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Stumpage Prices in the Iranian Caspian Forests

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Abstract: Stochastic stumpage price is estimated through regression analysis (with alternative autoregressive models) with data from the Iranian Caspian forests. The parameter estimates indicate that the stumpage price may be regarded as a stationary stochastic process. Stumpage prices in Iran and Sweden were compared. The results show that there is not any significant relation between stumpage prices in Iran and Sweden.

Key words: Iranian caspian forests, stumpage price, harvesting cost, autoregressive model

INTRODUCTION

The area of natural forest in Iran is approximately 12.4 million hectares, equal to 7.5% of the total area of Iran (Fig. 1). Of this, approximately 1.9 m ha are commercial forests called Iranian Caspian, Hyrcanian or Northern forests. Other forests are waste and non-commercial forests (Fig. 2). The commercial forests located in the northern part of Iran, north of the Alaborz Range and south of the Caspian Sea. These forests grow, like a thin strip (800 km long and 20-70 km wide). Industrial harvesting occurs only in the Caspian forests. Because of the severe climatic conditions and forest degradation, forests in other regions are not exploited for industrial wood production. Forest industries in Iran produce sawnwood, wood-based panels, as well as pulp and paper from hardwood species. Moderate volumes of forest products, mainly paper, are imported. Modest quantities of wood are burned as fuel.

These forests are uneven-aged structures of varying species such as: beech (*Fagus orientalis*), hornbeam (*Carpinus* sp.), maple (*Acer* sp.), oak (*Quercus* sp.). These forests are located from sea level to 2800 m altitude.

The total stock at the Caspian forest is about 405 million m^3, average stock is about 213 m^3 ha^{-1} and annual growth is about 3.5 m^3 ha^{-1} (Saeed, 1992). Two types of forest management systems are currently utilized: shelterwood and selection. The first forest management plan was prepared for the shelterwood method in 1959. This method is suitable for even-aged oak and beech forests in central Europe and without enough study this method was introduced in the Iranian Caspian forest which suffered from domestic animals (cows, sheep and goats) in the forest (Heshmatol Vaezin, 2000). Studies on animal husbandry indicate that there are 33,100 traditional animal husbandry units with 5.7 million domesticated animals in these forests (Shamekhi, 1993).

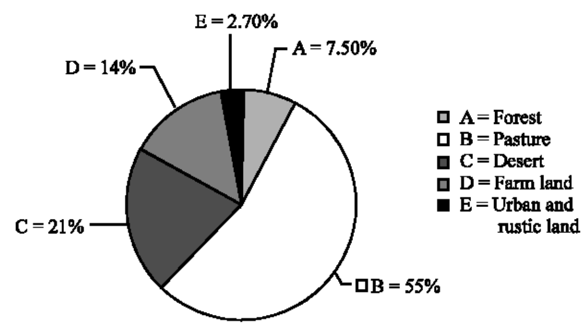

Fig. 1: The percentage of land use in Iran

Table 1: Iranian northern forests harvest variations over the last decade

Year	Area under forest management plans (ha)	Total harvest (m^3)	Average harvest (m^3 ha^{-1})
1989	659000	2015000	3.05
1998	914000	1342000	1.46

During the past decade, considerable changes have been made in forest management plan selection criteria due to the reinforcement of ecosystem point of view. Even-aged stands have been changed into uneven-aged stands, clear cutting in restoration areas at vast extents have been stopped, spot cutting in limited areas have attached attention and the harvest rate has been diminished (Table 1). This means a 32% reduction in forest utilization versus 47% increase in forest planned areas (Sagheb-Talebi *et al*., 2003).

According to present inexact statistics an average of 4.2 million m^3 wood of these forests were exploited each year as commercial and non commercial products.

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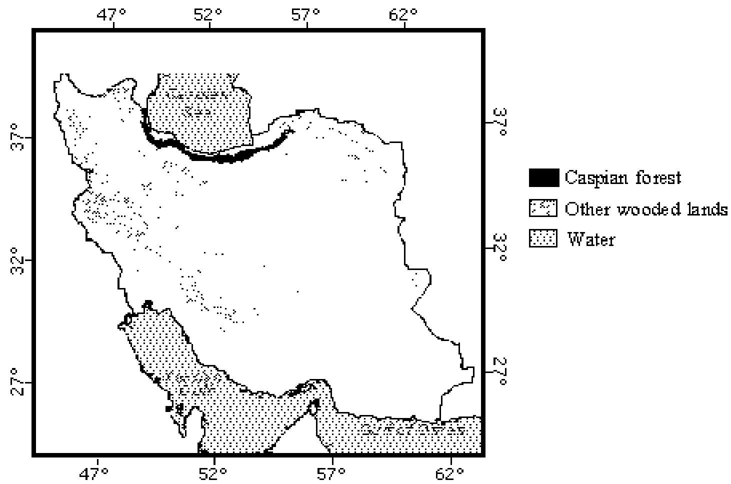

Fig. 2: Iranian forest map (Anonymous, 1999)

- Legal utilization: Annual utilization of plans underway is around 1.3 million m^3.
- Illegal utilization: Each year, the rural community residing in the forests and those engaged in animal husbandry use around 2.9 million m^3 of logs and firewood (Shamekhi, 1993). Based on inventories carried out about 45 years ago, the total forested areas of the northern part of the country was about 3.4 m ha and now is 1.9 m ha (Sobhani, 2000). This shows how far the forests have been invaded and destroyed during these 45 years. The main factors in this destructive trend are overgrazing, clear cutting and conversion into rangelands and exploitation for fuel wood.

All of Iranian forests are nationalized and the Forests and Ranges Organization (FRO) of Iran under the Ministry of Jihad-e-Agriculture is in charge of rehabilitation, harvest scheduling and supervision of forests. This responsibility is carried out through compiled action plans and policies in accordance with social, national, regional and institutional requirements.

In the Caspian forests most timber is harvested by ground skidding systems.

Utilization of these forests is subject to three types of management:

- **State-owned firms:** Using government investment within the framework of the constitution of state-owned firms.
- **Private firms:** Using private sector investment and management and aiming at absorbing capital in the field of forests.
- **Cooperative firms:** Which have been set up not only for utilization of forests but also for protection and restoration of the forests and afforestation of devastated forests. The share of this sector in utilization of Iran's northern forests is 1%. With the lapse of time and acquisition of more experience in specialized affairs, these cooperative firms can play a more salient role in relation to forestry.

With all of this background on Iranian Caspian forests, the objective of this study is to investigate the average price paid for standing timber, commonly called stumpage price and harvesting cost in Iranian Caspian forests. Stumpage price forecasts are an important component in forest investment decisions. It is economically optimal to adaptively adjust the harvest activities to the sequentially revealed stumpage prices since there is no method of perfect price prediction available. Theoretically, the stumpage price is determined by a balance of stumpage supply and demand. The ruling price would be at such a level that the total amount of stumpage that forest owners are willing to sell equals the total quantity that the buyers are willing to buy.

Average stumpage prices published in this study are calculated from actual timber, roundwood, fire and pulpwood prices at road side minus the variable harvesting costs.

Lohmander (1987a) investigated the time series of stumpage prices in Sweden, Norway and Finland. He has shown that AR models with $\beta < 1$ give reasonable representations of the three price series. Gong (1990) used AR models for Swedish saw timber prices and price predictions. The autocorrelation graphs in Gong (1990) are not inconsistent with the assumption of stationary prices. In fact, they are typical for stationary price. Howard (1995) estimated price trends for stumpage and selected agricultural products in Costa Rica. He also describes earlier studies of stumpage prices in different countries other periods. Linden and Uusivuori (2000) investigated the stochastic properties of timber prices in Finland during the period 1900 to 1995. They conclude: However, it is interesting to note, that in our analysis the data first appear non-stationary, but that this efficiency result is later dis-illusioned by the stationarity and non-orthogonality of the forecast error series.

Linehan *et al.* (2003) investigated the stumpage price in Pennsylvania with log-linear regression to determine nominal and real price growth rates.

Gong and Yin (2004) examined the impact of serially correlated prices for multiple outputs on harvest.

Penttinen (2006) analyzed timber harvesting in the Finnish economic and wood production environment based on historical stumpage prices and selvicultural costs.

Many studies of optimal adaptive forest harvesting under influence of stochastic prices exist. Among them, we find Lohmander (1985, 1987a, b), Brazee and Mendelsohn (1988) and Rollin *et al.* (2005). They are all based on the assumption of stationary price processes. It is well known that time series models fitted with the historical values can be used to predict future values of the series. In this study we used time series analysis to predict the future stumpage price.

MATERIALS AND METHODS

Stumpage price: There are two kinds of theoretical consideration about price:

One possible assumption is that the price is a stationary autoregressive (AR) process; in the sense that changes in one period are generally not assumed to affect expected prices very much in other periods. The best forecast of the future price is given by the mean of the process (when the time distance to the future period of interest approaches infinity). The price in this assumption can be estimated as $P_{t+1} = \alpha + \beta P_t$, $0 < \beta < 1$.

Another possible assumption is that the price process is a Martingale; this means that the expected price in period two (when the price in period one is known) is given by the price in period one. According to a Martingale assumption, $P_{t+1} = \alpha + \beta P_t$, $\alpha = 0$ and $\beta = 1$ (Fig. 3).

We used time series models to predict future stumpage prices.

Let us investigate the properties of such predictions:

In general case for price function, we have:

$$\Delta p_t = \Delta P(P_t, \varepsilon_t) \qquad (1)$$

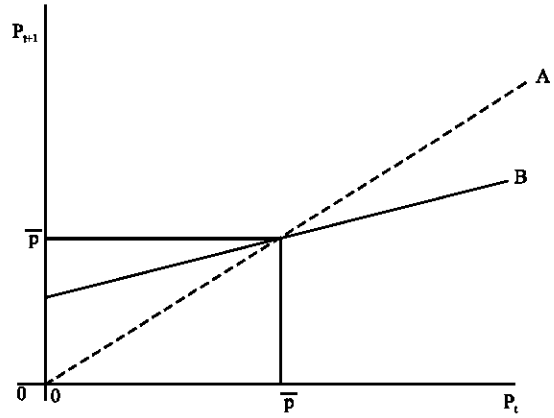

Fig. 3: Price process under two assumptions, when we assume the price is a Martingale (Line A) and when we assume the price is stationary AR model (Line B)

where, ε is a series of random errors with some distribution and autocorrelation zero. In the more restricted first order AR, we have:

$$P_{t+1} = \alpha + \beta P_t + \varepsilon_{t+1} \qquad (2)$$

We assume that ε is a series of normally distributed errors with mean zero and autocorrelation zero. If $0<\beta<1$, then the process P is stationary, with mean of the process $\mu = \alpha/(1-\beta)$.

Compare with Pindyck and Rubinfeld (1998).

It can be shown that the autocorrelation function of P declines geometrically in this case. The autocorrelation function approaches zero from above as the number of lags increases from zero.

From Eq. 2-2 we can write the timber price in period P_{t+2} like:

$$P_{t+2} = \alpha + \beta P_{t+1} + \varepsilon_{1+2},\ 0 < \beta < 1 \qquad (3)$$

Combining Eq. 2 and 3 we get:

$P_{t+2} = \alpha + \beta(\alpha+\beta P_t+\varepsilon_{t+1})+\varepsilon_{t+2}$ and
$P_{t+2} = \alpha + \alpha\beta+\beta^2 P_t+\beta\varepsilon_{t+1}+\varepsilon_{t+2}$ or
$P_{t+2} = \alpha + \alpha(1+\beta)+\beta^2 P_t+\beta\varepsilon_{t+1}+\varepsilon_{t+2}$

$$\frac{\partial\, E(P_{t+1})}{\partial P_t} = \beta,\quad \beta > 0 \text{ and}$$

$$\frac{\partial E(P_{t+2})}{\partial P_t} = \frac{\partial P_{t+2}}{\partial P_{t+1}} \frac{\partial P_{t+1}}{\partial P_t} = \beta^2$$

and in general,

$$\frac{\partial E(P_{t+i})}{\partial P_t} = \beta^i$$

The expected price in a future period $E(P_{t+i})$ is an increasing function of the present price P_t, when $\beta > 0$. When the process is stationary, $0 < \beta < 1$, then,

$$\frac{\partial E(P_{t+i})}{\partial P_t} \longrightarrow 0 \text{ as } i \longrightarrow \infty$$

Even for rather low values of i, $E(P_{t+i})$ is almost independent of P_t for typical values of β, since

$$\frac{\partial E(P_{t+i})}{\partial P_t} = \beta^i$$

As an example (Fig. 4), if $\beta = 0.5$ and $i = 5$,

$$\frac{\partial E(P_{t+i})}{\partial P_t} = \left(\frac{1}{2}\right)^5 = 0.032$$

Very similar results were derived by Kaya and Buongiorno (1987). They estimated this stumpage price model:

$$P_{t+5} = 31.4 + 0.03P_t$$

That is a first order AR process model. If we assume that the model is a first order AR model defined in one year time periods such that the model estimated by Kaya and Buongiorno in five year periods is correct, then this model should look like this:

$$P_{t+1} = \alpha + \beta P_t$$

These two conditions must be satisfied:

$$\beta = 0.03^{\frac{1}{5}} \text{ and } \frac{31.4}{1\text{-}0.03} = \frac{\alpha}{1-\beta}$$

As a result we get: α = 16.311717 and β = 0.4959344. Hence, the first order AR stumpage price process defined in one year periods consistent with the results reported by Kaya and Buongiorno (1987) is:

$$P_{t+1} = 16.37 + 0.4959P_t$$

When we work with a time scale where each time step is sufficiently large and the process is stationary, we may use the approximation:

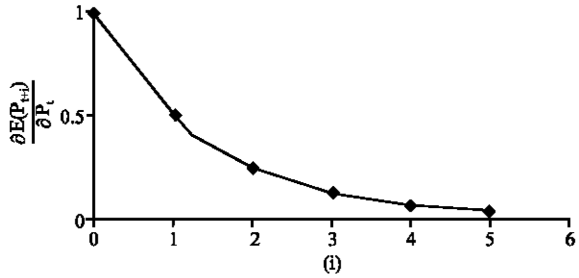

Fig. 4: The derivative of $\frac{\partial E(P_{t+i})}{\partial P_t}$ approaches zero as i approaches infinity

$$P_t = \mu + \underline{\varepsilon_t} \tag{4}$$

The underlined epsilon denotes a series of normally distributed errors with mean zero, standard deviation σ and autocorrelation zero.

If timber price at period t is known, from Eq. 2 the timber price in period t+l can be predicted by the following process:

$P_{t+1} = \alpha + \beta P_t$, $0<\beta<1$. We can look many periods ahead. The forecast of P_{t+2} in period t (when P_t is the latest observation of the process P) is given by $\hat{P}_{t+2}$:

$$\hat{P}_{t+2} = \alpha + \beta(\alpha + \beta P_t)$$
$$\hat{P}_{t+3} = \alpha + \beta(\alpha + \beta(\alpha + \beta P_t))$$
$$\hat{P}_{t+3} \text{ can be expressed as: } \hat{P}_{t+3} = \alpha(\beta^0 + \beta^1 + \beta^2) + \beta^3 P_t.$$

The forecast of P_{t+l} in period t is:

$$P_{t+l} = \alpha\sum_{i=0}^{l-1}\beta^i + \beta^l P_t \tag{5}$$

When l is large we have:

$S = \beta^0 + \beta^1 + \beta^2 + ... + \beta^n$
$\beta S = \beta^1 + \beta^2 + \beta^3 + ... + \beta^{n+1}$
$S\text{-}\beta S = \beta^0 \text{-} \beta^{n+1}$ and $S(1\text{-}B) = \beta^{0}\ \beta^{n+1}$ or $S = \frac{\beta^0 - \beta^{n+1}}{1-\beta}$

$$\lim_{n \to \infty} S = \frac{1-\beta^{n+1}}{1-\beta} = \frac{1}{1-\beta}$$

So, $E(P)_t \approx \frac{\alpha}{(1-\beta)}$, i.e., predicted stumpage price in the distant future converges to the mean value of the series.

If stumpage price is truly a first order AR process, from Eq. 2-2, $P_{t+l} = \alpha + \beta P_{t+l-1} + \varepsilon_{t+l}$ by successive substitutions of $P_{t+l-1}, P_{t+l-2}, P_{t+l-3}, \ldots, P_t$, we get:

Table 2: Historical wood material price[1], harvesting costs[2] and stumpage price[3] in Iranian Caspian forests during 1980-2004(€/m³), deflated by CPI at year 2004

Year	Consumer price index[4]	Historical wood material price (€ m^{-3})	Historical harvesting cost(€ m^{-3})	Historical stumpage price (Real net price) (€ m^{-3})	Expected stumpage price (€ m^{-3})
1980	3.59	67.61	9.34	58.26	58.26
1981	4.42	67.95	8.13	59.81	54.22
1982	5.26	58.80	7.15	51.64	51.22
1983	6.04	61.87	7.99	53.87	49.01
1984	6.67	57.70	8.84	48.86	47.37
1985	7.13	59.02	9.20	49.81	46.16
1986	8.82	51.62	9.79	41.82	45.26
1987	11.26	41.61	10.53	31.06	44.59
1988	14.52	41.97	8.17	33.79	44.10
1989	17.05	52.95	8.15	44.79	43.74
1990	18.60	47.37	8.09	39.26	43.47
1991	22.40	37.77	8.60	29.16	43.27
1992	27.90	43.99	7.42	36.56	43.12
1993	34.30	38.13	8.16	29.96	43.01
1994	46.30	32.03	6.87	25.16	42.93
1995	69.20	46.99	5.25	41.74	42.87
1996	85.20	72.97	4.63	68.33	42.82
1997	100.00	66.02	5.16	60.86	42.79
1998	118.10	62.19	4.63	57.55	42.77
1999	141.80	68.96	6.17	62.79	42.75
2000	159.70	73.26	5.58	67.67	42.74
2001	177.90	67.50	7.66	59.84	42.73
2002	206.00	60.57	7.95	52.62	42.72
2003	238.20	63.50	7.98	55.51	42.71
2004	265.50	66.10	9.10	57.00	42.70

1: Wood material price in this study is the average of timber, roundwood, fire and pulpwood prices road side price. 2: Harvesting cost includes the costs of felling, bunching and ground skidding to the forests roads side. 3: Average stumpage prices published in this report are calculated from actual timber, roundwood, fire-and pulpwood prices at road side minus the variable harvesting costs. 4: Consumer price index data of Iran was collected from the Central bank of the Islamic Republic of Iran

$$P_{t+1} = \alpha\sum_{i=0}^{l-1}\beta^{i} + \beta^{l}P_t + \sum_{i=1}^{l}\beta^{l-i}\varepsilon_{t+i} \quad (6)$$

The mathematical expectation of P_{t+1} (conditional on P_t) from Eq. 2-5 is:

$$E(P_{t+1}|\,P_t) = \alpha\sum_{i=1}^{l-1}\beta^{i} + \beta^{l}P_t \quad (7)$$

From Eq. 2-5 and 2-7, $\hat{P}_{t+1} = E(P_{t+1}|P_t)$

The prediction is unbiased. The error of the prediction $e(l)$ is:

$$e(l) = P_{t+1} - \hat{P}_{t+1} = \sum_{i=1}^{l}\beta^{l-i}\varepsilon_{t+i} \quad (8)$$

Since ε_{t+i} is independent, identically distributed with mean zero and variance σ^2, we have: $E[e(l)] = 0$ and

$$\text{var}\left[e(l)\right] = \sum_{i=1}^{l}(\beta^{l-i})^2\sigma^2 = (\beta^{l-1})^2\sigma^2 + (\beta^{l-2})^2\sigma^2 + \ldots + (\beta^{l-1})^2\sigma^2$$

$$S = \beta^0 + \beta^2 + \beta^4 + \ldots + \beta^n,\ \beta^2 S = \beta^2 + \beta^4 + \ldots + \beta^{n+2},$$

$$(1-\beta^2)S = \beta^0 - \beta^{n+2},\ S = \beta^0 - \frac{\beta^{n+2}}{1-\beta^2} = \frac{1-\beta^{n+2}}{1-\beta^2}, = l-1,$$

$$S = \frac{1-\beta^{2l}}{1-\beta} \text{ and } \text{var}\left[e(1)\right] = \frac{\sigma^2(1-\beta^{2l})}{1-\beta^2},$$

$$\text{when } 1 \text{ is large}, \text{var}\left[e(1)\right] = \frac{\sigma^2}{1-\beta^2}.$$

In the previous analysis we have shown that, if the stumpage price series satisfies assumption (2-2), the mean and variance of timber price in period t+1 can be predicted by the AR model. Indeed, if stumpage price development is governed by (2-2), the Eq. 2-5 provides the best predictions on future values of the series.

In the numerical calculation in this study, the data of the period 1980-2004 was collected from the Iranian FRO. The average stumpage price was derived from actual timber, roundwood, fire and pulpwood prices at road side minus the variable harvesting costs. Then it was adjusted by Consumer Price Index (CPI) of Iran for the base year of 2004 (Anonymous, 2004) by the following function (Table 2):

$$I_t = \frac{P_t * 265.5}{Y_t} \quad (9)$$

I_t = Real price adjusted to the price level of year 2004.
P_t = Price at year t.
Y_t = CPI at year t (Y_{2004} = 265.5).

Regression analysis was used to determine an estimator for price process. At the first stage, the regression used P_{t+1} as dependent variable, P_t and time (year) as independent variables. The results showed that there is a significant relation between P_{t+1} and P_t with t-statistics 4.82 but there is not a significant relation between time (year) and P_{t+1}. Hence at the next stage the variable time was deleted. The results showed that there is a significant relation between P_{t+1} and P_t with t-statistics 5.103. Residuals of stumpage price and predicted price at next year (t+1) are found in Fig. 5 and 6.

The parameters of the first order AR process ($P_{t+1} = \alpha + \beta P_t + \varepsilon_{t+1}$) are found in Table 3.

If we would use the traditional analysis of the regression model, we get the following results and conclusions:

Using a one sided test, the probability that the true value of β>1 is less than 5%. The estimated β value is 0.740, the standard deviation of the β estimate is 0.145 and there are 21 df. Hence we can reject the hypothesis that β = 1, which would mean that the process is a Martingale. 0<β<1. These estimates indicate that the process is stationary.

However, when we run the more modern unit root test, more specifically the so called Augmented Dickey Fuller (ADF) test compare with Dickey and Fuller (1979). We can not reject the hypothesis of nonstationary prices with 95% probability. One can always discuss the 95% probability level. Nothing really says that this level should always be selected. It is just a standard selection in statistics. If we would select a lower level of probability, we could be able to reject the nonstationarity hypothesis.

The estimates of the parameters are almost the same when we use the different methods. The parameters are needed in stochastic dynamic optimization in case we want to determine the optimal harvest levels and expected present values in forestry. In such a case, we must take the best parameter estimates that we can get even if the parameters are not known with certainty. In statistical analysis we can, on the other hand, almost never get perfectly certain results. This case is, in this respect, typical.

It has been shown by Lohmander (1995) that the expected objective function value in a stochastic dynamic programming optimization model increases if the parameters associated to increasing price levels are adjusted downwards, in case these parameters are not known with certainty. If the parameters indicate that high prices have a higher probability than what they really have, you should optimally wait for prices that never occur in reality. In such a case you lower the expected objective function value very much. If you think that the probability of high prices is lower than what it really is, you will probably harvest at a price that is lower than optimal. Then you will also reduce the expected present value, but not as much as in the case when you overestimate the probability of high prices. This is one more reason why we prefer to use the assumption β<1 to β>= 1.

The Autocorrelation Functions (ACF) for different lags were calculated. The result showed that when the number of lags increases the autocorrelations goes to zero. Also the graphs of the original price observations show the same tendency as the number of years between

Table 3: Parameters based on the stumpage price data for the first order AR process from the period 1980-2004

Parameters	α	β	σ(SD of ε_{t+1})	R^2	R
Parameter value	12.367	0.740	8.817	0.555	0.745
Standard deviation	7.188	0.145			
t-statistics	1.720	5.103			

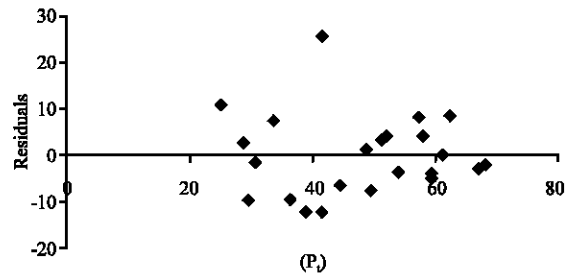

Fig. 5: Residuals (deviations from the function) of stumpage price (P_t)

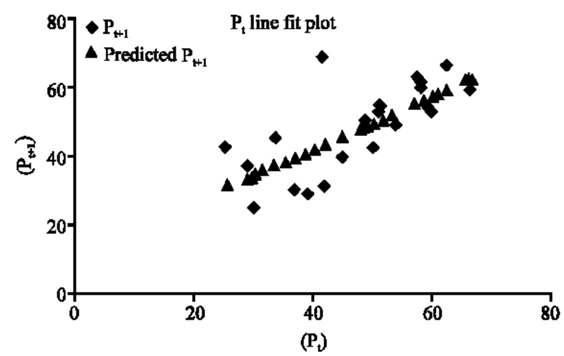

Fig. 6: Price at t+1 and predicted price at t+1 as a function of the price at t

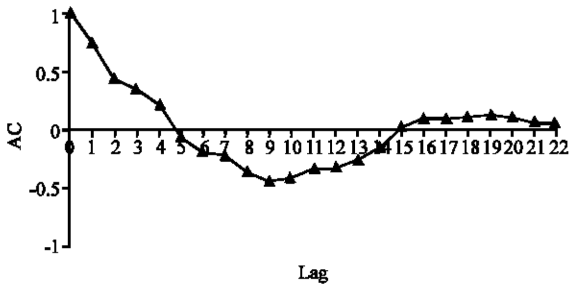

Fig. 7: Autocorrelation function for stumpage price

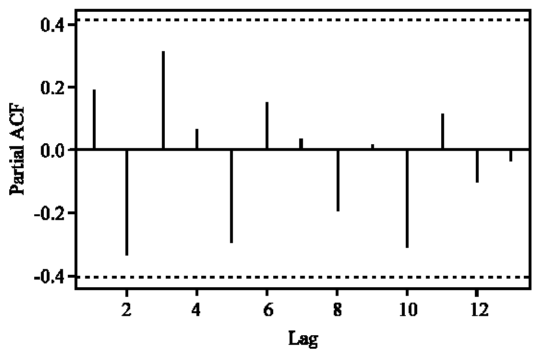

Fig. 8: Partial autocorrelation function of the residuals based on the first order AR process

two observations increases, the correlation between the two prices decreases. The autocorrelation coefficients at various lags are shown in Fig. 7.

The partial ACF of the residuals for first order AR process was calculated (Fig. 8). It indicates that there are no severe problems with the model specification.

In order to choose the best model for the stumpage price prediction we also estimated second and third order AR processes.

Second order AR process:

$$P_t = \alpha + \beta P_{t-1} + \delta P_{t-2} + \varepsilon_t \quad (10)$$

The estimated parameters for the second order AR process are:

(t-statistics in parenthesis)

$$P_t = 14.881 + 0.9097P_{t+1} - 0.2207P_{t-2} + \varepsilon_t$$
$$(1.843) \quad (3.964) \quad (-0.979)$$

δ_{ct} = 9.1545 (δ_{ct} is the standard deviation of error term ε_t).

Third order AR process:

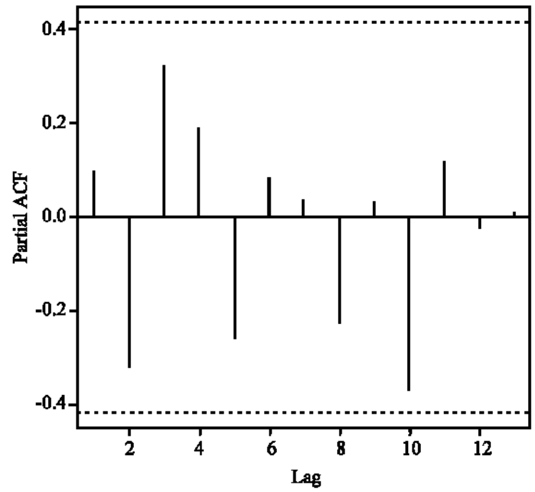

Fig. 9: Partial autocorrelation function of the residuals based on the second order AR process

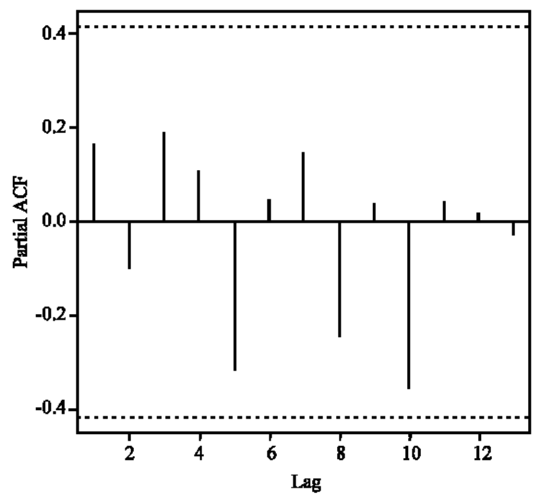

Fig. 10: Partial autocorrelation function of the residuals based on the third order AR process

$$P_t = \alpha + \beta P_{t-1} + \delta P_{t-2} + \psi P_{t-3} + \varepsilon_t \quad (11)$$

The estimated parameters for the third order AR process are:

(t-statistics in parenthesis).

$$P_t = 9.619 + 0.9968P_{t+1} - 0.5344P_{t-2} + 0.3388P_{t-3} + \varepsilon_t$$
$$(1.117) \quad (4.329) \quad (-1.748) \quad (1.467)$$

δ_{ct} = 8.87471

The partial ACF of the residuals for the second and third order AR were also calculated (Fig. 9 and 10).

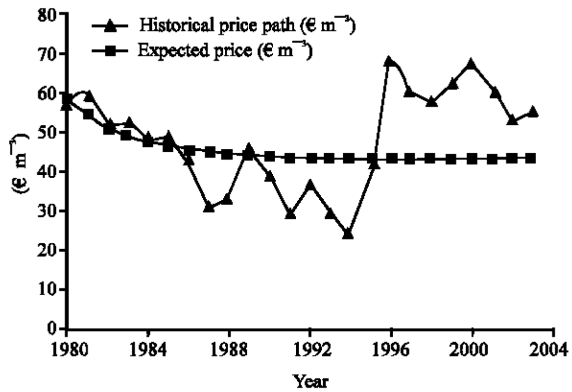

Fig. 11: Historical stumpage price path and expected stumpage price (€ m^{-3})

As the t values of parameters estimated for the second order AR process (δ) and the third order AR process (δ, ψ) are very low and the partial ACF of the residuals in the first, second and third AR processes are close to each other. Hence, we prefer the first order AR process.

With the first order AR process, the expected price based on the price in year 1980 (58.26 € m^{-3}) was calculated (Fig. 11).

A stochastic price path was simulated. ε_{t+1} is assumed to be normally distributed with mean 0 and SD $\sigma = 8.817293$.

Using estimator (2-2) a sample path of the stochastic price process was calculated and depicted (Fig. 12).

The mean of the price process may be calculated based on the first order AR model:

$$P_{eq1} = \varepsilon + \beta P_{eq1} \text{ as } (1-\beta)P_{eq1} = \alpha \text{ and } P_{eq1} = \frac{\alpha}{1-\beta} \quad (12)$$

If we use the estimates of α and β from Table 3, the mean of the stumpage price process will be 47.57 € m^{-3}.

Harvesting cost: Harvesting cost includes the costs of felling, bunching and ground skidding to the forests road side. The data of the period 1980-2004 was collected from the Iranian FRO. The CPI of Iran was used to deflate the harvesting cost (Fig. 13). Regression analysis was used to determine a harvesting cost function. The regression analysis used C_{t+1} as dependent variable and C_t and time (year) as independent variables. The results show that there is a significant relation between C_{t+1} and C_t with t-statistics 4.17 and there is not a significant relation between C_{t+1} and time (year). Hence, in the next stage, the variable time was deleted. The results show that there is a significant relation between C_{t+1} and C_t with t-statistics 5.78.

Table 4: Parameters based on the harvesting cost data from the period 1980-2004

Parameters	α	β	σ(SD of ε_{t+1})	R^2	R
Parameter value	1.728	0.763	1.014	0.615	0.784
Standard deviation	1.017	0.132			
t-statistic	1.699	5.780			

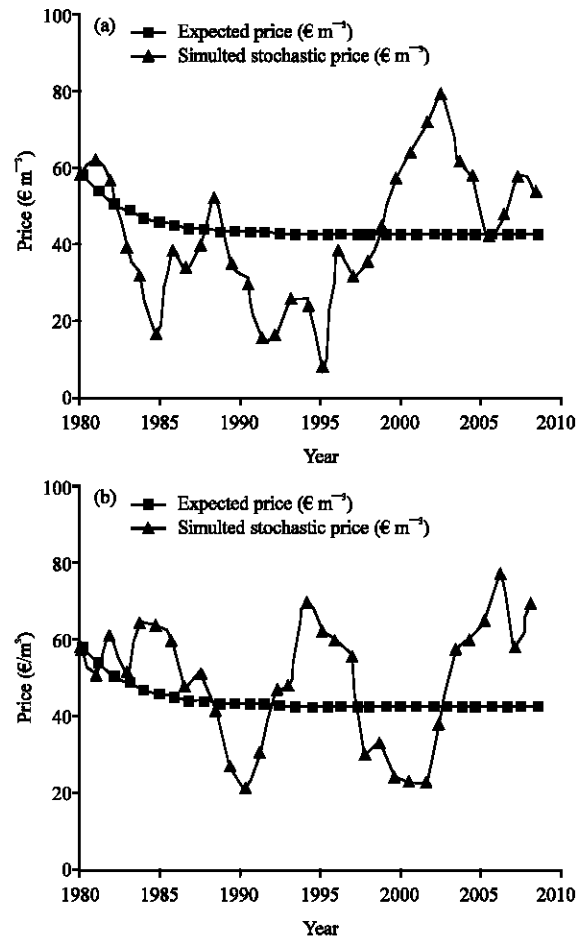

Fig. 12: Simulated stochastic and expected price paths with two different stochastic processes

The following first order AR process was used to estimate the harvesting costs function:

$$C_{t+1} = g_0 + g_1 C_t + \varepsilon_{t+1} \quad (13)$$

The parameters of the first order AR process are found in Table 4.

Comparing stumpage price in Iran and Sweden: The results of the regression analysis show that there is not any significant relation between stumpage prices in Iran and Sweden. From Fig. 14 it can be seen that the stumpage prices in Iran and Sweden during the years

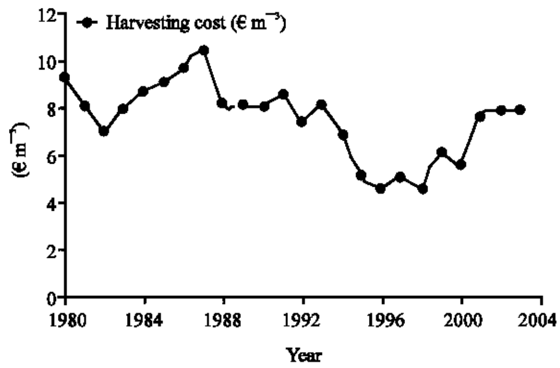

Fig. 13: Historical harvesting costs during the period 1980- 2004 in Iran (€ m^{-3})

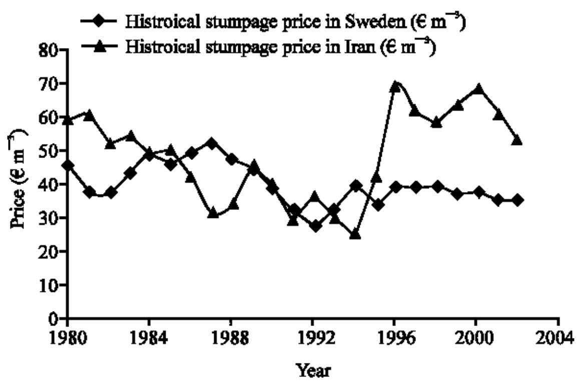

Fig. 14: Historical stumpage price in Iran and Sweden (€ m^{-3})

1980 to 1995 show rather similar development. In 1995 the price in Iran suddenly increased. One reason could be that the demand for sawnwood increased after the Iran and Iraq war. Houses had to be repaired and rebuilt. The demand for forest products increased and subsequently the stumpage price increased.

CONCLUSIONS

In this study, it has been showed that the stumpages price in Iran during the period 1980-2004 fluctuates over time. The mean of the stumpage price process according to the first order AR process estimated was 47.57 € m^{-3}. The investigations of the autocorrelation function for different lags show that, as the number of lags increase, the autocorrelation goes to the zero. The parameter estimates indicate that the stumpage price may be regarded as a stationary stochastic process.

There are many things that affect the stumpage prices which are not predictable and depend on socio-economic conditions in the future. Changes in forest policies and regulations may also have influences on future supply and/or demand for stumpage. Since such possible changes are not happen in advance, it is reasonable to handle future stumpage price as stochastic variables. The regression analysis shows that there is not any significant relation between stumpage prices in Iran and Sweden.

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