NON-COMPETITION GUARANTEED VALUE AND EFFECT ON THE TOLL ROAD PROJECT

Guo-Xing Zhang\textsuperscript{1}, Peng Wang\textsuperscript{2}, Ju-E Guo\textsuperscript{3}, Guorong Chai\textsuperscript{4}, Peng Liu\textsuperscript{5}

\textsuperscript{1, 4, 5}School of Management, Lanzhou University, 730000 Lanzhou, China
\textsuperscript{2}Qingdao Ocean Shipping Mariners College, 266071 Qingdao, China
\textsuperscript{3}School of Management, Xi'an Jiaotong University, 710049 Xi'an, China
E-mails: \textsuperscript{1}guoxingzh@lzu.edu.cn (corresponding author); \textsuperscript{2}wangpzj@126.com; \textsuperscript{3}guojue@mail.xjtu.edu.cn; \textsuperscript{4}chaigr@lzu.edu.cn; \textsuperscript{5}liupenglzu05@yahoo.cn

Received 12 July 2010; accepted 20 April 2011

Abstract. A non-competition guarantee has been widely used for financing the toll road project. However, to our best knowledge, there seems to be no research about the value and incentive effect of the non-competition guarantee. In the competitive and non-competitive condition respectively, this paper constructs the models of investment value and investment threshold by adopting the option game theory and measurement approach. The results of theory derivation indicate that the non-competition guarantee plays a strong role in investment incentives by reducing investment threshold. The simulation results indicate that the non-guaranteed value increases as the expected growth rate of traffic flow increases, and decreases as volatility increases.

Keywords: non-competition guarantee, toll road project, option game, investment threshold.

1. Introduction

Considering requirements for private investors to reduce risk and avoidance of excessive competition, the government often provides a certain degree of a non-competition guarantee for private investors in many toll road projects (Zhang et al. 2010). A non-competition guarantee, which is also called a restrictive competition guarantee, refers that in order to encourage investors to invest in infrastructure projects, the government promises not to invest or limit investments on similar projects in the same area within a certain number of years for the purpose of avoiding the negative effect of excessive competition on the return and profit of the existing investment. It is primarily used in toll road projects, toll bridges, toll tunnels and other transport projects. It is an indirect revenue guarantee provided by the government for non-state-owned capital, which has become the regular practice of financing the toll road project. According to different time and scope, the non-competition guarantee can be classified into two main forms: one of those directly makes the commitment of preventing from building the same or a similar project at the same area during a certain period, for example, the British Channel Tunnel project in which the Governments of the United Kingdom and France promised that they would not build another link facility across the English Channel in 33 years. The other is that the government will not allow building similar projects in the agreed regions when traffic flow maintains in a certain range, which is very common in China.

The non-competition guarantee provided by the government entitles the project investors to the exclusive operation right of the toll project at a certain area within a certain period, avoids a part of the demand risk of investors and is helpful for the entry of private investment into infrastructure. Definitely, it is valuable. However, nearly no literature on how to objectively evaluate the value of the non-competition guarantee and what role the latter plays in decisions made by investors is available. Taking into account the above discussed points, this paper will construct a valuation model of the non-competition guarantee. Section 2 analyzes the problem of the non-competition guarantee. Section 3 develops the valuation model of the non-competition guarantee with a real option. Section 4 deduces the result of the guaranteed value with respect to the non-competition guarantee. This section incorporates sensitivity analysis and demonstrates the guaranteed value upon traffic flow, the expected growth and volatility of traffic flow, and finally draws some referential implication for government's guaranteed decision-making.
2. Problem Analysis

The non-competition guarantee is relative to competitive investment. We haven't found quantitative research literature on the non-competition guarantee but investigation into investment decision-making under the context of competition is very common. Under the situation of competition, the investors investing in the same project have investment options. Their investment decisions affect one another. One of the parties implements the investment option while the value of the option of the other party will be greatly reduced. Affected by the before discussed situation, an investor as a follower can get the opportunity to invest only when market demand is further expanding. In the case of the non-competition guarantee, the government would regulate the investment to encourage investors to invest as soon as possible and ensure the leader obtains reasonable investment return; for the followers, once they lose the opportunity to lead investment, which also means that only when the non-competition guarantee expires, they can obtain the opportunity to invest. Clearly, when studying a competitive environment of investment, decision-making becomes the premise of studying the non-competition guarantee.

The option game theory has been widely used in investment decision-making in the competitive environment. As a combination of the real option theory and game theory, the option game theory is used for evaluating the value of the project including a real option on the basis of the ideology and methods of the option pricing theory. At the same time, the option game theory, which makes the use of the ideology and modelling method of the game theory, is a theoretical method of making scientific management and decision in the investment project. It is proposed for the problems and shortcomings while evaluating and making decisions on investments in the projects of the old-fashioned enterprises, i.e. it not only assesses the value of investment projects by making the use of the option method but also provides the basic method of making a decision under an uncertain environment by making the use of game theory analysis. Smets (1991) was the first to introduce the game theory about the framework for real options analysis and established a duopoly basic model used for studying two companies competing for direct foreign investments on investment timing. His model is one of the basis for continuous-time option games, whereas the existing option game model mostly is the extension of that. Dixit and Pindyck (1994) made a further extension to the model of the value function of investment stimulated by the leading and following investors as well as offered means of calculating investment threshold. Huisman and Kort (1999) provided complete information on the static game model under duopoly conditions and solved the 'coordination problem' in which enterprises will invest when 'the first to equilibrium' exists in the game. In the project investment decision-making process, enterprises must take into account the market structure, market conditions, investment decisions of competitors etc., and then make a scientific decision on different market structures and a situation of competitors (Amram, Kulatilaka 1998). At present, the option game theory has been widely used in R&D investment decision-making (Shackleston et al. 2004; Doraszelski 2004), real estate development (Grenadier 2005; Wang, Zhou 2006), business valuation (Kong, Kwok 2007; Smit, Trigeorgis 2006) and many other fields.

In the current study, the option game theory is mostly carried out under the conditions in the duopoly the ideas of the general study of which are as follows. In a competitive environment, taking into account continuous time $t \in [0, \infty)$ and assuming that two companies have the same opportunities, the enterprise that invests for the first time is called the leader (the leader, below 'l' means 'leader'), whereas the other is called the follower (the follower, below 'f' means 'follower'). Assuming that two enterprises have the same products and face the same customers and the market, the goal of decision-making is to choose the best investment opportunities to maximize the value of their investment. Therefore, under competitive conditions, there are a number of threshold values for state variables $Y(t)$ (e.g. project earnings, traffic volume, project value etc.):

1) when $Y(t) < Y_f$, where $Y_f$ is the threshold value of the investment of the leader, waiting (an investment option) is optimal. When $Y(t) \geq Y_f$, investing (implementation option) is optimal;
2) when $Y(t) < Y_l$, where $Y_l$ is the follower's investment threshold of time, waiting (an investment option) is optimal. Moreover, when $Y(t) \geq Y_f$, investing (implementation option) is optimal.

When $Y(t) \geq Y_f$, investing (implementation option) is optimal. The order of investments in a competitive investment environment is shown in Fig. 1, where $T_f$ is the best investment opportunities for the leader, which is the moment stating variable $Y(t)$ for the first time to reach (up through) $Y = Y_f$ i.e. $T_f = \inf \{t | Y(t) \geq Y_f \}$ is the same token $T_l = \inf \{t | Y(t) \geq Y_l \}$ and $T$ is the concession period.

Jones and Mason (1980) used the option theory to study the value of the guarantee and pointed out that the value of the project guaranteed could be regarded the guaranteed value and the value of the project unguaranteed, i.e. the guaranteed value equals to the value of the project guaranteed minus the value of the project unguaranteed. The study by Jones and Mason's reveals a line for the thought of studying such government-guarantee. After the problem of the project value under a competitive environment has been resolved referring to the option game theory, the key is to solve the value problem of the non-competition guaranteed project considering the non-competition guarantee. Taking into account that the non-competition guarantee is the government's guarantee that mainly attracts investment and protects the interests of investors, it targets mainly the leader's earnings (e.g. investment income of the leader) in infrastructure projects and guarantees them a monopoly on operating their investment in infrastructure projects in a certain period under certain conditions. Therefore, it is necessary to analyze the pathway of the non-competition guarantee in the competitive environment.
Taking into account the above discussed points, this section will study the non-competition guarantee drawing option game modelling and the value estimating approach to government guarantees. First, in the competitive environment, we construct the investment value model of the follower based on constructing the investment value model of projects; the value estimating method is combined with the optimal Behrman equation by means of the optimal Behrman equation reasoning backward, i.e. for leaders, the optimal investment decision should be made with a rational expectation for their potential competitors. For a newly-built toll road, volatility can be evaluated by the analysis of data on the history of traffic flow; for the existing toll road projects, its volatility can be evaluated by the standard assumption of a positive correlation between traffic flow and GDP (Banister 2006); $dt$ indicates time increment; $dz$ an increment in a standard Wiener process.

All investors are assumed to be risk-neutral with risk-less interest rate $r$ and act to maximize their profits. They adopt competitive behaviour with rational expectation for their potential competitors. The charge for a vehicle is assumed to be constant, $R$, given that the government always holds a relative stable charge policy in such infrastructure project. The inverse demand function of project revenue at time $t$ is:

$$P(t) = RY(N)Y(t)dt,$$

where: $P(t)$ denotes revenue flow with the given parameters of market demand; $N = \{1.2\}$ points to the number of projects; $\gamma (0 < \gamma < 1)$ denotes the shunting coefficient of traffic flow.

3.2. A Model for Investment Value in Competitive Context

The essence of backward induction is ‘looking forward, reasoning backward’, i.e. for leaders, the optimal investment decision should be made with a rational expectation of the followers’ reaction. We use backward induction to obtain an optimal follower’s strategy and analyze investment strategy and its threshold of the leading investor.

3.2.1. The Option Value of the Follower

Under the strategy given by leading investors, we consider an optimal investment decision of the follower, the value of which can be written as $F(Y)$. A rational follower must make an optimal decision with the realization of its following status. The follower’s investment value can be deduced from the following ordinary differential equation by means of the optimal Behrman equation combined with Ito lemma:

$$dY(t) = \mu Y(t)dt + \sigma Y(t)dz,$$

where: $\mu$ denotes the expected growth rate of traffic flow indicating an increase in the potential of traffic flow; $\sigma$ indicates the volatility of traffic flow as the key parameter representing the uncertainty of traffic flow (for the existing toll road projects, its volatility can be evaluated by the analysis of data on the history of traffic flow; for a newly-built toll road, volatility can be evaluated by the standard assumption of a positive correlation between traffic flow and GDP (Banister 2006)); $dt$ indicates time increment; $dz$ an increment in a standard Wiener process.

All investors are assumed to be risk-neutral with risk-less interest rate $r$ and act to maximize their profits. They adopt competitive behaviour with rational expectation for their potential competitors. The charge for a vehicle is assumed to be constant, $R$, given that the government always holds a relative stable charge policy in such infrastructure project. The inverse demand function of project revenue at time $t$ is:

$$P(t) = RY(N)Y(t)dt,$$

where: $P(t)$ denotes revenue flow with the given parameters of market demand; $N = \{1.2\}$ points to the number of projects; $\gamma (0 < \gamma < 1)$ denotes the shunting coefficient of traffic flow.

3.2. A Model for Investment Value in Competitive Context

The essence of backward induction is ‘looking forward, reasoning backward’, i.e. for leaders, the optimal investment decision should be made with a rational expectation of the followers’ reaction. We use backward induction to obtain an optimal follower’s strategy and analyze investment strategy and its threshold of the leading investor.

3.2.1. The Option Value of the Follower

Under the strategy given by leading investors, we consider an optimal investment decision of the follower, the value of which can be written as $F(Y)$. A rational follower must make an optimal decision with the realization of its following status. The follower’s investment value can be deduced from the following ordinary differential equation by means of the optimal Behrman equation combined with Ito lemma:

$$dY(t) = \mu Y(t)dt + \sigma Y(t)dz,$$

where: $\mu$ denotes the expected growth rate of traffic flow indicating an increase in the potential of traffic flow; $\sigma$ indicates the volatility of traffic flow as the key parameter representing the uncertainty of traffic flow (for the existing toll road projects, its volatility can be evaluated by the analysis of data on the history of traffic flow; for a newly-built toll road, volatility can be evaluated by the standard assumption of a positive correlation between traffic flow and GDP (Banister 2006)); $dt$ indicates time increment; $dz$ an increment in a standard Wiener process.

All investors are assumed to be risk-neutral with risk-less interest rate $r$ and act to maximize their profits. They adopt competitive behaviour with rational expectation for their potential competitors. The charge for a vehicle is assumed to be constant, $R$, given that the government always holds a relative stable charge policy in such infrastructure project. The inverse demand function of project revenue at time $t$ is:

$$P(t) = RY(N)Y(t)dt,$$

where: $P(t)$ denotes revenue flow with the given parameters of market demand; $N = \{1.2\}$ points to the number of projects; $\gamma (0 < \gamma < 1)$ denotes the shunting coefficient of traffic flow.
Under conditions that the follower invests, the value of the project with concession period $T$ is:

$$V(Y) = \frac{RY}{\delta}(1-e^{-rT}),$$

where: $\delta = r - \mu$ at the follower’s investment threshold $Y_f$, according to the follower’s value, matching conditions and critical investment conditions, we obtain:

$$F(Y_f) = V(Y_f) - I;$$

$$F_f(Y_f) = V_f(Y_f).$$

When solving equations (7) and (8), we obtain:

$$Y_f = \frac{\beta_1 \delta}{\beta_1 - 1} \frac{Ie^{rT}}{RY(Y_f - I)};$$

$$A = \frac{RY_f (1-e^{-rT})}{\delta Y_f};$$

When substituting $A$ and $Y_f$ into equation (5), the option value of the follower should be:

$$F(Y) = \begin{cases} 
\frac{RY_f (1-e^{-rT})}{\beta_1 Y_f} & Y \leq Y_f; \\
\frac{RY}{\delta}(1-e^{-rT}) - I & Y \geq Y_f.
\end{cases}$$

3.2.2. The Option Value of Leader’s Investment

Due to the insistence of the followers on their optimal investment strategy, they start investing at the time, namely $T_f$, when random demand shock $Y$ reach $Y_f$ for the first time.

We assume that $G(Y) = L(Y) + I$, where $L(Y)$ denotes the value of the leader’s option and $G(Y)$ – the total value including leader’s investment $I$. The leader’s investment value can be deduced from the following differential equation by means of the optimal Behrman equation $rG(Y)dt = E(dG(Y) + YRdt)$ combined with Itô lemma.

$$\frac{1}{2} \sigma^2 Y^2 G_{YY} + \alpha Y G_Y - rG + RY(1-e^{-rT}) = 0.$$  \hspace{1cm} (12)

The general solution is:

$$G(Y) = CY^\beta + DY^\beta + \frac{RY}{\delta}(1-e^{-rT}),$$

where: $\frac{RY}{\delta}(1-e^{-rT})$ is a special solution to equation (13); $C$ and $D$ are constants to be determined.

When $Y = 0$, the leader’s investment option value – $G(0) = 0$. Thus, $D = 0$ and equation (13) becomes:

$$G(Y) = CY^\beta + \frac{RY}{\delta}(1-e^{-rT}).$$

For the leader, when $Y = Y_f$, $G(Y) = F(Y)$ exists as the condition for matching the value:

$$CY^\beta + \frac{RY_f}{\delta}(1-e^{-rT}) = \frac{RY_f}{\delta}(1-e^{-rT}).$$

A solution to equation (15) is:

$$C = R\frac{\gamma - 1}{\delta Y_f^\beta}(1-e^{-rT}).$$

When substituting equation (16) into equation (14), the solution of the leader’s investment option value is:

$$L(Y) = \begin{cases} 
\frac{RY}{\delta}(1-e^{-rT}) - RY_f(\frac{Y}{Y_f})^\beta (1-e^{-rT}) - I, & Y < Y_f; \\
\frac{RY}{\delta}(1-e^{-rT}) - I, & Y \geq Y_f.
\end{cases}$$

Due to threat when entering the first one and the fact that the government would never permit monopoly gains in a competitive context, the investment threshold of the follower $Y_f$ when $L = F$, i.e.:

$$\frac{RY}{\delta} - RY_f(\frac{Y}{Y_f})^\beta (1-e^{-rT}) - I = 0. \hspace{1cm} (18)$$

There is no analytical solution, only a numerical solution to $Y_f$.

3.3. The Investment Value Model under Non-Competition Guarantee Context

Let $T_g$ be corresponding to non-competition guarantee $Y_g$ provided by the government and satisfies $T_g > T_f$ from a perspective of competitive investment. The followers will not be permitted to invest during period $t \in [T_f, T_g)$ due to the government’s guarantee, namely, the investment timing of the follower is postponed from $t = T_f$ to $t = T_g$. Thus, at $t \in [0, T_g)$, the leader obtains monopoly gains; at $t = T_g$, the follower invests; at $t \in [T_g, \infty)$, the leader and follower operate simultaneously. According to value matching condition $L_g(Y) = F(Y)$ at $t = T_g$, we can obtain the function of the leader’s investment value under the government’s non-competition guarantee as follows:

$$L_g(Y) = \begin{cases} 
\frac{RY}{\delta}(1-e^{-rT}) - RY_g(\frac{Y}{Y_g})^\beta (1-e^{-rT}) - I, & Y < Y_g; \\
\frac{RY}{\delta}(1-e^{-rT}) - I, & Y \geq Y_g.
\end{cases}$$

The main purpose of the government offering the non-competition guarantee is to encourage investors to invest as soon as possible. Therefore, before investing, every investor has the intention of investing first when investment threshold comes. Let $Y_{Y_g}$ to be the investment threshold of the leader under the government’s guarantee of non-competition. Apparently, $Y_{Y_g}$ corresponds to $L(Y_{Y_g}) = F(Y_{Y_g})$, which can be simplified as:

$$\frac{RY}{\delta} - RY_g(\frac{Y}{Y_g})^\beta (1-e^{-rT}) - I = 0. \hspace{1cm} (20)$$

There is no analytical solution, only a numerical solution to $Y_{Y_g}$.
3.4. A Model for the Non-Competition Guaranteed Value

The non-competition guaranteed value is the difference between the leader’s project value under the guarantee and that without the guarantee. By means of equation (19) minus (17), the value of the non-competition guarantee is:

\[ V_g(Y) = \begin{cases} 
R(Y - Y_f) - Y_g \frac{1 - \gamma}{\delta} (1 - e^{-rT}), & Y < Y_f; \\
R(Y - Y_f) - \left(\frac{Y}{Y_g}\right)^{b_1} \frac{1 - \gamma}{\delta} (1 - e^{-rT}), & Y_f \leq Y < Y_g; \\
0, & Y \geq Y_g.
\end{cases} \]  

Equation (21) indicates that the value of the non-competition guarantee is affected not only by competition, but also by the non-competition guarantee.

4. Analysis

This section mainly analyzes the impacts of guarantee level \( Y_g \), the rate of increase and the volatility of traffic flow on the value of the non-competition guarantee. We also investigate the incentives of the guarantee level on the leader’s investment.

4.1. The Guaranteed Value with Respect to the Non-Competition Guarantee Level

In equation (21), the derivative of \( V_g(Y) \) with respect to \( Y_g \) is denoted as follows:

\[ \frac{dV_g}{dY_g} = \begin{cases} 
(\beta_1 - 1)R(Y - Y_f) - \frac{1 - \gamma}{\delta} (1 - e^{-rT}) > 0, & Y < Y_f; \\
0, & Y \geq Y_g.
\end{cases} \]  

This indicates that the value of non-competition increases as the level of the guarantee goes up within a certain scope. Notably, there is a cap for the guarantee level, which means that the value of the guarantee cannot keep increasing by pushing up the guarantee level unlimitedly. From a perspective of constraints on the concession period, \( T_g = \inf\{t | Y(t) \geq Y_g\} \) exists; thus, the value of non-competition increases as the level of the guarantee goes up only at \( T_g \leq T \). From the perspective that the toll road project has limited traffic load, when \( Y_g \) exceeds the maximum traffic load, an excessive emphasis on the non-competition guarantee without permission of new similar projects will lead to the development that does not meet demand for economic growth, which is not realistic.

4.2. Investment Incentives of the Non-Competition Guarantee

Investment threshold is a key parameter for investment decision making. Investment in the project will become feasible only when the initial value of the project (such as the initial traffic flow, the initial revenue flow and other indicators) is not less than investment threshold. In toll road projects, with a certain charge standard, traffic flow is one of the important determinants of investment revenue. The investors will consider about investment only if traffic flow exceeds a certain level. In the absence of an analytical solution to the investment threshold of the leader (equations (18) and (20)), we analyze numerically the impact of different guarantees of the government on the investment threshold of the leader. Fig. 3 displays some basic parameters, including risk-free interest rate \( r \) which is initially 0.07 at \( t = 0 \), the expected growth rate of \( \mu \) which is 0.03, variance \( \sigma^2 \) which is 0.09, charge for per vehicle \( R \) which is 73 CNY, concession period \( T \) which is 25 years, investment cost \( I \) counting 2.28 billion CNY and the shunting coefficient \( \gamma \) of the follower which is 0.5.

As can be seen from Fig. 3, under the non-competition guarantee, only single investment threshold may exist, which is independent from revenue flow. For the leader, if revenue flow is below investment threshold, it is rational not to invest until revenue flow exceeds investment threshold; if given the government’s non-competition guarantee, investment threshold will decrease as the level of the guarantee increases. The latter situation demonstrates that, when the initial revenue flow is below investment threshold, the government reduces the threshold of revenue flow by means of offering the non-competition guarantee, and thus encourages investment in projects.

On the other hand, notably, a reduction in investment threshold is gradually flating as the level of the guarantee increases, which implies that an excessive increase of the guarantee level would not produce an additional incentive. In fact, besides the concession period and maximum traffic load, there are two factors determining the level of the guarantee: first, excessive competition would result in a waste of resources, whereas in contrast, when a single project is unable to meet demand, an excessive stress on investment incentives for the non-competition guarantee of the leader investor is bound to harm the interests of consumers. However, this is a non-rational decision like one to put the cart before the horse.

Second, considering the characteristics of project financing, if the revenues of the project were too low to
fulfil repayment, even low investment threshold would become unattractive for investors with the intention of financing a project. Therefore, the government’s guarantee should aim at ‘no excessive competition’ which is of strong practical significance to simulate investment by the non-competition guarantee with the premise of the reasonable extent of competition.

4.3. Non-Competition Guaranteed Value with Respect to Traffic Flow

The expected growth rate and volatility are two key factors describing changes in traffic flow. When given settings for certain parameters, we analyze numerically how the expected growth rate and volatility of traffic flow make an impact on the value of the non-competition guarantee.

Fig. 4 illustrates the dependence of the guaranteed value on volatility. Fig. 4 shows that non-competition guarantee $Y_g$ is equal to 9 million vehicles, and the other necessary parameters are the same as those in Fig. 3. Fig. 4 indicates that when the other parameters are constant, the value of the non-competition guarantee improves as the expected growth rate goes up. Holding the expected growth rate, the value of the non-competition guarantee also increases as the initial traffic flow increases. Even though the government does not incur any payment or liabilities resulting from offering the guarantee, the value of the non-competition guarantee exists objectively and is affected by traffic flow, which should be taken into account when evaluating the value of the non-competition guarantee scientifically.

Fig. 5 illustrates the dependence of the guaranteed value on volatility where all parameters are the same as in Fig. 4. Fig. 5 shows other related parameters of how the value of the non-competition guarantee decreases as volatility increases, which is clearly different from the general situation that the value of real options increase as its volatility increases. A reasonable explanation may be that along with high volatility, traffic flow is more likely to reach the level of non-competition provided by the government, which reduces the effectiveness of the non-competition guarantee and further decreases its value.

5. Conclusions

The non-competition guarantee has been widely used for financing toll road projects and has an important impact on investors’ decision-making. This paper constructs a model for evaluating the value of the non-competition guarantee by the adoption of the options game theory and develops the measurement approach to the value of the government guarantee. Theoretical derivation and numerical analysis show that:

1) the value of the non-competition guarantee increases as its guarantee level increases;
2) the non-competition guarantee plays an important role in simulating investment by reducing investment threshold of investors (it promotes investors to invest as soon as possible and further helps with fulfilling infrastructure project successfully);
3) an increase in the rate and volatility of traffic flow both have a strong influence on the value of the non-competition guarantee (specifically, the value of the non-competition guarantee increases as the rate of increase goes up and decreases as volatility increases).

The non-competition guarantee by the government taking into account the project of toll transport plays a fundamental role in investment incentives. However, considering traffic load, constraints on the concession period, requirements for minimum revenue flow and avoidance of an excessive guarantee, we cannot lay too much emphasis on the role of the non-competition guarantee. Only with the premise of no excessive competition, the non-competition guarantee is of practical significance.

Acknowledgements

The authors are grateful for financial support from the National Natural Science Foundation of China, under the numbers of grants 70773091 and 70702013. We are also grateful for financial support from the Ministry of Education, Humanities and Social Sciences project, under grant number 10YJC630377.
References

Amram, M.; Kulatilaka, N. 1998. *Real Options: Managing Strategic Investment in an Uncertain World*. Oxford University Press. 246 p.

Banister, D. 2006. *Unsustainable Transport: City Transport in the New Century*. Routledge. 304 p.

Brandao, L. E. T.; Saraiva, E. 2008. The option value of government guarantees in infrastructure projects, *Construction Management and Economics* 26(11): 1171–1180. doi:10.1080/01446190802428051

Dixit, A. K.; Pindyck, R. S. 1994. *Investment under Uncertainty*. Princeton University. 476 p.

Doraszelski, U. 2004. Innovations, improvements, and the optimal adoption of new technologies, *Journal of Economic Dynamics and Control* 28(7): 1461–1480. doi:10.1016/S0165-1889(03)00112-X

Francis, P. N.; Björnsson, H. C.; Chiu, S. S. 2004. Valuing a price cap contract for material procurement as a real option, *Construction Management and Economics* 22(2): 141–150. doi:10.1080/0144619042000201349

Grenadier, S. R. 2005. An equilibrium analysis of real estate leases, *The Journal of Business* 78(4): 1173–1214. doi:10.1086/430858

Huisman, K. J. M.; Kort, P. M. 1999. *Effects of Strategic Interactions on the Option Value of Waiting*. Paper provided by Tilburg University, Center for Economic Research in its series Discussion Paper with number 1999–92. 41 p. Available from Internet: <http://arno.uvt.nl/show.cgi?&id=3964>.

Jones, E. P.; Mason, S. P. 1980. Valuation of loan guarantees, *Journal of Banking & Finance* 4(1): 89–107. doi:10.1016/0378-4266(80)90036-9

Kong, J. J.; Kwok, Y. K. 2007. Real options in strategic investment games between two asymmetric firms, *European Journal of Operational Research* 181(2): 967–985. doi:10.1016/j.ejor.2006.07.006

Shackleton, M. B.; Tsekrekos, A. E.; Wojakowski, R. 2004. Strategic entry and market leadership in a two-player real options game, *Journal of Banking & Finance* 28(1): 179–201. doi:10.1016/S0378-4266(02)00403-X

Smets, F. R. 1991. *Exporting Versus FDI: The Effect of Uncertainty, Irreversibilities and Strategic Interactions*. Technical Report. Yale University.

Smit, H. T. J.; Trigeorgis, L. 2006. Real options and games: competition, alliances and other applications of valuation and strategy, *Review of Financial Economics* 15(2): 95–112. doi:10.1016/j.rfe.2005.12.001

Wang, K.; Zhou, Y.-Q. 2006. Equilibrium real options exercise strategies with multiple players: the case of real estate markets, *Real Estate Economics* 34(1): 1–49. doi:10.1111/j.1540-6229.2006.00158.x

Zhang, G.-X.; Guo, J.-E.; Chai, G.-R.; Wang, X.-J. 2010. Using jump-diffusion modeling for valuing real options in infrastructure projects, *Frontiers of Computer Science in China* 4(2): 263–270. doi:10.1007/s11704-010-0509-1