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FACTORS INFLUENCING THE CHANGES OF FOREST COVER (A CASE STUDY ON SUMATRA ISLAND)

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ABSTRACT

In Indonesia, decreasing the forest cover or deforestation in 2000-2005 period had increased up to 1,09 million ha per year, and in Sumatera island alone the deforestation reached 0,27 million ha per year. The primary factors that caused the changes of forest cover in Sumatera are logging, both legal and illegal, and forest conversion for other land uses. This paper used panel data model for eight provinces in Sumatera from 2000 to 2006 to analyze direct causes of changes of forest cover. In the model of changes of forest cover caused by logging, resulted a positive correlation between deforestation and price of timber. These results implied that the rise of timber price made illegal loggers try to get maximum profit in a short time, and it could stimulate illegal logging. In the model of changes of forest cover caused by forest conversion for other land uses, the results showed a positive correlation between deforestation and GDP per capita. The result concludes that the increase of GDP per capita makes consumption for agricultural goods increase, and it can stimulate forest conversion for other land uses.

Keywords*: forest cover, illegal logging, deforestation, forest conversion*

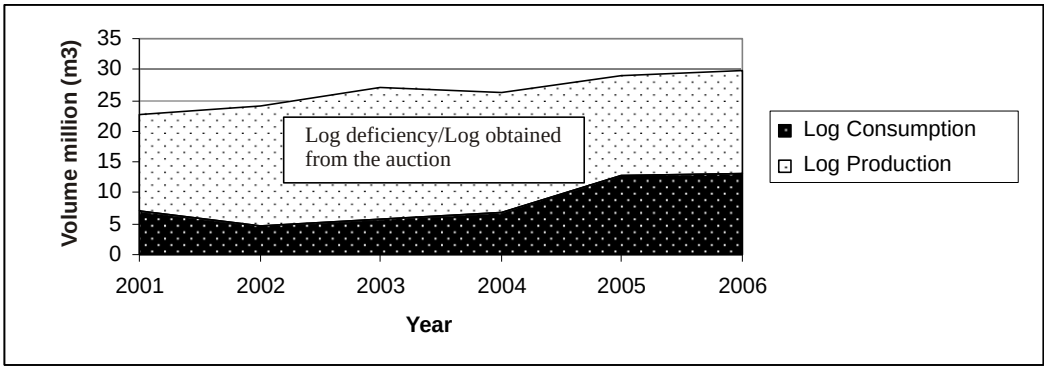
INTRODUCTION

Indonesia has the third largest tropical forest after Brazil and Zaire, 10% of the world forest resource. This vast spread of tropical forest has strategic role in economic, social and cultural aspects (Pagiola, 2003).

Land covering (vegetation) at forest areas in Indonesia, especially the one related with forest cover, is very dynamic and changes very fast. Meanwhile the forest condition and its area are decreasing. The extreme condition of the forest in Indonesia is shown by the satellite scanning done by the Department of Forestry.

Based on the data of 1985 – 1997, the forest reduction in Indonesia had reached 1.87 millions hectares per year while the forest area reduction on Sumatra Island during the same period was 0.6 million per year (Holmes, 2000). However, in the period of 1997 – 2000 it increased into 2.8 millions hectares per year, while on Sumatra island it increased into 1.34 million hectares per year. Furthermore, in the period of 2000-2005 the forest reduction in Indonesia was 1.09 hectares per year while on Sumatra alone was 0.27 hectares per year (Department of Forestry, 2006). The speed of the forest area reduction is predicted to be caused by illegal logging activities, wood smuggling, and forest conversion for other purposes.

Based on the data of the fulfillment of industrial basic commodity in period 2001-2006 on Sumatera island, the legal logging consumption was bigger than legal logging production as shown in Figure 1. The difference between log consumption and log production is obtained from the result of the



Source: BPS (2007)

Figure 1. Log Production VS Log Consumption in Sumatera

auction of illegal log which were confiscated by the Department of Forestry (Directorate of **forest** utilisation and forest product marketing, 2007)

The number of logs which was confiscated, found, and used by timber industries was approximately between 15.4 millions m3 (2001) and 16.9 millions m3 (2006). This value excluded the amount of log smuggled to other countries and the one needed by small sawmills and to produce other forest products such as particle board, fiber board, and venire, so the real number of illegal logs was much bigger. The gap between supply and demand has caused an exploitation of the forest resources through illegal logging activities and it has caused the forest area to decrease.

Through the governmental regulation number 31 of 1989, government regulates the ban of using reforestation fund to rehabilitate forest in the forest concession area where reforestation fund was collected. Furthermore, it regulates that in the selected planting and cutting down system, reforestation is the responsible of the forest concession meaning that the fund for it is also part of the responsible of the forest concession. It is still effective until now that the forest rehabilitation inside the forest concession area is not financed with reforestation fund. The collection of reforestation fund from forest concession to rehabilitate forests with their own money is considered to be *double taxation* (Warsito, 2006). This double taxation causes industrialists to be burdened more because the selling price of timber products (especially plywood) has been far below the product cost. This is one of the causes of the corruption in the forest management that result in the reduction of the forest covered area.

To reduce the speed of deforestation, the government has issued many policies such as prohibiting log export, imposing tariffs on product and processed wood export, stopping converting forests for other purposes, proclaiming 2003 as the year to start the land rehabilitation movement, and so on. However, it seems that those policies are not effective to stop the speed of deforestations. It can be indicated from both *forest pillage* and *illegal logging* practices that happen more and more. This condition can be used as a sign that the threat to forest reservation come from various directions, both from outside and inside the forest sectors, for both their logs and their lands use. Therefore, it is necessary to handle this problem thoroughly to reduce even to stop the speed of deforestation by identifying the factors causing the decrease of forest covered area as priority.

The Originality of the Research

Scrieciu (2000) identified the causes of deforestation in tropical forests through family farming sector which used subsistent farming land expansion model. In his research, the empiric analysis used market approach and farming land expansion model with five variables in the macro level, like deflator price of exported and imported products (EPD and IPD), GNP per capita (GNPPC), farming product (CY), and population (POP).

With this panel data model of 900 observations in 50 countries in Africa, Latin America, and Asia between 1980-1997, analysis was done to get a picture of the causes of the global deforestation.

The result of regression showed that market and subsistent approach models statistically influenced the increase of the speed of deforestation. The first variable that influenced the increase of deforestation speed more significantly was the level of population. The growth of population caused farm land use to increase. The second variable, deflator price of exported products, influenced the increase of deforestation speed. The export high price caused farmers to expand their farm areas into forests to increase their farming products. The next significant variable was GNP per capita which showed that the use of farm land decreased when their income was rising.

According to Sunderlin and Resosudarmo (1996), the factors causing deforestation to happen in Indonesia were (a) the existence of shifting cultivation activities done by both transmigration programme and *'spontaneous' migrants*). (b) Forest conversion for farm areas (c) Logging activities, both legal and illegal.

ITTO (2001) divided the factors that caused illegal logging into two groups: (a) direct cause, like the demands of log that could not be fulfilled, big profit obtained as a result of low product cost because they neither paid tax nor spent money to plan and to build infrastructure, investors' desire to get much profit in a short time, weak law enforcement, and the existence of market for illegal logs in other countries, and (b) indirect cause, like the low risk of illegal logging activities, poverty, and unemployment at villages.

Pagiola (2001) stated that there were two factors that could be indicated as the main causes of deforestation in Southeast Asia. They are logging and forest conversion for farm areas.

From various studies mentioned above, it seems that the factors that influence the decrease of forest cover in this research are differentiated into two main causes:

1. as a result of logging. It happens because of the forest management by forest concession, timber industries, and illegal logging activities.
2. as a result of forest conversion. It happens because of the forest conversion for transmigration area, both spontaneous or local ones, illegal occupancy of forest areas as an impact of population growth, forest conversion for public plantation, and shifting cultivation.

The analysis method used is double regression model with panel data from countries that have tropical forests.

Research Questions

Based on the discussion above, the problems that need to be investigated are:

1. Do timber price, forest concession area, basic commodity for industry, and reforestation fund influence the forest cover as an impact of logging in Sumatra?
2. Do forest concession area and timber production simultanously influence timber price?
3. Do the price of oil palm, PDRB per capita, population, and rice production influence the forest cover as a consequence of forest conversion in Sumatra?

Research Objectives

The objectives of this research are as follows:

1. to understand the infulence of timber price, forest concession, basic commodity for industries, and reforestation fund on the forest cover as the effect of logging on Sumatra Island.
2. to see the simultaneous relationship between forest concession area, timber product and timber price.
3. to understand the infulence of oil palm price, PDRB per capita, population and rice production on the forest cover as a consequence of forest conversion on Sumatra Island.

Research Advantages

From the results of the research, it is expected that there will be an alternative action to prevent deforestation that has alradey been a threat to the forest resources on Sumatra island. This research is expected to become a guidance for policy decision makers to stop the deforestation on Sumatra island.

LITERATURE REVIEW AND ANALYSIS TOOLS

Literature Review

Land cover (vegetation) is a condition of land surface that represents the appearance of land cover which can be divided into two main groups. They are forest group and non-forest group. Furthermore, each of this group can be classified in more detail into the following classes:

- **Forests** consist of primary dry land forest, secondary dry land forests, primary swamp forest, secondary swamp forests, primary mangrove forests, secondary mangrove forests, and plant forests.
- **Non forests** consist of bushes, swamp bush, dry land farming, bush mixture, plantation, settlement, swamp, and savana (Department of Forestry, 2006)

The changes of forest cover in this research is used as an approach of the speed of deforestation. Angelsen dan Kaimowitz (1998) stated that data of deforestation are difficult to find so the use of data of forest cover as empirical data anaylisys of the cuase of deforestation can be recognised. The data of forest cover used is a result of interpretation from sattellite in a forest area both inside and outside the forest regions regardless their forest types.

According to Von Amsberg (1994), timber price would stimulate logging activities. Researches conducted differentiated *unmanaged forests* from *managed forests*. Lower price of timber, ceteris paribus, would increase logging activities in *unmanaged forests* and converse the function of forest for more benefitial farm land. Consequently, the speed of deforestation in *unmanaged forests* becomes faster. The low price of timber stimulated industries to reduce timber product. Consequently, it reduces deforestation in *managed forests*.

Tjandrakirana, R (2006) stated that forest concession area influenced the reduction of forest area in Indonesia. The wider the forest concession area, the more the production forest area which are burdened by forest concession would be. It means that the forest cover change becomes wider because there are a great number of ex-forest concession left to be unproductive land.

With the presidential decree number 40, 1993, the amount of reforestation fund (DR) levied depends on log types and regions. Its amount varies from US$10.50 to US$20.00 per m3 for logs, with the domination of US$16.00 for Morantee wood type on Sumatra, Kalimantan, and Maluku Islands. While reforestation fund (DR) of wooden chips as much as US$2.00 per m3.

Reforestation fund is not collected from plant forest timber.

Timber trade is believed to be the main cause of deforestation. Most of natural forests in the developing countries have experienced deforestataion as an impact of timber production beyond their optimal capasity to regenerate. There are many countries that at the beginning they gave concensus for logging license but finally they made policy to reduce logging activities. (Akbarwati, 2006).

The direct cause of deforestation as the effect of logging is presumed to be influenced by demand of timber industries. The behaviour of timber industries will influence the market of plywoods, saw mills, and logs. This will indirectly influence the behaviour of the forest management and at the same time will influence the speed of deforestation in Inodnesia.(Indartik, 2007).

Culas (2006) stated that as commercial plants the high price of oil palm would motivate people to expand oil palm plantations to forest areas to get more profits.

Maureen Crooper dan Charles Griffiths (1994) said that the reason of quadratic relationship between deforestation level and GDP per capita was that timber and firewood users at the beginning would increase in line with the rise of their income and then it would decrease in a certain level. Research findings show that there is "U" up side down relationship between GDP per capita with deforestation level. The highest deforestation level will be achieved at GDP $ 4760 for Africa and $ 5420 for Latin America.

Weinstock and Sunito (1989) suggested the fundamental differences between shifting cultivation and forest pillage. Shifting cultivator is defined as people who practice shifting cultivation system with fallow period longer than planting period. The forest illegal occupator are defined as people who may use the system of cutting down and burning the available vegetation, but with the main purpose to establih permanent or semi permanent farming business acivities. Although they may plant various food plants to support their own need, commercial plants (very often year-long plants) are the focus of their cultivation. The land is usually not fallow but it is used continuously and it is left only after it becomes infertile because they do not have plan to come back to the same place in long time.

THEORETICAL REVIEW

Theoretical Framework

Perfect labour market assumption gives impacts that production decision can be separated from consumption and supply of domestic workers (Angelsen, 1998). It is assumed that every activity to make use of land has no interaction. Thus, production decision (land expansion) can be analysed with profit maximisation as follow:

$$\pi = \sum_{j=1}^{m} \sum_{i=1}^{n} \left[p_{ij} \; A \; f(L_{ij}, H_{ij}, F_{ij}) - q_{ij} F_{ij} - w_{ij} \; [L_{ij} + h(H_{ij})] \right]$$

subject to:

$$H = \sum_{j=1}^{m} \sum_{i=1}^{n} H_{ij} \qquad (1)$$

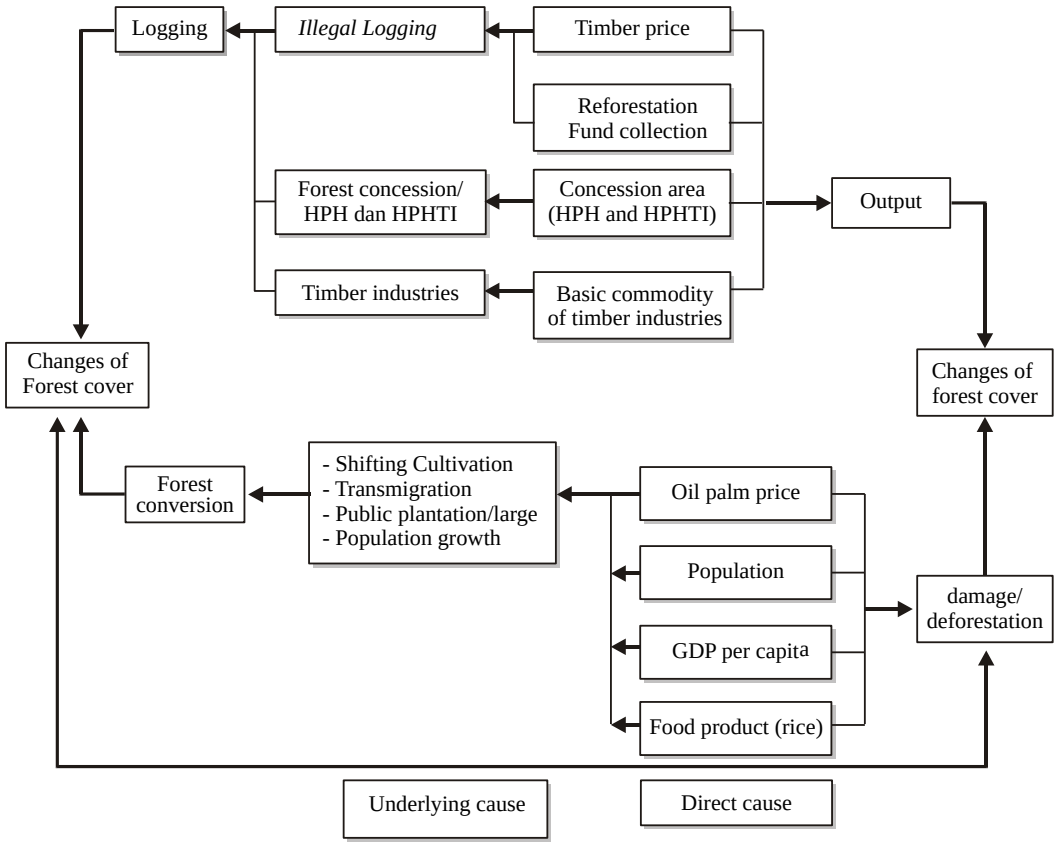
where:

- π : Profit made in farming production (in land expansion)
- A : Technology level.
- L : The number of labour employed to open agricultural land.
- H : Total area
- F : number of input
- p : output price
- q : input price
- w : Wage level
- h(H) : cost of land opening
- i : output of agent's activity
- j : Province

This research used an approach with market theory at family farming level to connect deforestation (described as forest area expansion) and agent's behavior to do deforestation.

Theoretical framework to build an econometric model of forest cover changes is shown in Figure 2 below. It is shown that the causes of deforestation can be differentiated into *direct causes* and *underlying causes* (Contreras Hermosilla, 2000; Kaimowitz and Angelsen, 1998).

The estimated variables in this resesarch are exogenous variables that discuss *supply side* as a direct cause of the change of forest cover as the effect of loging activities presumed to be influenced by timber price, reforestation fund collection, forest concession area (area of HPH and HPHTI), and the realitation of basic commodities for timber industries. The choice of this variable of illegal logging causes is limited only two vaiables: timber price variable and reforestation fund variable. The approach used refers to Palmer's research in 2000 in which



Source: Angelsen.A & Kaimowitz.D (1998)

Figure 2. Conceptual framework to build regression model of forest cover.

direct causes of illegal logging activities were the market and goverment's failure.

If the area is used for other purposes outside forest sector, the exogenous variable of the changes of forest cover is presumed to be influenced by oil palm price, number of population, regional domestic product, gross per capita, and food product (rice product). The approach used refers to Scrieciu's research in 2000.

Model of Forest Cover Change as the Effect of Logging

Based on the theoretical framework above, to understand the influence of logging on forest cover, estimation of exogenous variable toward the change of forest cover is done. The model uses *double log equation* in order to see its elasticity, so that structural equations can be formulated as follows:

$$\begin{aligned} Ln\,FCOV = {} & \lambda_0 + \lambda_1\,(Ln\,PKayu) \\ & + \lambda_2\,(Ln\,DR) \\ & + \lambda_3\,(Ln\,LHPH) \\ & + \lambda_4\,(Ln\,BBI) + \varepsilon_1 \end{aligned} \qquad (2)$$

Forest concession area variable (LHPH) is influenced by timber price (Pkayu), according to Von Amsberg (1994) where the timber price will stimulate logging activities. High price of timber will cause intensity of logging to be done by industries for maximum profit as an effect of the decrease of forest concession area. LHPH = f (Pkayu) or to form the equation:

$$LHPH = \alpha_0 + \alpha_1\ Pkayu + \gamma_1 \qquad (3)$$

Based on the governmental decree number 40 year 1993, the amount of reforestation fund collected is country's income from log production on which certain tarrifs are imposed, adapted to various log types produced. Von Amsberg (1994) stated that timber price would stimulate logging activities, meaning that the high price of timber would cause timber product to increase, and it also cause reforestation fund to rise. So, timber production = f (timber price) or to form an equation:

$$QKayu \;=\; \beta_0 + \beta_1\ Pkayu + \omega_1 \qquad (4)$$

This research model is categorised as simultaneous equation model. The solution of this simultaneous equation with different problem identification can be done with *indirect least squares* method. (indirect smallest quadratic method).

Model of Forest Cover Change as the Effect of Forest Conversion

To understand the influence of forest conversion on forest cover exogeneous variable estimation was done. This model uses *double log equation* to see elasticity. So, the sturctural equation can be formulated as follows:

$$\begin{aligned} Ln\,FCOV = {} & \delta_0 + \delta_1\,(Ln\,Psawit) \\ & + \delta_2\,(Ln\,Pop) \\ & + \delta_3\,(Ln\,GDPPC) \\ & + \delta_4\,(Ln\,Qpadi) + \eta_1 \end{aligned} \qquad (5)$$

Research Hyphothesis

To direct this research to the problem and its objectives, the hypothesis are formulated as follows:

1. Timber price variable (Pkayu), forest concession area (LHPH) and industrial basic commodity (bbi) influence the changes of forest cover (FCOV*)* negatively and significantly.
2. Since the forest concession area is influenced by the timber price, that influence negatively and siginificantly, reforestation fund variable (DR) influence timber price positively and significantly.
3. Oil palm variable(Psawit), PDRB per capita (GDPPC), number of population (GDPPC) and food plant production

(Qpadi) influence negatively and significantly. They also have influence on the changes of forest cover (Fcov).

Analysis tool

This research uses Quantitative analysis method using time series data from 2001-2006 and cross section data of 8 provinces on Sumatra island. This research also uses regression analysis of *Generalised Least Squares* (GLS) with panel data for all provinces in Sumatra and then they are predicted using simultanteous equation model.

DATA ANALYSIS

Types and Sources of Data

Data of the forest cover with hectare (ha) in this research was based on the result of estimation from sattellite in the forest area both inside and outside of the forest regions regardless their types. It was because of the limited acces to data, especially spacial data available. Data of forest cover were obtained from Forestry Planning Beurou, and Department of Forestry. Extrapolation approach was used to get annual data based on forest cover from one starting time to another time connected with the speed of deforestation and the density of population in each province on Sumatra Island.

Log price was obtained from the average domestic log price per province adapted to the exchange value of rupiah for US dollar. This data with unit of rupiah/m^3 were taken from ITTO (*international trade timber organisation*) and *Perhutani* (Association of Indonesian Forests). While data of forest concession area with unit of hecatare (ha) was obatained from the sum of forest concession (HPH) area and HPHTI area which were taken from General Directorate of Forest Production, Department of Forestry.

The limited acces to data in the Directorate of Forest Contribution and Forest Product Circulation, Department of Forestry, had caused the researcher not to be able to obtain the data of reforestation fund collection per province. The approach used was by multiplying the sum of log production with certain tarrif that was with the dominant value of US$16,00 for morantee types considering that the production of this type was very dominant in Sumatra. It was also adapted to the exchange value of rupiah for US dollar. Data of the exchange value of rupiah was obtained from Bank Indonesia.

The data of basic commodity for timber industries with unit of m^3 were obtained from Directorate of Processing and Marketing of Forest Product. That data were the one of the realisation of basic commodity of timber industries per province obtained from natural forests through forest concession activitites, legal activities to exploit timber (IPK) to open forest area, industrial plant forests, public forest activities and the result of auctions of illegal logs confiscated by the Department of Forestry.

Data of oil palm price with unit of rupiah per ton (Rp/ton), population with unit of people and gross per capita regional domestic product with the unit of rupiah based on constant price in 2000 were obtained from Central Statistics Bureau/Office. The constant price was used in order that the vlaue would not be influenced by the price change (Mankiw, 2000). While the data of food plant product (rice) with unit of ton were taken from the Department of Agriculture.

ANALYSIS RESULT AND DISCUSSION

Model of the changes of forest cover as the effect of logging

In this research, structural equation estimation on simultaneous equation was solved with *limited information method* with *indirect least squares* / ILS. ILS was used to get value of structural parameter of the over identified equation.

Model of the changes of forest cover as an effect of logging indicated that the forest concession was influenced by timber price, so that it formed a simultanous equation with model:

$$LHPH = \alpha_0 + \alpha_1\ Pkayu + \gamma_1$$

where α_0 is constant of each province.

Thus, the steps of solution for this equation are:

1. to estimate the equation identifying that forest concession area was influenced by timber price. The following table shows the estimation result of the panel regression equation:

Table1. Result of regression equation of forest concession area (LHPH))

Dependent Variabel: LOG(LHPH?)

Variable	Coefficient	t-Statistic	Prob.
PKAYU?	-1.16E-07	(-3.716975)*	0.0006
Fixed Effects			
NAD—C	13.76745		
SUMUT—C	13.40581		
RIAU—C	14.54182		
SUMBAR—C	12.81384		
LAMPUNG—C	12.05050		
BENGKL—C	10.94233		
SUMSEL—C	13.83237		
JAMBI—C	13.91926		

R-squared = 0.999777
Adjusted R-squared = 0.9999
*Significant at α = 1%

Source: Processed Data

Estimation result shows that timber price variable influenced the forest concession area negatively and significantly. It was based on the t-statistical probability value of 0.0006<0.005 (pada α=1%) and resulting the equation:

$$Ln(LHPH) = \alpha_0 - 1{,}16 * 10^{-7} * Pkayu$$

This shows that one rupiah increase of timber price would simultaneously reduce the forest concession to $1.16*10^{-7}$%. While the value of R^2 as much as 0.999777 explains that variety of timber price variable towards forest concession was 99.98%, while the role of other variables in explaining the forest concession area was 0.02%.

2. to obtain the predicted value of HPH area by substituting timber price (Pkayu) for each province.
3. substituting the predicted value of forest concession area with its actual value when model of the changes in forest cover as an effect of logging was estimated.

Model of changes in forest cover as a result of logging also identified that log production area was influenced by timber price making an equation:

$$QKayu = \beta_0 + \beta_1\ Pkayu + \omega_1$$

where β_0 is constant for each province.

The solution steps for this equation are:

1. estimating equation that identifies that timber price was influenced by timber production. The following table shows the estimation result of panel regression equation:

Table 2. Result of regression equation of log production

Dependent Variables: LOG (Qkayu?)

Variables	Coefficients	t-Statistics	Prob.
PKAYU?	7.55E-07	(5.862099)*	0.0000
Fixed Effects			
NAD—C	9.722315		
SUMUT—C	12.87082		
RIAU—C	14.10432		
SUMBAR—C	10.19562		
BENGKL—C	8.226591		
LAMPUNG—C	10.39759		
SUMSEL—C	13.51337		
JAMBI—C	11.88856		

R-squared = 0.996064
Adjusted R-squared = 0.995256
*Significant at α = 1%

Source: Processed Data

Estimation result shows that timber price variable influenced the forest concession area positively and significantly. It was

based on the t-statistic probabiliy value as much as 0.0000<0.005 (pada α=1%) and resulting an equation:

$$QKayu = \beta_0 + 7{,}55 * 10^{-7} * Pkayu$$

It shows that one rupiah increase of timber price will simultaneously increase log production to $7.55*10^{-7}$%. While the value of R^2 as much as 0.996064 explains variety of timber price towards log production variable as much as 99.61%, while other variables has role in explaining HPH area as much as 0.39%.

2. to determine predicted Q value of timber by substituting the value of timber price (Pkayu) for each province and its anual period. Multiplying predicted Q of timber with tarrif in order to obtain predicted value of reforestation fund.
3. substituting predicted reforestation fund value with its actual value when model of forest cover change as a result of logging is estimated.

With logarithm of independent variable of timber price (LnPkayu), logarithm of basic industrial commodity (LnBBI), logarithm of actual forest concession area (LnHPHakt) and logarithm of actual reforestation fund (LnDRakt). The estimation result of model of forest cover as the effect of logging was obtained as follows.

Table 3. Estimation result of model of changes in forest cover as the effect of logging.

Dependent Variabel: FCOV (Forest Cover)

Number	Independent Variabel	Coefisien	t-stat (prob)
1.	Ln(Pkayu)	-0.102585	-2.519455 (0.0163)**
2.	Ln(BBI)	-0.012699	-2.557426 (0.0149)**
3.	Ln(LHPHakt)	0.031537	1.315220 (0.1968)
4.	Ln(DRakt)	0.005088	7.958617 (0.0000)*

R-squared = 0.9999
Adjusted R-squared = 0.9999
*Significant at α = 1%
**Significant at α = 5%

Source: Processed Data

$$Ln\ FCOV = c - 0{,}103 * Ln\ PKayu + 0{,}005 * Ln\ DRakt + 0{,}032 * Ln\ LHPHakt - 0{,}013 * Ln\ BBI$$

Values of C (constant) are different among provinces:

NAD	: 16,264	Sumut	: 15,545
Riau	: 16,004	Sumbar	: 15,329
Bengkl	: 14,645	Jambi	: 15,069
Sumsel	: 14,612	Lampung	: 13,535

The estimation result had value of R^2 as much as 99.99%. This value shows the ability of the model to explain the variety of changes in forest cover as a result of logging as much as 99.99%, while the role of other variables in explaining dependent variables was 0.01%.

Based on the estimation result, the value of t-stat probability obtained was:

1. timber price variable (LnPkayu) as much as 0.0163<0.025 (significant at α=5%). It means that timber price variable ini (LnPkayu) influenced forest cover variable (LnFcov) significantly. It also shows that 1% increase of timber price variable (LnPkayu) would reduce 0.103% forest cover variable (LnFCov).
2. t-stat probability value variable of industrial basic commmodity (LnBBI) was 0.0149<0.025 (significant at α=5%). It means that industrial basic commodity variable (LnBBI) influenced forest cover variable (LnFcov) siginificantly, showing that 1% increase of industrial basic commodity variable (LnBBI) would reduce 0.013% of forest cover variable (LnFCov).
3. t-stat probability value variable of actual HPH area (LnHPHakt) was 0.1968>0.025 (not significant at α=5%). It means that actual forest concession variable (LnHPHakt) did not influence forest cover variable (LnFcov).
4. t-stat probability value variable of actual reforestation fund (LnDRakt) was

0.000<0.005 (significant at α=1%). It means that actual reforestation fund variable (LnDRakt) influenced forest cover variable significantly, showing that 1% increase of actual reboisation fund variable (LnDRakt) would add 0.005% to forest cover variable (LnFCov).

Statistically, all of the independent variables in this model alltogether influenced the forest cover variable (LnFCov) significantly. This was based on F-stat probability value of 0.000<0.05 (significant at α=5%).

Economic analysis of independent variables of the changes of forest cover shows that:

1. the first significant parameter influencing changes in forest cover was timber price. The rise in timber price in Sumatra stimulated illegal logging practice. The rise in timber price as a result of high demand made illegal loggers try to get big profit in a short time which was obtained as a result of low production cost because they neither pay tax nor spend expense for planning nor infrastructure building. Consequently, the rise in timber price had triggered the forest cover reduction.
2. The second significant parameter influencing the changes of forest cover was industrial basic commodity. The enormmous need for industrial basic commodity and the high price of timber cuased the timber industry owners who did not have forest concession not to be able afford to buy timber legally. To fulfill basic commodity of their industry, the industry owners would buy timber from illegal logging. So, the need for industrial basic commodity had stimulated illegal logging practice.
3. The third significant parameter influencing the changes in forest cover was reforestation fund. Reforestation fund had a positive influence on the changes of forest cover. Although it had relationship as expected, the coeficient obtained shows that reforestation fund was not managed and used to rehabilitate forests effectively yet.
4. The actual area of forest concession (LHPHakt) did not influence the changes of forest cover significantly. It shows that reforestation level at production forests that had license for forest concession was high as a manifestation of industrialists' responsibilty to manage forests sutainably.

Model of changes of forest cover as a resutl of forest conversion

With logarithm of independent variable of timber price (LnPsawit), logarithm of PDRB per capita (LnGDPPC), logarithm of population (LnPop) and logarithm of food product (LnQpadi), estimation results were obtained as follow:

Table 4. Estimation result of Model of changes of forest cover as a result of forest conversion

Dependent Variable : FCOV (Forest Cover)

Number	Independent Variable	Coefisient	t-stat (prob)
1.	Ln(Psawit)	-0.085380	-2.429947(0.0202)**
2.	Ln(GDPPC)	-0.355044	-2.805366 (0.0081)**
3.	Ln(Pop)	-0.230609	-0.983152 (0.3321)
4.	Ln(Qpadi)	0.981711	29.02131 (0.0000)

R-squared = 0.9999
Adjusted R-squared = 0.9999
*Significant at α = 1%
**Significant at α = 5%

Source: Processed Data

$$Ln\,FCOV = c - 0{,}085 * Ln\,PSawit - 0{,}355 * Ln\,GDPPC - 0{,}231 * Ln\,Pop + 0{,}982 * Ln\,Qpadi$$

The values of c (constant) were different for each province:

NAD	: 10,850	Sumut	: 9,793
Riau	: 12,428	Sumbar	: 9,896
Bengkl	: 10,150	Jambi	: 15,069
Sumsel	: 9,186	Lampung	: 8,018

The estimation result had value of R^2 as much as 99.99%. This value show that the model had ability to explain variety of changes of forest cover as a result of forest conversion as much as 99.99%. While the role of other variables in explaining dependent variable was 0.01%.

Based on estimation result, t-stat probability value obtained was:

1. t-stat probability value variable of oil palm price (LnPsawit) was 0.020<0.025 (significant at α=5%). It means that oil palm variable (LnPsawit) influenced forest cover variable (LnFcov) significantly, showing that 1% rise of oil palm price variable (LnPsawit) would reduce forest cover variable (LnFCov) by 0.085%.
2. t-stat probability value of PDRB per capita variable (LnGDPPC) was 0.0081<0.025 (significant at α=5%). It means that PDRB per capita variable (LnGDPPC) influences forest cover variable (LnFcov) significantly, showing that 1% rise of PDRB per capita variable (LnGDPPC) would reduce forest cover variable (LnFcov) by 0.355%.
3. Although population variable shows sign as expected, its t-stat probability value (LnPop) was 0.3321>0.025 (not significant at α=5%). It means that population variable did not influence the changes of forest cover.
4. t-stat probability value of rice production variable (LnQpadi) was 0.0081<0.001 (significant at α=1%) but the sign obtained was not suitable with the hypothesis. It means that rice production variable did not influence the forest cover.

Statistically, all independent variables in this model altogether influenced the forest cover variable (LnFCov) significantly. It was based on the F-stat probability value of 0.000<0.05 (significant at α=5%).

While economics analysis of independent variables toward the changes of forest cover shows that:

1. the first significant parameter influencing the changes of forest cover in Sumatra was PDRB (gross regional domestic product) per capita. The increase of PDRB percapita caused the forest expoitation to increase. It was caused by the increase of farming and forest product consumption. The high demand had motivated farmers around the forest occupy forest illegally to be planted with agricultural commodity. Farm land expansion toward forest area was also done to increase farming/plantation product. While demand for forest product for settlement was increasing in line with the population growth.
2. the second significant parameter influencing the changes of forest cover in Sumatra was the price of oil palm. The rise of oil palm price had stimulated investors to propose for forest release (pelepasan) for oil palm plantation area.
3. Although insignificant, the direction of population variable shows the increase in population growth will rise the need of land for farming and settlement.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

From the result of analysis using regression toward model of the changes of forest cover as a result of logging and model of the changes of forest cover as a result of forest conversion using *Generalised Least Square* (GLS) method, it can be concluded:

1. based on panel data with 8 provinces in Sumatra between 2001-2006 using *fixed effect* model, both logging activities and forest conversion had contribution to the changes of forest cover.

2. timber price simultaneously influenced the area of forest concession negatively and significantly with elasticity of $1.16*10^{-7}$, which shows that the high price of timber would cause logging intensity. So, timber price simultaneously also influenced the changes of timber product positively and significantly with elasticity of $7.55*10^{-7}$.
3. in the model of the changes of forest cover as a result of logging, timber price variable influenced the changes of forest cover negatively and significantly with elasticity of variabel of 0.103. It shows that the rise of timber price in Sumatra stimulated *illegal loging* practice. The rise of timber price caused illegal loggers to try to get big profit in a short time which was obtained becuase of low production cost. The basic industrial commodity was the second variable that also influenced the forest cover negatively with elasticity of 0.013. The enormous need for basic commodity together with high price of timber made the timber industry owners who did not have forest concession not be able to aford to buy timber legally. Therefore, to fulfill the basic commodity need for their industries, they would buy timber from illegal logging. So, the demand for industrial basic commodity had also stimulated illegal logging practice. While actual reforestation fund collection (DRakt) influenced positively and significantly showing that the reforestation fund had been managed and used for forest rehabilitation as expected although it had not given maximum result yet.
4. In the model of the changes of forest cover as a result of forest conversion, PDRB per capita variable influenced forest cover negatively and significantly with elacticity of 0.355. It shows the rise of PDRB per capita caused the forest land exploitation to increse as a result of the increase of farming/plantation and forest product consumption. Oil palm price was the second significant variable that also influenced the forest cover negatively with elasticity of 0.085. The rise of oil palm price had motivated investors to propose the release of forest area for oil palm area, so that variable had role in reducing the forest cover area as an impact of forest conversion in Sumatra.

Recommendation and Policy Implication

Based on the result of this research, discussion, and conclusion above, the writer suggest the followings:

1. We can keep the forest cover area as the effect of logging by reducing both the timber price and the need for industrial basic commodity. However, it is difficult to do them because they are related to market mechanism although these two variables have strong indication to stimulate *illegal logging* practice. Therefore, it is necessary for the government both central and local, especially Provincial Office of Forestry in Sumatra, to do some proper efforts. Among of them are:
   - To create laws and regulations which are comprehensive and strick so that there will be no confussion or duplication among them.
   - To strengthen supervision and strict law enforcement by enforced the authorised office.
   - To give intensive socialisation about the need to preserve forests.to people living around them.
   - To implement previous concession policy that is suitable with plant regeneration circle, maximum 55 years. It is aimed to give opportunity to forests to repair their condition and also to be used by present and future generations.
2. We can preserve or reduce the forest cover area as a result of forest conversion by reducing both PDRB per capita and the price of oil palm. However, deforestation is

difficult to handle if we use those two ways only. There should be a strong commitment in all elements of community including both central and local government for forest preservation. One of them is:

- The policy to release forest area for large plantation area (conversing forest function for plantation) should consider not only the economic aspect but also the balance among economic, social, and ecological ones. In addition, it must be realised, accepted, and agreed by all parties.

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