that it was obviously important for the urban regeneration and renaissance agendas which posit attractive and well-designed environments as a way to create the right conditions for promoting economic growth [3]. Whitley, R and Prince, M recognized that urban socio-environmental conditions could affect the development and course of numerous health problems in their research, who suggested that urban regeneration programs could have on everyday functioning, coping and recovery for people with a mental illness [4]. Lawless, P examined the relationship between transport investment and urban regeneration based on an English provincial city, and pointed out that new investment had only a relatively limited impact on regeneration [5]. Biddulph, Mike examined the economic and governance context through which new forms of urban design policy and guidance have emerged, and discussed whether and how they have been applied to developments emerging across the centre [6]. Lloyd, MG researched the urban regeneration and the community development, and suggested that community planning and social inclusion partnerships were the vehicles for the urban regeneration [7]. Rogers, Chris D.F. thought that little had been done to test urban regeneration solutions in his paper and described a methodology that has developed future scenarios for the year 2050 against which to test the robustness of current engineering solutions, thereby

* ***Corresponding author*** e-mail: lslcqu@126.com

providing unique insights into the potential impacts of present urban planning and design decisions, and thus financial investments [8].

Urban regeneration is embodied by a more deliberate and harmonious progress of development, which takes a series of more sensible and multiple regeneration ways to achieve the goals, such as protection, repair, reuse and redevelopment. Researchers suggest that urban regeneration has positive effects on urban development and social economic system. Improvements in urban systems mainly originate from the environmental improvement, including ecological environment, social environment and the neighbourhood environment. Construction project of urban regeneration and its decision making become one of the important research content of urban regeneration.

2 Problem Description

Urban regeneration is often consisted of two aspects. The first one is the regional regeneration, considering the holistic regeneration, which includes the urban environment, planning, economic growth, and transportation and so on. The other one is the construction, which mainly considers the decision of construction projects in various conditions. Urban regeneration in the aspect of construction projects has experienced several stages, including tear down and reconstruction, neighbourhood repair, economic recovery and public private partnerships and then turn to multi stakeholder partnerships. Due to the urban environmental degradation caused by urban function hysteresis, such as the traffic congestion and unmerited waste disposal, it is called to improve the urban living conditions and environment quality by urban regeneration construction project. It is suggested that urban regeneration construction project usually tends to appear by form of the modified construction in environment, economy, society or urban personal behaviour, which decision-making model is a kind of complex, hierarchical structure, multi-objective and uncertain system model. It is also considered with the random, high dimension and nonlinear characteristics [9].

Urban regeneration construction project is often chosen by the economy cost and considered as a one-time injection from the perspective of urban developers in the process of planning and development, but failed to consider long-term economic, social and cultural factors. Actually, urban regeneration often involves scientific and rational allocation of unit space increment, which is needed to grasp and update the related information of the urban unit, and then to make the choices and judgments, including the scale of the urban regeneration construction project and the project portfolio. The project decision-making model is often used to be the ANP model, system dynamics model and so on. In the research field, it is limited in the discussion about the model and method of the urban regeneration construction project selection, which is mainly because of the complexity of the urban regeneration construction project. In this paper, it is suggested to define the decision-making model of the urban regeneration construction project as the government environmental governance project decision-making model, which is from the perspective of the government governance research.

3 Model Establishment

3.1 ANALYSIS OF MODEL ESTABLISHMENT

This paper discusses urban regeneration from the angle of project and especially the decision-making model, which often involves the conflicting economic, environmental, and socio-ecological impacts. However, too much emphasis is focused on the economic goal implementation in the former research, which may neglect the social and environmental demand. It is suggested that the DM-URCP (decision-making model of the urban regeneration construction project) is multi objective decision-making model, which is restricted by the following aspects.

3.1.1 Risk constraint

Risk is composed of risk factors, risk accidents, risk loss and so on. Generally, there are two kinds of risk definitions. The first definition emphasizes uncertainty, which illustrates the possible results of loss, profit or balance. The second definition just emphasizes uncertainty of the loss. In this paper, it is suggested that risk constraint of the urban regeneration construction project and its decision-making comes from the probability of decision-making failure and the environment safety risk in the process of the urban regeneration construction, which is described by the loss cost. Decision maker needs to undertake corresponding consequences, which cannot be transferred. The evaluation for the risk constraint of DM-URCP is the smaller the better, which usually uses the method of the fuzzy mathematics.

3.1.2 Cost constraint

In the urban regeneration construction project, finance and its source are usually to be thought and discussed in front of the decision-making. According to the classical research results, it is suggested that weighing the finance constraints and agency costs of the capital budgeting is very important, which are concern with the construction cost. Resources are limit in any projects. Supposing the limitation of the resource reflecting in capital, it is difficult to estimate the cost of URCP, which is affected by the long construction cycle and various contents. Furthermore, funds will be limited in the urban regeneration construction project when regeneration result cannot be confirmed. According to the theory of

value engineering, cost and function regeneration have a matching degree between them. It will reduce the cost where two or more projects are implemented at the same time. Therefore, it will cause the different cost by selecting the different project portfolio selection in the DM-URCP.

3.1.3 Environment constraint

Bearing capacity of resources and environment is limited. It is widely recognized that intense of the energy supply, unbalance of the energy consumption, low utilization of the energy use and environmental pollution caused by energy consumption inevitably lead to the environmental pollution. In the process of the urban regeneration construction project, carbon emissions will be produced during the demolition of buildings. Meanwhile environment will be occupied during the process of the new construction. In this paper, it is suggested that environmental constraints embodied in the water resource and land constraints. If the construction or demolition amounts of the urban regeneration construction project exceed certain amounts, more urban land will be occupied and will cause the land damage, which means that more broken lands cause environmental problems. Then, consumption of water resources will rise with the increase of the construction scales.

3.1.4 Technology constraint

Technology constraint of the urban regeneration construction project usually appears in some special projects or areas, which are caused by position of plan and construction project stationary, such as harmless treatment of the soil and super building construction etc. For most of the urban regeneration construction projects, it is not to be considered of the technology constraint. Then, in this paper, it is thought that the technology constraint is without any influence on the decision-making.

3.1.5 Culture constraint

Culture is very important towards the city. One of the culture carriers is the construction projects in the city. The culture may be destroyed with the implement of the project. It is recognized that culture constraint consists of attitudes of the urban residents to the urban regeneration construction project and the elasticity alteration of the urban veins, which is a kind of soft constraints and difficult to measure. In this paper, culture constraint is not considered in the decision-making model of the urban regeneration construction

3.2 PARAMETERS DEFINITION AND THE MODEL

In decision making of the urban regeneration construction project, it is important to reduce the risk, cost and the environment effects as well as implement the programs in accordance with the technology constraint and the culture constraint.

Suppose i (i=1,2,3,……n) is the urban regeneration construction project point. Firstly, analyse and establish the model for a single project. It is suggested that the decision making of the urban regeneration construction project depends on the cost and the risk, which consists of the construction, demolition and the environmental effects, if do not consider the culture and technology constraints. According to the principle of construction, urban regeneration construction project will bring out the environment pollution and the resources consumption, which can also be translate into the cost, defined as the environmental loss cost.

Demolition cost of the urban regeneration construction project $\cos t_i^1$ is a function of demolition scale Q_i^d . Environment capacity in specific region is limited. Thus, if demolition scale of the urban regeneration construction project outnumbers the maximum capacity, which usually estimated as a certain demolition amount Q_0^{d1} . If demolition scale of the project is less than the min capacity Q_0^{d2} , it will cause the land fragmentation which is also the environmental loss cost. Then,

$$\cos t_i^1 \begin{cases} = \alpha Q_i^d + \lambda \left| Q_i^d - Q_0^{d1} \right| + C_0^{d1} \\ s.t.\ \alpha > 0; \\ \quad \lambda > 0; \\ \quad Q_i^d > Q_0^{d1}; \\ = \alpha Q_i^d + \lambda \left| Q_i^d - Q_0^{d2} \right| + C_0^{d2} \\ s.t.\ \alpha > 0; \\ \quad \lambda > 0; \\ \quad Q_i^d > Q_0^{d2} \end{cases}, \tag{1}$$

where $\cos t_i^1$ represents the demolition cost of the urban regeneration construction project i. α is the unit of demolition cost of the urban regeneration construction project. λ is the unit of environmental loss cost. C_0^{d1} and C_0^{d2} are the constants. Meanwhile, the risk will rise corresponding with the increase of the demolition cost. Construction cost of the urban regeneration construction project $\cos t_i^2$ is a function of construction scale Q_i^b . In the decision making of the urban regeneration construction project, large scale of construction may mean better quality and more comfortable environment. Certainly, the $\cos t_i^2$ will rise with the ascendant of the construction scale.

Decision should balance the function of the urban regeneration construction project and the cost. Meanwhile, scale of the regeneration will bring out the risk corresponding with the cost. Risk reserve should be considered in the decision making model. Construction of

the project is different from the demolition, which is relevant with the use of funds system. If the construction scale outnumbers a certain scale Q_0^{b1} or less than a scale Q_0^{b2}, cost will rise or decrease correspondingly. Thus, it is suggested that the cost of the construction includes the direct construction cost, the exceed cost and the risk cost. Then,

$$\cos t_i^2 = \begin{cases} wQ_i^b + \rho \dfrac{\left|Q_i^b - Q_0^{b1}\right|}{Q_i^d} + C_0^{b1} \\ s.t.\ \ w > 0; \\ \quad \rho > 0; \\ \quad Q_i^b < Q_0^{b1} \\ wQ_i^b + \rho \dfrac{\left|Q_i^b - Q_0^{b2}\right|}{Q_i^d} + C_0^{b2} \\ s.t.\ \ w > 0; \\ \quad \rho > 0; \\ \quad Q_i^b < Q_0^{b2} \end{cases}, \tag{2}$$

where $\cos t_i^2$ represents the construction cost of the urban regeneration construction project i. w is the unit of construction cost of the urban regeneration construction project. ρ is the compound cost unit of exceed cost and risk cost, which is a function of the proportion exceed cost and risk cost in the same project. C_0^{b1} and C_0^{b2} are the constants. Meanwhile, the risk will rise corresponding with the increase of the construction cost.

$$\begin{aligned} & M_i = \eta_i \cos t_i^1 + \delta_i \cos t_i^2 + \theta_i \left(\frac{1}{f(U)} \right) \\ & s.t.\ \ 0 < \eta_i < 1; \\ & \quad 0 < \delta_i < 1 \end{aligned}, \tag{3}$$

where M represents the single urban regeneration construction project cost and the $\theta_i \left(\dfrac{1}{f(U)} \right)$ represents the risk utility level of the project implementation achievements, which is to judge the cost risk and environmental impact of the urban regeneration construction project. η_i and δ_i represent the demolition and construction coefficients, which are not constants. According to the description above, define

$$\begin{aligned} & f(U) = r_i' x_i = r_i' \left(\frac{1}{\cos t_i^2} \right), \\ & s.t.\ 0 < r_i' < 1 \end{aligned} \tag{4}$$

where r_i' is the coefficient of the risk utility.

In the urban regeneration, there is more than one project, which may have the compound possibility of construction. It is suggested that joint exploitation will reduce the cost in the urban regeneration construction project. Set,

$$\begin{aligned} & f(c) = \sum_{i=1}^{n} M_i - \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} c_{ij} \left(M_i + M_j \right) \\ & - \sum_{i=1}^{n-2} \sum_{j=i+1}^{n-1} \sum_{k=j+1}^{n} \beta_{ijk} \left(M_i + M_j + M_k \right) - \ldots \\ & - \sum_{i=1}^{1} \sum_{j=i+1}^{2} \sum_{k=j+1}^{3} \cdots \sum_{t=n}^{n} \varpi_{ijk\ldots t} \left(M_i + M_j + M_k + \ldots + M_t \right) \\ & s.t.\ c_{ij} > 0; \\ & \quad \beta_{ijk} > 0; \\ & \quad \ldots \\ & \quad \varpi_{ijk\ldots t} > 0; \\ & \quad f(c) < C^0 \end{aligned}, \tag{5}$$

where $f(c)$ represents joint exploitation cost of URCP, c_{ij}, β_{ijk} and $\varpi_{ijk\ldots t}$ represent cost saving coefficient of the two projects joint exploitation of i, j, cost saving coefficient of the three projects joint exploitation of i, j, k and cost saving coefficient of n projects joint exploitation of $i, j, k \ldots n$. The cost saving coefficient between each other is relevant with the attribute of the project and often determined by the ANP method. C^0 is a budget threshold.

Actually, DM-URCP is to search the combination of the projects, which joint exploitation cost, is minimal. Thus, DM-URCP is set as,

$$\begin{aligned} & \min R = \min f(c) \\ & s.t.\ \min f(c) < C^0 \end{aligned}. \tag{6}$$

4 Solving the Model

According to the model established in this paper, it is a typical combinatorial problem to search the min risk, max construction scale and the min cost. Particle swarm optimization is a swarm intelligence optimization method, which finds the overall optimum in a complex search space through the competition and collaboration among the particles and has the advantage of solving speed and stability. It has mature calculation program and acceptable for the model solving if variable value is controlled.

In a basic particle swarm optimization algorithm, it establishes an effective information sharing mechanism through the simulation of the birds flying [10]. Compared with traditional optimization method, the particle swarm optimization algorithm has characteristics of such as faster and convergence speed, smaller scale calculation etc. According to the particle swarm optimization algorithm, if there are M particles in N-dimensional space, the spatial coordinates of particle i is $x_i = \left\{ x_{ij} \right\}^T$

and the displacement is $v_i = \{v_{ij}\}^T$, the optimal solution could be found as the following iterative method: $v_i = w \cdot v_i + c_1 \cdot rand_1(\cdot) \cdot (pbset_i - X_i) + c_2 \cdot rand_2(\cdot) \cdot (gbset - X_i)$, $x_i = x_i + v_i$, where i=1,2,3,……,M; j=1,2,3,……N.

w is a N-diagonal matrix, which represents the inertia weight. $pbset_i$ is the optimal value of particle i in the spatial location before. *gbset* is the optimal value of all particles in the spatial locations before. C_1 and C_2 are the constant acceleration. $rand_1(\cdot)$ and $rand_2(\cdot)$ produce the figure between 0 and 1 randomly. In addition, in the process of iteration, define the displacement threshold $v_{ij\max}$, and then, $\forall v_{ij} > v_{ij\max}$, $v_{ij} = v_{ij\max}$.

5 Case Simulation

5.1 CASE DEFINITION

Because of the urban regeneration demand, construction is associated with the demolition. The decision is that the less of the demolition the better corresponding with the more of the construction the better, which should also meet the risk and cost constraints. In this paper, Decision-making model of urban regeneration construction project does consider the culture and technology constraints temporarily and define the risk and environment constraints into measurable cost constraint. Suppose there are nine urban regeneration construction project points. The amount of demolition and construction are showed in Table 1.

TABLE 1 Demolition and Construction Amount

Points	Demolition(m^2)	Construction(m^2)
1	1200000	3000000
2	450000	750000
3	600000	1150000
4	800000	1600000
5	550000	350000
6	1250000	1000000
7	620000	1150000
8	700000	650000
9	4500000	3500000

5.2 Parameters setting and the result

According to application of particle swarm optimization research, it suggested to solve the model by particle iteration. The parameters of ρ and $r_i^{'}$ value form the empirical data. Adopt the method of ANP, which is a mature method, c_{ij}, β_{ijk} and $\varpi_{ijk\ldots t}$ value [0,1] placed in the calculation process. The other parameters setting are shown as following Table 2.

TABLE 2 Parameters setting

Parameter	Value	Parameter	Value
α	0.35	w	1
λ	0.5	Q_0^{b1}	2000000
Q_0^{d1}	1500000	Q_0^{b2}	1000000
Q_0^{d2}	1000000	C^0	200000
C_0^{d1}	0	C_0^{b1}	0
C_0^{d2}	0	C_0^{b2}	0

By the model established in this paper and the solving method, which is set by controlled stages, the result, which is processed by the planning empirical data is $\begin{cases} i = (4,7) \\ (\eta_4, \delta_4) = (0.75, 0.8) \\ (\eta_7, \delta_7) = (0.55, 0.9) \end{cases}$.

6 Conclusion

This paper discusses the urban regeneration from angle of project, and tries to describe a situation of the decision making model of the project. It can determine the amount and the joint exploitation strategy through the model established in the paper and solving method. However, it is only a simulation, which defines many constraints, it is suggested that urban regeneration consist of constraints and patterns research besides the project. It is only a simulation, which defines many constraints, it is suggested that urban regeneration consist of constraints and patterns research besides the project.

References

[1] Han Zhang, Linfei Song 2008 British and American Urban Regeneration Research Review from the Domestic Scholars *Urban Problems* **2**(2) 78-83 *(In Chinese)*

[2] Zhao Yinghui 2010 Low-carbon Design Strategy in Urban Renewal Planning – The Case of Mutoulong Project in Shenzhen City Renewal Programme *Urban Planning Forum* **192**(7) 44-7 *(In Chinese)*

[3] Whitehead T, Simmonds D, Preston J 2006 The Effect of Urban Quality Improvements on Economic Activity *Journal of Environmental Management* **80**(1) 1-12

[4] Whitley R, Prince M 2006 *Health Promotion International* **21**(1) 19-26

[5] Lawless P 1999 Transport Investment and Urban Regeneration in a Provincial City: Sheffield, 1992-96 *Environment and Planning C-Government and Policy* **17**(2) 211-26

[6] Biddulph M 2011 *Progress in Planning* **76**(2) 63-103

[7] Lloyd M G 2002 Urban Regeneration and Community Development in Scotland: Converging Agendas for Action *Sustainable Development* **10**(3) 147-54

[8] Rogers C D F, Lombardi D R, Leach J M, Cooper R F D 2012 *Proceedings of the Institution of Civil Engineers: Engineering Sustainability* **165**(1) 5-20

[9] Hai Zheng 2007 Algorithm Study on Models of Multiple Objective Risk Decision under Principal and Subordinate Hierarch Decision-making *Operations Research and Management Science* **16**(1) 1-8 *(In Chinese)*

[10] Shen S Y, Liu Y K 2010 A New Class of Fuzzy Location-Allocation Problems and Its Approximation Method *Information-an International Interdisciplinary Journal* **13**(3) 577-91 *(In Chinese)*

Authors

Shilong Li, born in September, 1981, Shapingba District, Chongqing City, P.R. China

Current position, grades: the Assistant Professor of Faculty of Construction Management and Real Estate, Chongqing University, China.
University studies: received his B.Sc. from Chongqing University in China. He received his M.Sc. from Chongqing University in China.
Scientific interest: His research interest fields include Urban Planning, Environmental Engineering and Management.
Publications: more than 10 papers published in various journals.
Experience: He has teaching experience of 7 years, has completed five scientific research projects.

Hongyan Tian, born in August, 1972, Nanan District, Chongqing City, P.R. China

Current position, grades: the Associate Professor of Chongqing Vocational College of Architectural Engineering, China.
University studies: received her B.Sc. from Chongqing University in China. She received her M.Sc. from Chongqing University in China.
Scientific interest: Her research interest fields include Project Management, Environmental Engineering and Management.
Publications: more than 15 papers published in various journals.
Experience: She has teaching experience of 12 years, and has completed six scientific research projects.