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Core Model of the Forestry Investment Project Decision Support System Based on the Real Option

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Abstract

The forestry investment project has the typical characteristics such as the flexibility, phases, uncertainty, and so on, and needs reasonable applicable decision method and decision support system. The traditional forestry investment project evaluation mostly adopts the net present value method, and ignores option property of the forestry investment project, which is easy to cause the decision-making bias and erroneous judgment. This paper analyzes the real option characteristics of the forestry investment project from the perspective of real option, constructs the analysis model of real option based on the binomial tree theory, and applies the instance to verify. The instance proves that forestry investment project decision will be more scientific based on the real option model. Finally, on the basis of this model, the forestry investment project decision support system is preliminarily studied.

***Keywords**: forestry investment project, real option, binomial tree pricing, decision support system.*

1. Introduction

Forestry industry is one of the important components of national economy as well as one of the important basic industries in our country. In recent years, our country has been strongly supporting and propelling the forestry industry, which makes the forestry investment project increase sharply, presents the new trend of the investor diversification and the management form diversification.

The forestry project investment is a relatively complex process. First of all, investors need to collect a large number of basic data with respect to development, operation, management, and etc. of the forestry project. Secondly, the basic data are arranged and analyzed by applying the proper forestry project investment model according to the strict forestry project investment theory, which can provide effective decision information support for the investors. Finally, the investors need to make a decision according to the results of the data processing.

There are many shortcomings of the current forestry project investment. First of all, the forestry investment project has the characteristics of typical flexibility and uncertainty which are the characteristics of option to be given. The dynamic changes of the environment require the decision maker to consider the uncertainty of the project in future when making decisions. Traditional project evaluation methods such as net present value (NPV) and return on investment (ROI) are suitable for the static environment, don't consider the uncertainty of project in the future, and ignore the value from the future uncertainty for the project (Wei jun[1], et al. 2006). It is difficult to accurately evaluate the forestry investment project value on the whole in the scientific and objective manner, which is easy for investors to make wrong judgment. Secondly, forestry project investment doesn't have a set of molding decision support system, and lacks effective tools, which brings inconvenience to decision-making investors. Therefore, it has

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important theoretical and practical significance to study the investment model which is suitable for the forestry project and then to design a decision support system which is suitable for forestry investment project.

2. Forestry Investment Project Features and Option Characteristics Analysis

2.1 Definition of Forestry Investment Project

Forestry investment project is mainly divided into public welfare forest, commercial forest and compatibility forestry (《Chinese forestry development road》 research group[2], 1992) according to the difference of its function and investors. The public welfare forestry includes shelter forests and the forest for special purposes, and its investment is mainly from the nation. It refers to maintenance and improvement of the ecological environment, protection of the ecological balance and biodiversity, and so on for meeting the ecological and social demand. It regards the sustainable development as the main function. In addition, it mainly provides the forest, woods and forest land of public welfare and social products or services.

The commercial forest industry includes the timber stands, economic forests and firewood forests, and its investment is generally from the social capital. It is market-oriented. Moreover, it provides the forestry products, seeks to the maximum economic value, and focuses on the economic benefit. It is dominated by the use of wood and other forest products. The compatibility forestry refers to the transitional forestry which lays equal stress on the timber production and ecological service. The forestry project value includes the economic benefit, ecological benefit and social benefit. This paper mainly focuses on the economic benefit of forestry projects, namely, pursuing the maximization of economic value, but ignores the ecological sustainable value and social value of the forestry project, hence, the forestry project which appears in the article refers in particular to the commercial forest project.

2.2 Characteristics of Forestry Investment Project

The forest trees are the main investor of the forestry investment project, which is one kind of the natural living, grows in the natural environment, and makes the project gradually achieve value-added target after a long period of cultivation and growth. Therefore, the forestry investment project not only has the general characteristics of investment projects, but also has its own unique characteristics (Wei jun[3], 2013). They are mainly manifested in the four aspects as follows.

2.2.1 Uncertainty: Firstly, forestry investment project has natural exposure, and is vulnerable to be affected by the natural phenomena such as plague of insects, fire disaster, drought, freeze-up disaster, and so on. Those natural disasters and biological disasters not only happen frequently, but also have the truculency, which would cause the great uncertainty of the forestry projects earnings. Secondly, forestry investment project generally has a longer period. Generally speaking, the complete life period of a forestry investment project is about 15 to 30 years. In such a long period, the development of science and technology, the change of market environment, imbalance of the relation between supply and demand will all cause the price fluctuation of the forestry products, and thus result in the uncertainty of project value. Again, when making the policy with respect to the forestry industry, the government not only considers the economic benefit of forestry, but also considers ecological benefit and social benefit due to the multiple benefit function such as economy, ecology, society, and etc. of forestry. Moreover, according to the development of social economy, the government will constantly adjust forestry policy. For example, forest cutting quota policy is issued by the Chinese forestry department, and its cutting index changes every year. The policy limits the complete right to control the forestland for the project constructers, which doesn't only make the project constructers carry out the evaluation of project value and management of project with the goal of maximum project economy. This will result in the uncertainty of forestry project investment earnings.

2.2.2 Irreversibility: Forestry project, compared with other projects, needs huge capital invested in the earlier stage, and the capital is mainly used for afforestation and the construction of infrastructure. Once the capital is invested, that will form the completely "sunk cost", and it is difficult to recycle (Liang hehong[4], et al. 2009). Hence, the investment has the irreversibility. In addition, the period of the forestry project investment is longer, and the effect is slower. When the capital is invested, it will need more than ten years, even decades to recover the cost and gain benefits. And the liquidity of project asset is poor, which also can be regarded as the investment irreversibility.

2.2.3 Natural increment: It is the greatest difference between forestry projects and other projects that forest project has natural increment, which is decided by the regeneration increment of the forest resources. Once the investors invest the forest resources and possess them, they can not only benefit from the timber trade, even if they don't trade, but the forest trees are also continuously value-added under the role of the nature force after the forest resources are planted. Unlike other assets, if they aren't operated and used, they will be worthless and even depreciatory.

2.2.4 Managerial flexibility:"Managerial flexibility" means that when the project is carried out, the investors have the right to select or change the investment strategy, operation policy, and etc. so as to seek to the maximum project value according to the change of market, demand, and so on. The management flexibility of forestry investment project is determined by the forestry project features. These factors such as the longer project period and more uncertainty factors may not be fully reflected in a short period of the time. But as the project progresses, the role of the influence factors may be gradually clear, the uncertainty of much more information will reduce gradually, and even would be eliminated. Therefore, it is needed that project managers should not only fully consider and evaluate the risks and opportunities which are brought by these uncertainties when the project is initially decided, but also with the project proceeding, should adjust their operating decision according to the occurrence and change of uncertain risk.

2.3 Real Options Types and Option Value Analysis in the Forestry Investment Project

Forestry investment projects need undergo a period of rather long time from start to finish, and all contain the above mentioned four properties in the rather long project life cycle. This paper analyzes the real option forms corresponding to the above mentioned four properties in detail by applying real options theory, finds the real option types corresponding to each characteristic, and analyzes the values which are formed by the real option.

2.3.1 Real Option and its Value Corresponding to Uncertainty: Because the forestry project has uncertainty, the major measure adopted by the investors for the project uncertainty is adjusting the project scale, and deciding the project scale according to the external environment. If the project proceeds in accordance with the expected plan, the project should keep the original production scale. But if the market is in great demand and has a good prospect, investors can expand the scale of the project in order to gain more profit. In addition, when the market demand is less and the market is in the downturn, if continuing to run the project with original scale, it will be caused that the business cost is greater than the profits. Moreover, at this time, holding the original scale will inevitably lead to loss and be bad for management, therefore, the investors may be appropriate to reduce the project scale, reduce operating cost, and ensure benign operation of enterprise. When the market environment is not good, the company faces the risk of huge losses. It is difficult to reverse for the project investment in the early stage, and downsizing has been unable to reduce losses or doesn't make sense, consequently, the enterprise can consider to give up the project, and obtains the residual value from the abandoned project, which can make the loss to a minimum. The scale change is embodied most obviously in this characteristic, so the uncertainty characteristic of forestry investment project has the option with the scale change. The option whose scale is expanded amounts to a call option, the option whose scale is shrunk amounts to a put option, and abandoning option can be regarded as put option of the project（[America]Han T.J.Smit[5]et al.，2006）.

Table 1. Expansion and Narrowing of Options

Variable	Project	Call option	Put option
e%(c%) of V	Part of the project value	*e%* share price	*c%* share price
I	Present value of the additional investment cost	Exercise price	——
R_C	Current replacement value	——	Exercise price
T	Delay time length	Expiration time	Expiration time
R	Time value of currency	Risk-free interest rate	Risk-free interest rate
∂^2	Project earnings fluctuation	Variance	Variance

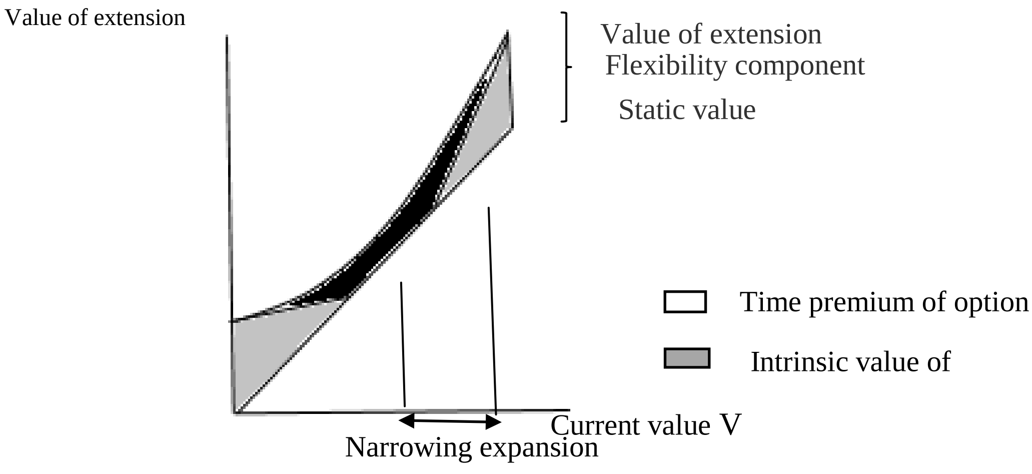


Figure 1. Expansion and Narrowing of Options

It is the foundation for generating the expansion option and narrowing option that the investors change the project scale and choose the decision that is the most beneficial to the project development according to the dynamic change of the market situation. Therefore, compared with the traditional evaluation manner which doesn't consider the dynamic change, they can generally increase the project value. As shown in Figure 1, the shadow part is the increased value of project by comparing with the traditional evaluation manner. If ignoring the value of this part according to the traditional evaluation manner, they would make a wrong decision that this project shouldn't be invested. In consideration of the expansion and contraction options, the project value is expressed as follows.

Project value = net present project value + expansion option value or shrinkage option value

Table 2. Abandonment Option

Variable	Project	Put option
V	Present value of cash flow	Share price
A	Resale value	Exercise price
T	Deferred time length	Due date
R	Currency time value	Risk-free interest rate
∂^2	Project income fluctuation	Variance

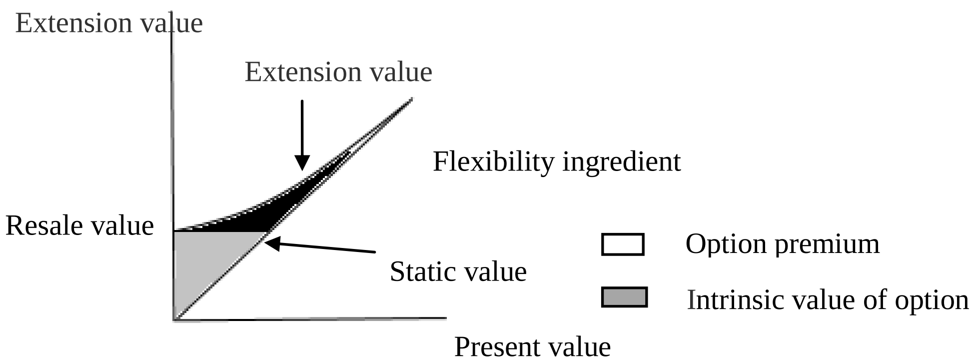


Figure 2. Abandonment Option

Compared with the traditional evaluation way, the value of the abandonment option project increases. And the increased value is the intrinsic value of the option and the option premium, namely, the resale value of the project and increased value of project in the operation period. But traditional evaluation way ignores this part of the value, when judging the project value, the wrong conclusion that $NPV < 0$ will be obtained. In addition, the project value in consideration of the abandonment option is as follows.

Project value= net present project value + abandonment option value

2.3.2 Real option and its Value Corresponding to Irreversibility: The irreversibility of forestry investment project requires the investors to choose the best investment opportunity and to carefully invest their money. Compared with other projects, the handling method of the investors for the unrecyclable project is generally to delay project investment until the project reaches the optimal investment opportunity. So investors have the right for deferred investment, and this right is equivalent to call option of the project.

Table 3. Deferred Option

Project	Variable	Call option
V	Present value of expected cash flow	Share price
I	Present value of the investment cost	Exercise price
T	Length of deferred time	Due date
R	Time value of currency	Risk-free interest rate
∂	Fluctuation ratio of project earnings	Variance of stock yield

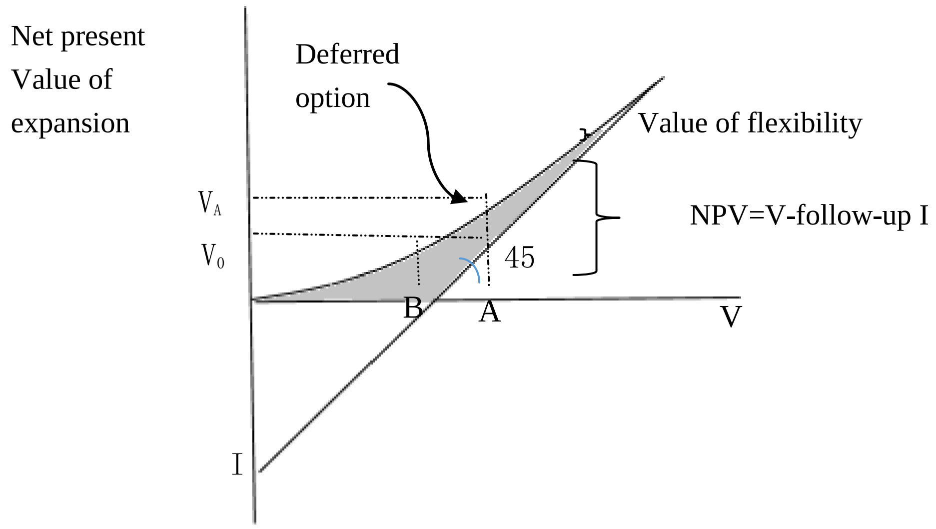


Figure.3 Deferred Option

If the deferred option is considered by the comparatively traditional evaluation manner, the project value will be more accurately evaluated, and the investment opportunity will be seized. It is assumed that the point of deserving investment is point A and the project value is V_0, after considering the deferred option, the point of deserving investment is point B and the patulous net present value is V_0 under the traditional evaluation way. But the NPV is negative value under the traditional evaluation way, the project is not worth investment. It is concluded that deferred rights evaluation method can better seize the investment opportunity and seize the best investment time by comparing the two types of evaluation manners. Under the competitive market environment, if the best investment opportunity isn't seized, it is likely to lose the competitive advantage. The forestry investment project can help investors seize the best opportunity for investment and create better development environment for the project. In consideration of the deferred option, the project value is expressed as follows.

Project value = net present value of immediate investment project+ deferred option value

2.3.3 Real Option and its Value Corresponding to the Natural Increment: Forest resource has the regenerative increment, which is the most important characteristic that forestry investment project is different from other projects. Natural growth of trees need investors to compare the market environment with the intrinsic value of forest trees. Hence, investors should sell the timber assets when the market environment and forest intrinsic value reach the optimum as a whole (Yang chunpeng[6], et al., 2005). The situations will be possibly faced in the process of future operation as follows. Market environment is very good, but the trees haven't grown to a certain specification, and the project investors may choose to give up the deal for keeping trees unceasingly growing and waiting for the optimal opportunity of the market environment and intrinsic value of the forest trees as a whole. Natural increment of the forest trees can make the inherent value of forest trees increase with the time increasing. The investors have the right to keep trees unceasingly growing and have a deal in the future. It is a kind of growth option that the right is to make a decision in the early stage and then obtain the opportunity in future, which is equivalent to a call option for a project. The project value of growth option is as follows.

Project value = net present value of project + growth option value

2.3.4 Real Option and its Value Corresponding to Management Flexibility: The essence of management flexibility is the conclusion of options which are brought by the uncertainty, irreversibility and natural growth, because no matter what kind of the feature is, all require investors to choose investment strategy flexibly. Management flexibility gives investors the right to choose the most advantageous decision-making for the enterprise according to the present situation, and it is amounted to an option behavior that the investors have the variable operating strategy (management flexibility) (Zeng yong[7], et al., 2007). On investment opportunity, the cycle of forestry investment project is longer, so the uncertain factors is more, and these factors can't be completely embodied in a short period of time. But the influence factors will be gradually clear as the time delays (Huang shanqin[8], 2013), the uncertainty of lots of information would lower, at the moment, it is more sensible to make a decision. Hence, investors can choose investment opportunity flexibly, namely, have the deferred option, which corresponds to the call option of projects. Similarly, in the process of project implementation, the investors have the investment strategy of "management flexibility", just like option contract in the financial market, investors can choose the strategy which is the most beneficial to project development according to the market situation. When the market conditions are good, the investors may choose the strategy to expand business, on the contrary, when the market conditions are bad, they can choose investment strategy to contract. The choice of investors for the strategy is equivalent to owning the expansion option, contraction option, and abandonment option, which corresponds to the call option or put option. The types of options according to the characteristics of forestry project are listed in Table 4.

Table 4. Options Category Based on Projects Feature

Characteristic	Corresponding options
Uncertainty	Expansion option, narrowing option, abandonment option
Irreversibility	Deferred option
Natural growth	Growth option
Management flexibility	Deferred option, expansion option, narrowing option, abandonment option

3. Construction of Forestry Project Evaluation Model based on the Real Option

3.1 Binomial Tree Pricing Model

At present, there are recognized two main types of real option pricing methods, namely, B-S pricing model and binomial tree pricing model(Yao mei[9], 2009). Because forestry projects have the uncertainty, irreversibility and natural increment and management flexibility, correspondingly, the forestry investment project decision-making has complexity, periodicity and dynamic nature. The binary tree pricing method can more embody the dynamic nature of choice, conforms to the characteristics of forestry investment project, and therefore is more suitable for building the evaluation model of forestry options by analyzing and comparing the B-S pricing model and binomial tree pricing model.

3.1.1 Binomial Model (taking the two-step binary tree model as an example): It is assumed that the current stock price is S_0, upstream price multiplier is u, downstream price multiplier is d, (in order to ensure that the standard deviation of the annualized rate of return is unchanged, both u and d can be speculated according to the standard deviation of the continuous compound interest rate of return of the underlying asset, specifically, $u = e^{\partial\sqrt{t}}, d = \frac{1}{u}$, where ∂ is the continuous compound interest rate of return of the asset, standard deviation, t is a period of time), and the binary tree model of the underlying asset ([British] Jamie Rogers[10], 2003) is obtained as follows.

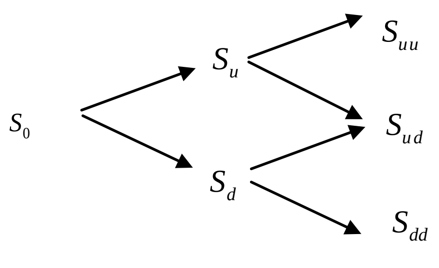


Figure 4. Binomial Model of Underlying Asset

The current price of call option is f_0, risk-free interest rate is r, risk neutral probability is p, and exercise price is X. The binomial model of the option value is concluded as follows.

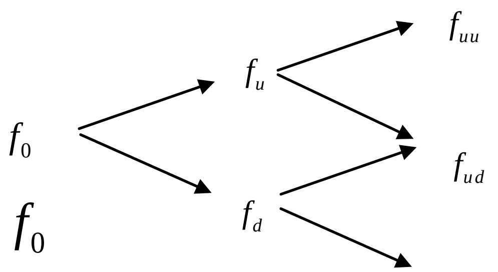


Figure 5. Binomial Model of Options

The initial value of option can be regarded as expected value discount of the option on the due date, initial value of options can be derived from back to forward.

Table 5. Two-step Binomial Model

Phase	Option
phase III	$f_{uu} = Max(\mathrm{X} - S_{uu}, 0)$ $f_{ud} = Max(\mathrm{X} - S_{ud}, 0)$ $f_{ud} = Max(\mathrm{X} - S_{dd}, 0)$
Phase II	$f_u = [p * f_{uu} + (1-p) * f_{ud}] * \mathrm{e}^{-rt}$ $f_d = [p * f_{ud} + (1-p) * f_{dd}] * \mathrm{e}^{-rt}$
Initial phase	$f_0 = [p * f_u + (1-p) * f_d] * \mathrm{e}^{-rt}$

So the initial value of the option is $f_0 = [p * f_u + (1-p) * f_d] * \mathrm{e}^{-rt}$.

3.1.2 Binomial Model Parameters: The period of time from the initial time to the due date of option are divided into n (n > = 3) equal time segments, cycle is T, and C_T is for calculating its option value. The parameters are needed in binomial model as follows.

Table.6 Basic Parameters

Parameter	Variable
Calculate option value	C_T
multiplier of future value rise	u, The corresponding option price is C_T^+
multiplier of future value fall	d, The corresponding option price is C_T^-
Risk-free interest rate	R
Probability of value rise under the risk neutral state	p
Fluctuation ratio of value	∂

Relationship among the parameters：

$$u = e^{\partial\sqrt{t}}, d = \frac{1}{u}, p = \frac{e^{r\partial t} - d}{u-d}, C_T = [\mathrm{p} * C_T^+ + (1-\mathrm{p}) * C_T^-] * e^{-rT}$$

3.2 Pricing Model of the Forestry Investment Project

The pricing model of forestry investment project is based on the binomial model, for the forestry investment projects, in any one node, the project may face a variety of choice, so has different options. Therefore, the model parameters are expanded on the basis of the binomial model, which make it more in line with the characteristics of forestry investment project.

3.2.1 Parameters Set According to the Forestry Project Investment Characteristics:

Table 7. Parameters in Forestry Investment Project

Project	Variable
The initial value of project assets	V_0 （Present value of future cash inflow）
The project assets value In different stages	$V_T = V_{T-1} u^x d^{(T-x)}$
The scale factor of expansion	$e\%$
Expansion cost	I
Narrowing scale factor	$c\%$
Narrowing balance	R
Liquidation balance	A
The holden option value in different stages of the project	$C_T = [p * C_T^+ + (1-p) * C_T^-] * e^{-rT}$ (C_T^+ is the rise option value of project value, C_T^- is the decline option value of project, both rise and decline options of project in the node are reflected in the next phase.)
Project expansion option value	$e\% * V_T - I$
Project narrowing option value	$R - c\% * V_T$
Project abandonment option value	$A - V_T$

3.2.2 Decision rule: Forestry investment project generally has a longer cycle, therefore, it is needed to consider that each stage has its own option in different stage of the forestry investment project. Decision-makers inevitably choose the most advantageous way for project development in the future in a certain node, namely, the operating may with the greatest option would be chosen in much more options. Different projects in different stages have different types of options, different options can affected each other (Tian ye[11], 2007), and each node has its own rule, consequently, specific project needs specific analysis.

4. Model Instance Analysis (Demonstration base of the Jatrohpa curcas L. bio-diesel raw material in Sichuan)

4.1 Basic Situation of Project and Evaluation of Net Present Value

4.1.1 Basic Project Situation: This paper takes Jatrohpa curcas bio-diesel raw material demonstration base construction in Sichuan province as an example. Jatrohpa curcas is the main raw materials of biomass liquid fuel which is energetically developed by our country. This project plans to construct 200000 mu Jatrohpa curcas demonstration base, a total investment of 90.4435 million yuan, started in 2007, a total of 15 years, and the construction for two years. According to the market situation, the deferred time allows for 1 year.

Jatrohpa curcas can produce fruit after the growth for two years, which can make this project enter the period of initial production. Then the production increases year by year, and can enter the period of abundant production after five years. That can reach raw materials for producing yearly 70000 tons of biomass diesel .The main income of this project comes from biomass fuels, so the project value is affected by the price of oil hole. With the oil price fluctuations, the several situations may appear as follows.

Under higher oil price and better market situation, enterprises can expand the scale of Jatrohpa curcas production with the expanding cost of 75 million yuan. Under lower oil prices and the worse market situation, the enterprise can reduce the scale of Jatrohpa curcas production. The recycling cost narrowing is different in different periods, 4.08 million yuan in construction period, 22.22 million yuan in initial production period , 38.58 million yuan in the abundant production period. If oil price falls to a certain price, the production of biomass fuel will have no profit. Moreover, this project will lost comprehensively, it is needed to abandon all assets. At this moment, Jatrohpa curcas demonstration bases are sold, which can obtain the salvage value income. And that is also related to project cycle, 50 million yuan in initial production period, 80 million yuan in abundant production period, shown as follows.

Table 8. Cost of Jatropha Curcas Raw Material Forest

	Construction period	Initial production period	Abundant production period
Expansion cost	7500	7500	7500
Narrowing cost	408	2222	3858
Abandonment cost	____	5000	8000

4.1.2 Evaluation value of project net present value: Cash flow of this project for fifteen years is shown as follows.

Table 9. Cash Flow of Project

Cash Flow (unit wan yuan)							
	1	2	3	4	5	6	7
Cash inflow	488.7	488.7	2168.7	4693.7	7213.6	8893.6	8893.6
Cash outflow	9160.9	722.4	1333.7	4078.2	5920.9	7150.8	7150.8
Net cash flow	-8672.2	-233.7	835	615.5	1292.7	1742.8	1742.8
Accumulative net cash flow	-8672.2	-8905.9	-8070.9	-7455.4	-6162.7	-4419.9	-2677.1

8	9	10	11	12	13	14	15
8893.6	8893.6	8893.6	8893.6	8893.6	8893.6	8893.6	8893.6
7150.8	7150.8	7150.8	7150.8	7150.8	7150.8	7150.8	7150.8
1742.8	1742.8	1742.8	1742.8	1742.8	1742.8	1742.8	1742.8
-934.3	808.5	2551.3	4294.1	6036.9	7779.7	9522.5	11265.3

Discount rate of forestry project: k =12%, Risk-free interest rate: r =4.61%

V = present value of cash inflow =73.06(million)

I = present value of cash outflow =85.03(million)

$NPV = V - I = 73.06 - 85.03 = -11.97$ (million), the net present value of project is -11.97million.

4.2 Evaluation of Project Value based on Real Option

4.2.1 Kinds of Project Options and Value Analysis

4.2.1.1 Kinds of Project Options: According to the project plan, the executive cycle of this project is 15 years, including 2 years construction period,3 years initial production period, 5 years abundant production period (earlier stage),and 5 years rich period(later stage). The analysis for various periods is shown as follows.

Project construction phase:

Investment for the forestry project aims to obtain continued operation value, rather than short-term arbitrage. So the special circumstances such as selling the project to earn price differences by investors and so on at this stage. At the same time, construction period produces deferred options for the choice of investment opportunity. To conveniently research, the deferred options in this phase will be discussed separately, and the effect of the investment opportunity choice on the projects is studied separately. Ignoring above two factors means that the investors set on foot independent investment construction immediately after the successful establishment of project.

During project construction phase, investors can flexibly expand, shrink or keep original scale, and easily change scale, hence, this phase has expand option, narrowing option, and continuation holding option.

Initial production period of project:

In the initial production period, the decision space for the investors is larger due to the less Jatrohpa curcas seed yield, earlier cultivation as well as less investment. And the investor can flexibly adjust the scale of the project based on the market conditions, consequently, they can expand, shrink, keep and abandon the project. Therefore, this phase has the expansion option, narrowing option, continuation holding option, and abandonment option.

Maturation period of project (earlier stage)

According to growth rule of Jatrohpa curcas, the initial production period can reach for 2 years, and abundant production period for5 years. The project cycle is 15 years. If expanding the scale of the project at this stage, it can be ensured that the newly planted Jatrohpa curcas reaches the abundant production period before the end of the project and the investment obtain the greatest return. Hence, it is valuable to expand scale in this stage. As well as the initial production phase, this phase has the expansion option, narrowing option, continuation holding option, and abandonment option.

Maturation period of project (later stage)

If expanding the scale of the project at this stage, the newly planted Jatrohpa curcas can’t reach the abundant production period before the end of the project and the investment doesn’t realize the obvious economic benefit. Hence, it has little value to expand scale in this stage. This phase has the narrowing option, continuation holding option, and abandonment option.

According the above analysis, options of different periods for projects are shown as follows.

Table 10. Project Options

Phase	Kinds of options
Construction period	Expansion option, narrowing option, and continuation holding option
Initial production period	Expansion option, narrowing option, continuation holding option, and abandonment option.
Abundant production period (earlier stage)	Expansion option, narrowing option, continuation holding option, and abandonment option.
Abundant production period (later stage)	Narrowing option, continuation holding option, and abandonment option.

4.2.1.2 Option Value of Project: Starting from the project termination time, from the back to forward, option measurement builds compound option value successively. At each node, investors must choose the option with maximum benefit, therefore option value in each stage is shown as follows.

Table.11 Option Value of Projects on Various Stages

N Value	Period	Option Value
n =15	End period of project	$Max(A_2 - V, R_{C3} - c\%*V, 0)$
n =11-14	Abundant production period (later stage)	$Max(A_2 - V, R_{C3} - c\%*V, (\mathrm{p}*C_T^+ + (1-\mathrm{p})*C_T^-)*e^{-rt})$
n =6-10	Abundant production period (earlier stage)	$Max(A_2 - V, R_{C3} - c\%*V, I - e\%*V, (\mathrm{p}*C_T^+ + (1-\mathrm{p})*C_T^-)*e^{-rt})$
n =3-5	Initial production period	$Max(A_1 - V, R_{C2} - c\%*V, I - e\%*V, (\mathrm{p}*C_T^+ + (1-\mathrm{p})*C_T^-)*e^{-rt})$
n=1-2	Construction period	$Max(R_{C1} - c\%*V, I - e\%*V, (\mathrm{p}*C_T^+ + (1-\mathrm{p})*C_T^-)*e^{-rt})$

4.2.2 Parameters Value

4.2.2.1 Present Value of Underlying Assets: The above shows that the present value of underlying assets, namely, the net present value, is -11.97 million.

4.2.2.2 Estimation of Fluctuation Rate: There are three methods to be often used for the fluctuation rate of the project values: (1) In perfect market, looking for listed companies with the same project and using historical data of the company market value to approximately calculate programs value fluctuation rate. (2) Analyzing possible uncertainty factors in the project, using Monte Carlo to simulate project value fluctuation rate, calculating expected return of underlying assets, using standard deviation to represent fluctuation rate. (3) Assuming that the project product is the major factor that affects underlying assets, using production price fluctuation rate over the years to express project value fluctuation rate. After analysis of realistic feasibility over the three methods, this article adopts the third method. In this project, the production is the Jatrohpa curcas seeds, hence, price fluctuation rate of the Jatrohpa curcas seeds is used to replace the underlying project value fluctuation rate. In our country, the usage of biomass fuel is still in the initial stage, so the data statistics is incomplete. Selected J atrohpa curcas price in this paper is accordance with its market price over the years. Although the data is not authoritative enough, they still have the stronger representativeness.

Table 12. Prices of Atropha Curcas Over the Years

Year	2007	2008	2009	2010	2011
Price(yuan)	20	21	25	22	30

Project fluctuation rate is 18.64% according to the market price of Jatrohpa curcas seeds over the years. The risk-free interest rate chooses the five-year treasury rate r =4.61%

4.2.2.3 Other Parameter Values: According to building rules of the binomial tree model, the parameter values are obtained as follows.
Rising range of underlying assets $u = 1.2049$.
Falling range of underlying assets $d = 0.8299$.
Risk neutral probability $p = 0.5794$.

According to the market survey, project expansion factor e % is 50%, shrinkage factor c % is 50%.

Based on the above analysis, all model parameter values are shown as follows.

Table 13. Parameter Values

Parameter	value
Present value of underlying assets F_0	-11.97
Perform deadline T	15
Fluctuation rate ∂	0.1864
Rising factor u	1.2049
Falling factor d	0.8299
Risk neutral probability p	0.5794
Risk-free interest rate r	0.0461
Expansion scale factor $e\%$	0.5
Contraction scale factor $c\%$	0.5
Expansion cost I	75
Contraction cost (construction period) R_{C1}	4.07
Contraction cost (initial production period) R_{C2}	22.22
Contraction cost (abundant production period) R_{C3}	38.58
Recycling cost (initial production period) A_1	50
Recycling cost (abundant production period) A_2	80

4.3 Analysis Diagram of Underlying Assets Value and Option Value

4.3.1Diagram of Underlying Assets Value (V_T): According to the rising and falling factors, we can get underlying assets value table as follows.

Table 14. Value of the Underlying Assets

Time: n=0	1	2	3	4	5	6	7
70.93	85.46385	102.9757	124.0759	149.4996	180.1326	217.0426	261.5154791
	58.86775	70.93	85.46385	102.9757	124.0759	149.4996	180.1326412
		48.8568	58.86775	70.93	85.46385	102.9757	124.0759
			40.54828	48.8568	58.86775	70.93	85.46384963
				33.65271	40.54828	48.8568	58.86775428
					27.92978	33.65271	40.54828455
						23.18008	27.92977922
							19.23811515

8	9	10	11	12	13	14	15
315.1011	379.6666	457.4618	551.1977	664.1403	800.2254	964.1949	1161.762
217.0426	261.5155	315.1011	379.6666	457.4618	551.1977	664.1403	800.2254
149.4996	180.1326	217.0426	261.5155	315.1011	379.6666	457.4618	551.1977
102.9757	124.0759	149.4996	180.1326	217.0426	261.5155	315.1011	379.6666
70.93	85.46385	102.9757	124.0759	149.4996	180.1326	217.0426	261.5155
48.8568	58.86775	70.93	85.46385	102.9757	124.0759	149.4996	180.1326
33.65271	40.54828	48.8568	58.86775	70.93	85.46385	102.9757	124.0759
23.18008	27.92978	33.65271	40.54828	48.8568	58.86775	70.93	85.46385
15.96651	19.23812	23.18008	27.92978	33.65271	40.54828	48.8568	58.86775
	13.25127	15.96651	19.23812	23.18008	27.92978	33.65271	40.54828
		10.99778	13.25127	15.96651	19.23812	23.18008	27.92978
			9.127515	10.99778	13.25127	15.96651	19.23812
				7.575304	9.127515	10.99778	13.25127
					6.28706	7.575304	9.127515
						5.217892	6.28706
							4.330545

4.3.2 Diagram of Underlying Assets Option Value (C_T): According to option rules in various stages above mentioned,we can get different option values of this project in different stages.

Table.15 Compound Option Value

Time: n=0	1	2	3	4	5	6	7
13.21049	12.61184	13.62188	16.92998	23.20275	32.99622	46.894026	65.47645785
	15.5167	12.63523	10.59339	10.18925	12.31644	17.555366	26.55972313
		21.22576	16.86465	12.33818	8.40226	6.4821741	7.122503241
			29.61307	24.99058	19.14304	11.989227	6.327276302
				39.30111	35.84743	31.143205	21.13224572
					48.46594	46.347294	39.45171545

56.819916	52.07022078
	60.76188485

8	9	10	11	12	13	14	15
89.15633	118.2123	153.7309	0	0	0	0	0
40.20555	59.13675	82.55054	0	0	0	0	0
10.744	18.6407	33.52128	0	0	0	0	0
2.933403	1.072778	0.236142	0	0	0	0	0
11.71139	5.825086	2.345414	0.587871	0	0	0	0
31.1432	21.13225	11.27104	5.029172	1.463493	0	0	0
46.34729	39.45172	31.1432	21.13225	10.50432	3.643334	0	0
56.81992	52.07022	46.34729	39.45172	31.1432	21.13225	9.07	0
64.03349	60.76188	56.81992	52.07022	46.34729	39.45172	31.1432	21.13225
	66.74873	64.03349	60.76188	56.81992	52.07022	46.34729	39.45172
		69.00222	66.74873	64.03349	60.76188	56.81992	52.07022
			70.87249	69.00222	66.74873	64.03349	60.76188
				72.4247	70.87249	69.00222	66.74873
					73.71294	72.4247	70.87249
						74.78211	73.71294
							75.66945

The obtained initial option value of project is C_T =13.21(million)

4.4 Analysis for Deferred Option

From the above, it is known that this project allows for one-year deferred time, that is to say, the project has deferred option in construction period. By analyzing deferred option, the effect of investment opportunity on decision-making is discussed.

4.4.1 Rules of Option: In the first year, managers can invest immediately, and can also defer investment for one year.

$n=1$	$Max(V-I,0)$

4.4.2 Diagram of Underlying Assets Value (V_T):

Time: $n=0$	1
70.93	85.46385
	58.86775

4.4.3 Diagram of Option Value (C_T):

Time: $n=0$	1
0.237	0.42799
	0

The obtained original option value ($n=0$) is 0.237(million).

4.5 Analysis of Evaluation Results

4.5.1 Whole Process of Project (project is executed immediately after being established):

Through network diagram of the above options value, we know that the compound options value is 13.21 million yuan. According to the simple NPV rule, the $NPV = V - I = -11.97$ (million), the NPV is negative, which means the project is not worth investing. But in consideration of the uncertainty of forestry investment project, the option value is added into the project evaluation, and then the expanded $NPV = NPV +$ option value = 11.97 + 13.21 = 13.21 (millions) > 0, namely, project investment is profitable. The traditional net present value method underestimates value of this project, which can easily make wrong judgment for managers.

4.5.2 Analysis Results of Deferred Option: It is known through the model that project value with one-year deferred option is 0.237 million, $0.237 > -11.97$, which means that value of one-year waiting exceeds that of immediate investment. At this moment, the expanded NPV is calculated as: the expanded $NPV =$ -11.97+0.237< 0. Hereby, this project is not only $NPV < 0$, but also project value including deferred option value is still less than 0. A sensible investor would not invest immediately and continue to observe market situation, then analyze after waiting for a period of time. The instances prove that it can realize the more scientific investment for the forestry investment project to use the real option method. Hence, this kind of model should be preferentially adopted in order to ensure the accuracy of the decision in the construction of forestry project investment decision-making support system.

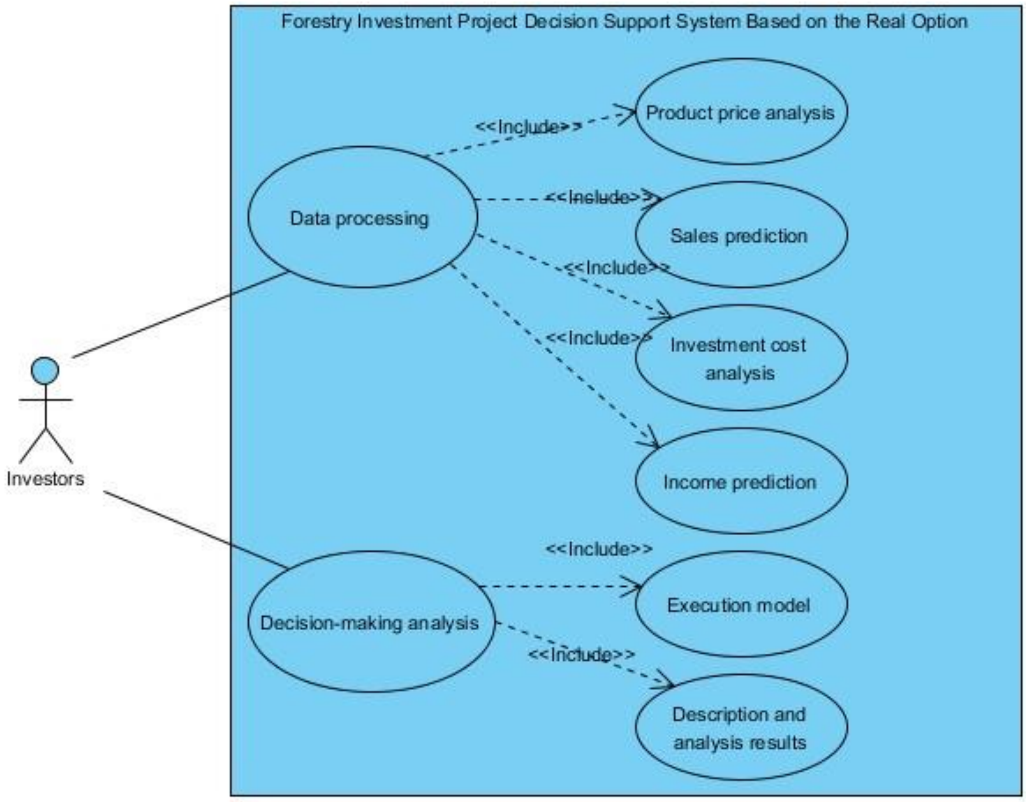
5. Construction of the Forestry Project Investment Decision-making Support System

The forestry project investment decision-making support system is structured from four aspects such as system function, system realization technology, system structure and system function module based on the above mentioned forestry project investment decision-making model.

5.1 Analysis of System Requirement

Currently, intelligent degree of information processing for the forestry project investment is lower. The most investors still use fundamental processing methods such as EXCEL, or text, etc. for the information processing method such as the project investment estimation, financial indicators calculation, project fluctuation ratio, market forecast and so on. These processing ways not only fail to fully excavate the value of information, simultaneously, they have the fault risk on the data processing. In addition, most investors can't select the appropriate investment model according to the characteristics of forestry investment project, which can lead to failing investments. The above two problems seriously affected the decision efficiency and decision quality of decision makers. Construction of forestry investment project decision support system can realize the intellectualization and scientization of the forestry project investment, and the system should have the features as follows.

Data processing functions: system can effectively manage lots of data such as forest product prices over the years, forest product sales, and so on of forestry project and be able to excavate and analyze basic data in depth.



Decision analysis functions: investors can apply the internal model of system for the project investment simulation, analyze the results of the model, and obtain the assistant decision support.

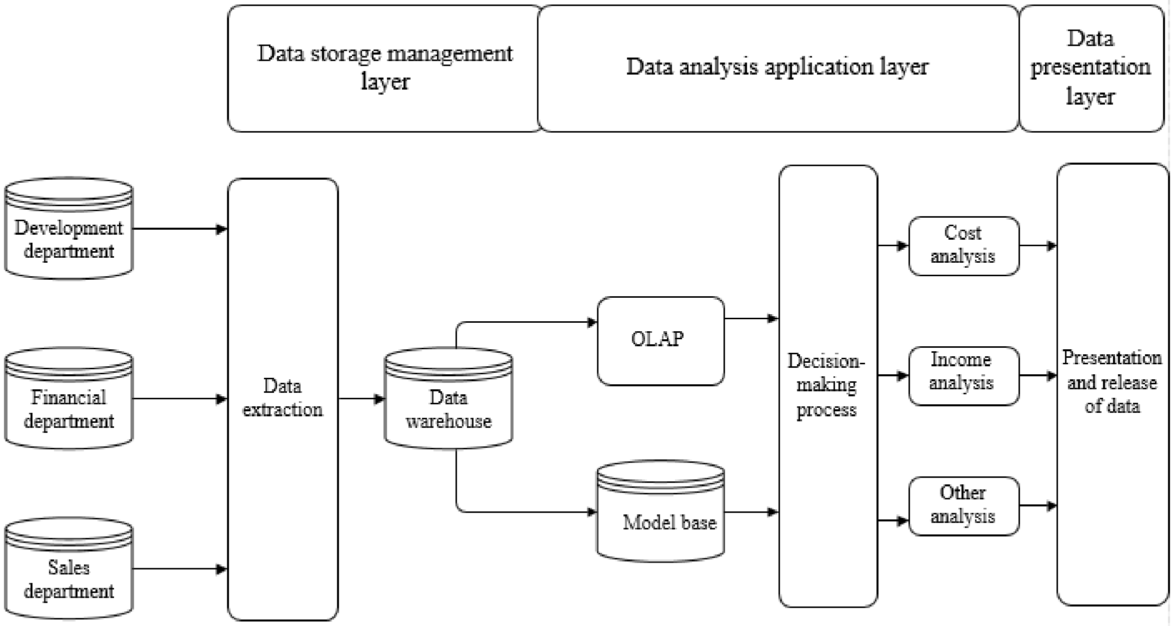
5.2 Realization of System Technology Research

Data warehouse technology is the core technology to construct forestry project investment decision-making support system, which has strong storage, analysis and integration capabilities. It can store vast amounts of the needed historical data, such as the price of forest products and the financial situation of project over the years, used in the process of forestry project investment. And it can also analyze the historical data according to the complexity and dynamic nature of forestry project investment process. Because the forestry investment process mostly faces the semi-structured question, the investors need to make decisions according to the data analysis result. Data warehouse technology can realize the integration of the data and model, provide information support for the semi-structured decision-making. However, the traditional database fails to reach these functions.

On-line analytical processing can carry on the multi-dimensional analysis, dicing, slicing and drilling and can excavate the information of data in different dimensions, which can provide multi-dimensional information support for decision makers and help decision makers synthesize all aspects of the factors to make a decision.

5.3 System Architecture Design

System design idea: scientific decision, practicality, timely feedback, and good human-computer interaction. System architecture: based on the system design idea, system must be able to realize three aspects of demand, namely, good human-computer environment, collection and arrangement of vast amounts of data, and semi-structured decision analysis. Based on the traditional decision support system architecture, decision support system structure of the forestry investment project is designed as follows.



5.4 System Function Module Design

In consideration of the investment process of forestry projects, forestry project decision support system is designed to have the following three functional modules: system management module, data management and measurement module, real option pricing module.

System management module: it can monitor and manage the whole system operation, coordinate each module in system, and can realize safe and reliable operation of system.

Data management and measurement module: it can complete basic operation of data, including the import, export, backups, query and etc. of data, simultaneously, it is able to summarize and analyze the data.

Real option pricing module: this module is constructed according to the forestry project investment model based on the real option in this paper, and is the core module of the decision support system. It can help investors calculate the real option value of forestry investment project, provide the decision-making information of the true value of project for investors, and assist investors for scientific decision-making.

6. Conclusions

This paper analyzes the option characteristics of forestry investment project in different stages, constructs the analytical model of real options of forestry investment project with binary tree model as the theoretical basis according to the characteristics of forestry investment project, takes the demonstration base of the Jatrohpa curcas L. biodiesel raw material in Sichuan as an example, and verifies the feasibility and scientificity of this model in the investment decision-making of forestry project. Moreover, based on this model, the investment decision support system of forestry project is preliminarily studied. Real option method is a fresh perspective to analyze the forestry investment project. It takes into account the uncertainty and flexibility of forestry investment project in future, and is able to evaluate the value brought by the flexibility and uncertainty of the project.

Moreover, it can overcome the malady of the evaluation methods of traditional projects which ignores the project uncertainty in the future, and can more accurately evaluate the real value of the project. The investment decision support system of forestry project based on the real option model can be more in line with the characteristics of forestry projects. And that can help investors more accurately grasp the investment opportunity, adapt to dynamic changes of market, flexibly choose investment strategy, and win greater economic benefits.

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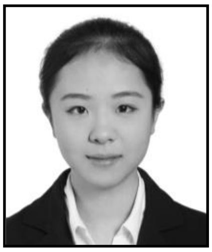

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