2011 3rd International Conference on Advanced Management Science
IPEDR vol.19 (2011) © (2011) IACSIT Press, Singapore

Risk management in forestry; Economics perspectives

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Abstract. Risk management of forest is an important issue. Forests managers are becoming increasingly risk averse and seeking tools and methods for manage the risk. The aim of this paper is to provide an overview of risk management in forestry, with a particular emphasis on economics perspectives. At this paper, different sources of risk in forest management will be discussed. Major sources of economics risk are financial risk and market risk. Results indicated that according to the Jensen inequality, adaptive harvesting provides better representations of forest management problems than deterministic model and increasing price risk could increase the expected producer surplus.

Keywords: Risk management, stumpage price, adaptive forest harvest

1. Introduction

Forestry operations are unique in that revenues are periodic. This means that income may be realized every 20 years and more. Many phenomenons could be happen and affect the optimal decision to long term harvesting age. The traditional forest management is based deterministic assumptions. The reason for deterministic assumption is the simplicity of decisions. Timber prices are difficult to predict accurately, since many things may influence the markets. The stumpage price fluctuates over time and it is very difficult to predict it with high accuracy. Therefore we can regard the stumpage price as a stochastic process. Some other phenomena, such as forest growth, also could be stochastic. Price variation is the most important source of risk in forest management (Mohammadi Limaei, 2011). Previous forest management decisions were based on deterministic approach. Risk management in forestry decisions was suggested by Hool (1966), who first used a Markovian framework to analyze the management of even-aged plantations. There are several studies dealt with forestry decision under risk such as: Teeguarden, 1969; Lembersky and Johnson, 1975; Lohmander, 1987, 2000; Kaya and Buongiorno, 1987; Haight, 1990; Buongiorno, 2001; Mohammadi Limaei, 2006.

Some sources of risk could change the forest production; here they called factors, such as pests and diseases, fire, wind, climate change, etc). Some sources of risk could change the net present values such as price fluctuation and marketing. Uncertainty exists in most of the factors which affect forest management decisions. However, it is usually impossible to incorporate uncertainties of all factors into a decision model which describes an actual forest management problem with a reasonable degree of accuracy. This research aims to discuses the sources of risk that could affect the expected net present value (NPV) gained from forest management activities.

2. Production risk:

The expected forest production can reduce due to different kind of environmental risk. Forest production could include seedling production, timber production and residual stands trees.

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Seedling survival after reforestation is an important issue for forest landowners. Different risks such as seedling competition, drought and flood, pests and insects could reduce the chance of seedling survival and increase the costs of reforestation. A forest harvester could damage the residual stand. For example, he can broke the residual tree crown and steam, remove bark from the steam and deform the tree. These injuries could introduce insects and diseases, and ultimately reduce the value of forest stand. Careful equipment operation and felling practices can help reduce the damage done to a timber stand during a forest harvesting operation. Ice storms, glaze wild animals, wind fire etc are the some other production risks in forests (Goerlich et al. 2009). Manley and Wakelin (1989) showed that this increase in costs and reduction in revenues reduces the net present value of a forest by up to 11% for an annual level of damage of 1%.

3. Market risk:

Standing timber or stumpage price is dependent on many factors. Prices primarily reflect the current state of the economy, the demand for different species at the time of the sale, the timber quality on the tract, and current market conditions in the area. In forestry and wood products, our markets are closely tied to the housing segment of the economy. As housing starts fluctuate, therefore it will affect the demand for lumber and associated products. When the demand for housing products goes down, the prices paid for standing timber and logs will eventually go down. The threat from substitute products such as plastic and steel also affect lumber prices. As more of these materials are used in home construction, less wood is used, which puts less demand on our forests. Technology influences log and lumber prices as well. As we increase recovery in sawmills with better cutting technologies, we produce more lumber from fewer logs, reducing the demand on our forests. Timber prices directly affect the net revenues of timber harvesting. When timber price is uncertain, the future timber price could be less or higher than the expected price. The time flexibility of timber growing makes it possible to postpone harvesting when timber price are low. If the timber price is stationary, then one should wait when timber price is low and harvest when it is high. As a result, the existence of timber price uncertainty implies that the timber price at harvesting time is usually higher than the expectations. It is not possible to take advantages when the timber price is non-stationary. There are many empirical studies show that timber price is stationary (Lohmander, 1987; Hultkrantz, 1993; Gong 1990, Mohammadi Limaei, 2001). Uncertainty in the forest management costs has the same nature as in timber price. The management costs affect the possible revenues. It is possible to take advantages from management costs fluctuation by adjusting the timber harvest and silvicultural decisions (Gong, 1994).

4. Forest management and risk:

The aim of forest management is to maximize the NPV. The NPV of forest harvesting function may be written as:

$$\text{Maximize } NPV = \sum_{t=0}^{\infty} e^{-rt} R_t \quad (1)$$

t is the time period, r denotes the rate of interest. R_t is net income. $R_t = P_t.h_t$, whereas, P_t is net price (price - variable harvesting cost) and h_t is harvest level.

In case there are uncertainty about timber price and harvesting costs, then the expected NPV could be written as:

$$\text{Maximize } NPV = E\left[\sum_{t=0}^{\infty} e^{-rt} R_{t\,m}\right] \quad (2)$$

m is the probability distribution of net timber price fluctuation. Obviously when the timber price is high, the expected NPV is high and vice versa.

If we consider multi period in forestry decision as it is in most real cases, decisions in different periods should not be analyzed independently. The optimal management alternative for the current period depends on the decisions in the future periods, which, in turn, are affected by the state of nature in the future. If the forest management objective is to maximize the NPV, then the optimal decision for the current period can be determined by the following optimization model:

$$\max_x \quad g(x) + E[W(i_2)]$$

$$\text{subject to} \quad i_2 = f(i_1, x) + \varepsilon_2 \tag{3}$$

Where x is the current period decision, $g(x)$ denotes the NPV associated with choice of x, i_2 the state of nature at the next period, and $W(i_2)$ is the maximum NPV when the state at the next period is known. ε_2 is a series normally distributed errors with mean zero and autocorrelation zero.

In real forest management, the state at the next period is uncertain, the mathematical expectation of $W(i_2)$ is used in the model (3). The future decisions affect the optimal decision for the current period through their impacts on the forest NPV in the next period. Then the following model can be written:

$$W(i_2) = \max \quad E\left[\sum_{m=2}^{n} e^{-r(m-1)} g(\pi_m(i_m))\right] \tag{4}$$

$$\text{subject to} \quad i_m = f(i_{m-1}, \pi_{m-1}(i_{m-1})) + \in_2 \quad \textit{and} \quad m = 3,4,\ldots,n$$

Model 4 is calculated to determine the maximum NPV for the next period. Accordingly it is possible to determine the maximum NPV for the future periods with the same procedures.

5. Adaptive harvesting

Adaptive harvesting provides better representations of forest management problems than deterministic model. Forest owner could benefit from stumpage price variation. A special case is adaptive harvesting (Figure. 1). It is assumed that the demand function in certainty case is always at level D_2. The supply function (S) is assumed to be deterministic. The market price is P_2. Then, the producer surplus is A plus B area. Furthermore, assume that demand is risky with 50% probability is D_1, and with 50% probability, the demand function is D_3. In the high demand case (D_1), the price is P_1. In the low demand case, the price is P_3. In the high demand case, the producer surplus is the same as the producer surplus in the certainty case plus C area. In the low demand case (D_3), the producer surplus is the same as the producer surplus in the certainty case minus B area. Since C area is larger than B area, it is clear that the expected producer surplus is higher in the risk case than in the certainty case. When the price is very low, then the supplied quantity is zero and the producer surplus is still not below zero, according to the Jensen inequality (Rudin, 1987). On the other hand, the producer surplus increases with increasing price, as long as the price is above the level where the supplied quantity is strictly positive. In addition, the producer surplus increases more and more with increasing prices. The reason is that the price and the quantity increase at the same time. For prices such that the optimal supply volume is strictly positive, the producer surplus is a strictly convex function of price. In such a case, increasing price risk means that the expected producer surplus strictly increases. The expected producer surplus is strictly higher under risk than under certainty in case the relevant prices are found in an interval where the optimal supply is strictly positive, which also means that the producer surplus function is strictly convex.

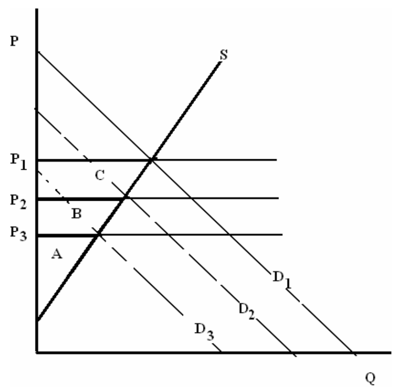

Fig. 1: Producer surplus under different demand assumptions.

6. Conclusion:

It is explicitly accepted that there are conditions in the environment that can not be perfectly predicted. Harvest revenue can vary widely due to weather, mortality, stock, insects, disease, fire, stumpage price fluctuations and many other factors. In the presence of stochastic phenomena it is important to have many available options. The harvest decision should be taking based on the latest available stumpage price and forest stock information. Actual forest management decisions are never made under conditions of certainty. Deterministic approach more used due to the simplicity in the analysis of forest management problem. Uncertainty in the future state of nature affects the optimal decisions in the current period. Under conditions of uncertainty, silivicultural investment and timber harvest decisions should be made to take advantage of the fluctuations of timber price and management costs, and to reduce the probability of the possible occurrences of undesirable states of nature or their impacts on the outcomes (Gong, 1994). It is suggested that the mixed species plantation has more advantages than single stands in a stochastic world and could reduce the disadvantages of production and market risks (Lohmander, 2000). The reasons are following:

1- The prices of different species unpredictably develop over time.

2- Environmental changes such as soil acidity, climate change will usually affect different species differently, hence some species could survive and it will be reduce the risk of losing profitability.

3- Insects and pests may appear, causing species specific damage.

4- Wind damage is less in mixed stands than pure stands.

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