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An Econometric Model for Deforestation in Indonesia

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An Econometric Model for Deforestation in Indonesia

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Abstract

The aim of this paper is to develop an econometric model of deforestation in Indonesia using time series analysis based on the annual data from 1961 to 2000. From the model, we should be able: (i) To examine the forces of agricultural and timber sectors to forest decline; (ii) To distinguish the sources, direct and underlying causes of deforestation; and (iii) To identify macro-level economic factors that give pressures on deforestation. In order to achieve these purposes, a two-stage methods for the recursive system is chosen. The robustness of the estimation is checked to ensure there are no serial correlation and heteroskedasticity in all our equations. The main findings of model estimation show that, the forest product exports and the change in cereal cropland are the main sources of deforestation in Indonesia. Therefore, the factors determining the two sources become important to be taken into consideration. However, further examination on the underlying factors of deforestation in Indonesia are adversely affected by poor estimators given by the model.

Keywords: Deforestation, econometric model, Indonesian forest
JEL Classification: Q23, C32

Introduction

Indonesia has the third largest area of tropical humid forests in the world, after Brazil and the Democratic Republic of Congo (FWI/GFW, 2002). Officially, about 78 percent of 189 million hectares of its land mass is classified as forestland but the actual extent of forest cover is remained unclear due to data reliability, with estimation ranging from 92 to 112 million hectares (World Bank, 2000). These forests serve as a main contributor to Indonesian economy in forms of gross domestic product, export earnings, and job creations (Nasendi 2000). The significance of Indonesian forests is also recognized internationally because of their biodiversity and their role as the world lung in absorbing global emission of carbon dioxide.

Sadly, Indonesia is listed at the second position amongst the top deforesting countries with the annual loss of 1.3 million hectares during 1990-2000 (Table 1). Another report not only provides a greater estimation of the rate of the forest decline in Indonesia, but also suggests that its rate has accelerated, from about 1.6 million hectares per annum in 1985-1997 to 1.38 million hectares during the period of 19972000 (Purnama 2003).

Table 1 **Top ten countries with the greatest annual forest cover loss, 1990-2000** (in 1000 hectares)

Ranking	Country	Annual loss	Ranking	Country	Annual loss
1	Brazil	-2 309	6	Myanmar	-517
2	Indonesia	-1 312	7	Nigeria	-398
3	Sudan	-959	8	Zimbabwe	-320
4	Zambia	-851	9	Argentina	-285
5	D. R. Congo	-532	10	Australia	-282

Source: FAO (2001), *processed*.

Indonesian forests have been exploited massively since mid 1970's soon after the new government led by President Suharto ruled out the status of all forest areas into estate forests for government income generating purposes. Due to the lack of infrastructure and the need for quick revenue, the initial investment in forestry sector was to directly extract the logs for exports. Indonesia, then, appeared to be the world's largest exporter of tropical hardwood in 1978 (Aswicahyono 2004). During 1980's the government launched industrialization program in the forestry sector to increase value added of exported forestry products (Christanty and Atje 2004). The government encouraged the development of sawn mill and plywood industries by increasing taxes and then banning log exports but introducing tax holiday to timber industry. Soon after that, Indonesia shifted to be the largest exporters of plywood in the world. In 1990's the international market for plywood products weakened but this was not the end of demand forces on forest clearing in Indonesia. Pulp and paper industry has risen and continued to exhibit a strong growth in its exports. This recent trend has raised concerns that demand of timber by the industry is already exceeding sustainable harvest rate (Barr 2001).

The pressure on forestland has been also widely recognized to meet the growing need of agricultural sector for food self-sufficiency and export crop promotion (Erwidodo and Astana 2004). Self-sufficiency in rice was the primary goal of agriculture sector in the early stage of national development program. Later, the government promoted investment in its main agricultural export crops of rubber, palm oil, coffee, tea, pepper and tobacco. To boost the production, not only forestlands have been cleared for crop plantation but also the input subsidies for fertilizer, pesticides and irrigation have been imposed, which later caused land degradation problems (Barbier 1998).

Since the high rate of deforestation in Indonesia seems to co-exist with the extension of commercial logging into forests and growing demand on forestland for agriculture land, this essay attempt to examine the relationship between deforestation and the forces from wood extraction and agriculture expansion using a time-series econometric method. According to a comprehensive review on 147 economic model of deforestation (Anglesen and Kaimowitz 1999), there is no economic model of deforestation that have attempted to use time-series national-level data for Indonesia so this essay also aimed at filling the gap on such study.

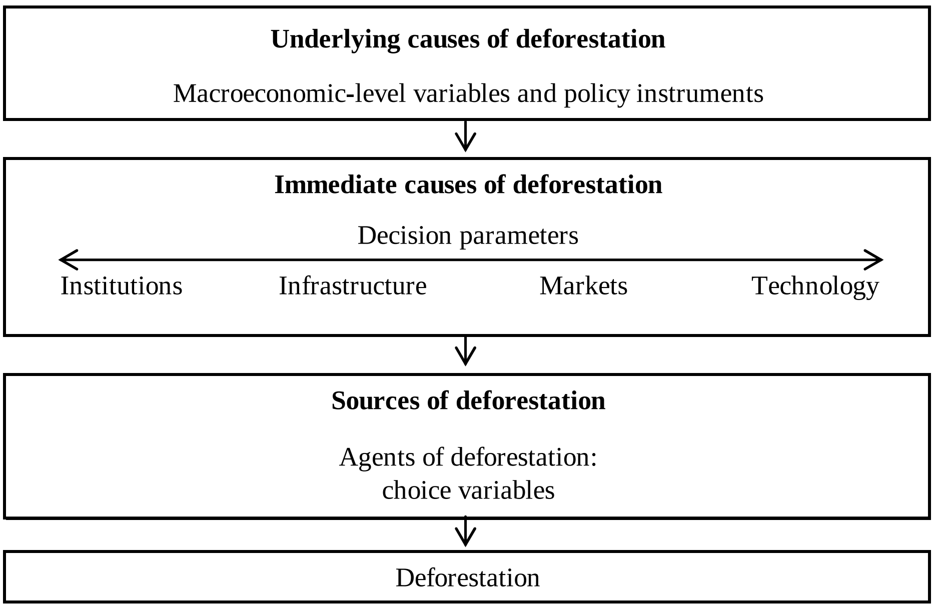
The organization of this essay will be as follows: the selected literature concerning deforestation is first reviewed, and issue in modeling deforestation is highlighted. Then, a conceptual framework of our deforestation model is presented along with data and its source. The econometric specification and its estimation issue are discussed. Finally, the results are presented with the discussion on important consequences of this study.

Literature Study

In searching the explanations for tropical deforestation, it appeared previously that shifting cultivators and population growth were to blame for the main sources of deforestation but later studies revealed that timber industry and agricultural sector are the main factors behind forest decline (Sunderlin and Resosudarmo 1996).

The complexity of deforestation problems around the world has brought some studies to classify the interaction of tropical deforestation causality into several categories. They can be defined generally as direct (or proximate) causes and underlying causes of deforestation (Rowe, Sharma and Browder, 1992; Geist and Lambin, 2002). Besides two categoriess, Contreras-Hermosilla (2000); and Anglesens and Kaimowitz (1999) added another group of variables, that is, agents of deforestation.

Figure 1. Variables Affecting Deforestation



Source: Angelsen and Kaimowitz, 1999: 75

More specifically, Angelsen and Kaimowitz (1999) define five groups of variables needed for deforestation models: the magnitude and location of deforestation as the main dependent variable; the agents of deforestation, which can be examined through their involvement in converting the land and their characteristics; the choice variables, which are the set of options available to allocate the land for the agents; agents' decision parameter which consists the external variables that affect agents' decisions; the macroeconomic variables and policy instruments, which are the group of variables that affects the agents' decision (see figure 1).

However, current literatures on economic models of deforestation make no distinction between direct and indirect causes of deforestation in their models but rather to put all variables in a single equation. As a result, the relationship between deforestation and multiple causative factors are many and varied, showing no distinct pattern. For example, it is reported that population growth increases deforestation in some studies but the other studies find it reduces deforestation (Angelsen and Kaimowitz 1999).

The work of Kant and Redantz (1997) is an exception and offers a better way to modeling deforestation because they are able to classify the causes of tropical deforestation in two levels: the first-level (or direct) causes and second-level (or indirect) causes. Then they developed one equation in first-stage where deforestation as dependent variable; and four first-stage causal factors, consisting consumption and exports of forest products and changes in land usage for cropland and pasture as independent variables. All the four explanatory variables in the first-stage equation are determined by the second-stage causes of deforestation through four equations where most discussed factors in deforestation such as population and income as the explanatory variables.

Conceptual Framework

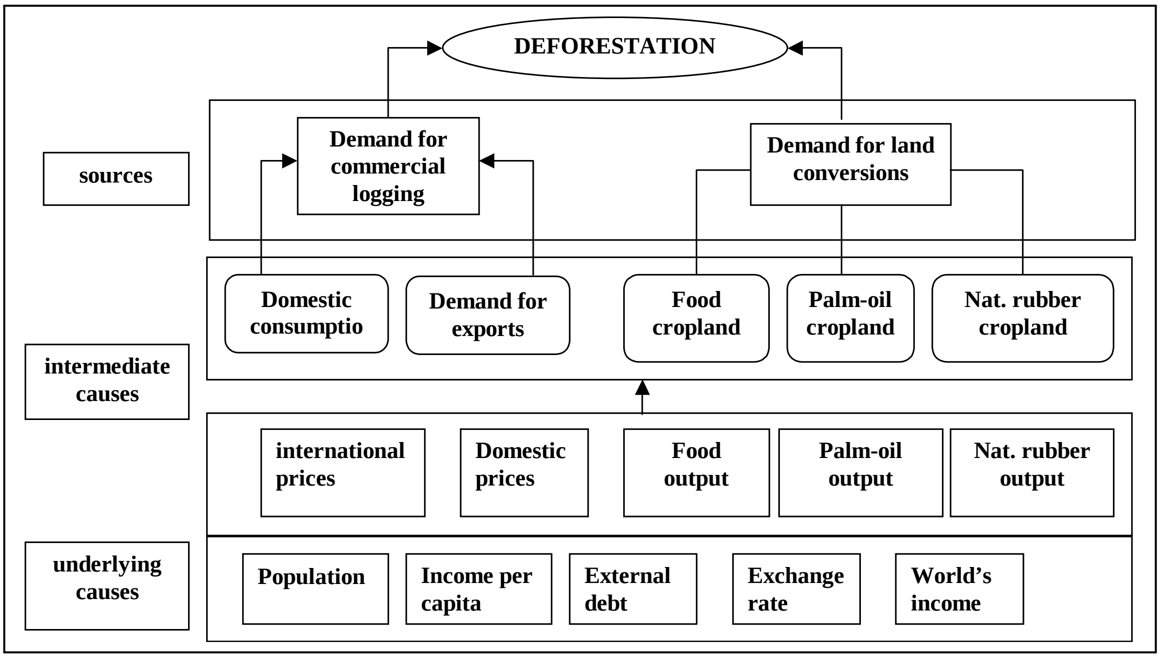
Following Kant and Redantz’s model (1997), we develop our model in the same way but with some modifications. The first modification is needed due to the fact that our model is a time series analysis not a cross-sectional one. Therefore, we will address different kind of econometric issues in modeling process.

The next modification is made to capture specific factors that more important in Indonesian case. The dynamics of the agriculture sector in Indonesia is too simplistic to be expressed in one equation as in the Kant and Redantz's model. Therefore we develop three equations to capture different trends in food cropland, oil-palm cropland and natural rubber cropland, respectively. However we omit pasture equation because it is less important in Indonesian case. The previous study also suggest that also suggests that increase in pasture is not significant in affecting deforestation in the region of Asia (Kant and Redantz 1997).

The final model is made off eight equations. The first equation consists of five explanatory variables shows the two sources of deforestation, i.e., demand for forests extraction due to domestic consumption and exports as the first two intermediate causes; and demand for land conversions due to the growing demands for food, palm-oil and natural rubber as the three additional intermediate causes.

All five intermediate causes are determined in the second-stage system. The intermediate causes for forestry are explained in two equations, consisting consumption of forest product and export of forest products. Meanwhile the intermediate causes for agriculture are expressed by three equations, containing respectively the changes in cereal cropland, oil-palm cropland and rubber cropland. The model framework of this study is given in figure 2.

Figure 2 **Deforestation Model Framework**



The deforestation equation shows the relationship between the amount of forest loss with the amount of round wood consumed, the amount of forest products exported, change in food cropland, change in oil palm cropland and change in natural rubber cropland. Each equation in the second-stage that become explanatory variables in the deforestation equation will be discussed in order.

For the roundwood consumption equation, the key variables explain individual's consumption following consumer theory is income level. Hence, the national consumption will be determined by the gross domestic product (GDP). the income level is referred to Indonesia's GDP in constant term (2000 prices) and valued at domestic currency.

The other main determinant is population, which is one of most discussed underlying factor of deforestation. Many analysts have linked the pressures of population on deforestation to shifting cultivations activity, as noticed by Myers (1994: 35-27) and discussed intensively by Jepma (1995: ch. 5). However, in the round wood consumption an increase in population increases demand for the wood products. Therefore, here, we take the impact of population on deforestation as indirect, as also suggested by Palo (1994: 45). The long run expected sign of all variables is positive.

The equation of forest product export consists three main explanatory variables: prices, real exchange rate, foreign income and the amount of debt service. The export price is international price denominated in US dollar. The expected sign of price is negative assuming demand-side approach (Kant and Redantz 1997:61)[1].

To show the export competitiveness of Indonesia there are two options available, i.e., the revealed comparative advantage (RCA) index and real exchange rate (RER). However we prefer RER or RCA because RCA is more appropriate to use in cross-country analysis[2]. RER represents the export competitiveness of a country because an increase in RER will make the county's price more expensive therefore will reduce demand for exports.

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[1] The sign of price can be argued to be positive if looked from supply side and negative from demand side. As the export quantities we use are derived form the actual exports, which means that these quantities represent the demand faced by exporter, the negative sign looks more plausible.

[2] RCA is an index based on the ratio of a country's export for specific commodity to its total export. Since it is constructed after export data, in time series analysis we can not treat it as one of the determinant factors of exports. However, we may use it for cross-country analysis as a proxy for the differences in competitiveness across the countries due to differences in their comparative advantages.

Foreign income or importer's income in particular will determine the demand for a partner's country exports. Here, we choose the Japanese income as a proxy of the importer because of its dominant share in export market of forest product from Indonesia[3]. The impact of Japanese GDP on Indonesia's exports for forest products should be positive.

Export of forest products contributes the largest foreign reserve flows in Indonesia's non-oil sectors. Therefore it is suspected that the government had promoted the forest product export in order to obtain certain amount of foreign reserve to service the large amount of Indonesian debt. As a result, we expect the positive effect of debt services on forest product exports.

In cereal cropland equation, the key explanatory variables determining change in food cropland are variation in the cereal outputs, change in population and change in income per capita. Variation in the output of cereals is represented by its production index. The need to feed large population in developing countries is as the main reason for their governments to pursue agriculture expansion towards food self-sufficiency (Capistrano 1994: 76). Therefore an increase in population increases demand for cereal lands. Income per capita affects the demand for cereal cropland indirectly based on the fact that a better income encourages people to work in non-agriculture sector. As a result, an increase in income per capita will be positively associated with less demand on cereal cropland. In sum, the sign of coefficients of the first two variables should be positive while the last should positive.

[3] The set of data obtained from FAO statistics home page : http://apps.fao.org/faostat/forestry/

For oil palm sub-sector, the main variables affecting change in oil palm cropland are external debt, world price, real exchange rate, income per capita and population. Crude palm oil production has played an important role as a valuable source of foreign reserve when exported and as the raw inputs of the main cooking oil consumed in Indonesia (Cason 2002: 223). The world price, real exchange rate and the amount of external debt will express the driving factor of exports while population serves as the variable affecting domestic consumption of palm oil.

The coefficients of external debt, real exchange rate and population are expected to be positive. Meanwhile the international price coefficient is more likely to be negative by assuming international demand driving the production so an increase in world price reduces the demand for cropland area following the decline in output demanded.

The last equation is for natural rubber sub-sector. According to FAOSTAT data, most of Indonesia's rubber outputs are for international supply[4]. Therefore variation in outputs, change in international prices and total external debt and economic growth are meant to be the key variables explaining the growing land area needed for rubber plantations. The expected signs for all coefficients are positive, except for international price due to demand driven assumption.

[4] During the period of examination (1961-2000), the average ratio of the amount of rubber exported to the total production is about 93%.

Data and its Sources

Most data in agriculture and forestry are from FAO statistics database, available on line at www.apps.fao.org. This database has enabled us to create a data series from 1961 to 2000. The macroeconomic data are obtained from International Financial Statistics of the IMF (CD-ROM August 2004) and The World Development Indicators of the World Bank (CD-ROM July 2004). Table 2 exhibits the definition and sources of the data used in this study in detail by sector.

Table 2 **Variable Descriptions**

SECTOR	VARIABLES	DESCRIPTION	UNITS	SOURCE
Forest	DEF	Annual forest cover decline	‘000 hectares	FAOSTAT, WB
	RWCON	Annual industrial roundwood consumption	million M3	FAOSTAT
	FOREXP	Annual forest product exports	million M3	FAOSTAT
Agriculture	DCERL	Annual change in cereal harvested area	‘000 hectares	FAOSTAT
	DPALML	Annual change in oil palm harvested area	‘000 hectares	FAOSTAT
	DRUBL	Annual change in rubber harvested area	‘000 hectares	FAOSTAT
	DCERIND	Annual change in the cereal production index (1999-2001=100)		FAOSTAT
	DCPOP	Annual change in production of crude palm oil (CPO)	‘000 metric tones	FAOSTAT
	DRUBP	Annual change in production of rubber	‘000 metric tones	FAOSTAT
International Prices	EXPR	Forest product export prices	US $ per M3	FAOSTAT
	DICPOPR	Annual change in the international CPO price indices (Malaysia, N.W. Europe, 2000 = 100)		IMF
	DIRUBRR	Annual change in the International rubber price indices (2000=100)		IMF
Macroeconomic	TGDP	total GDP (2000 prices)	Million Rupiah	IMF (processed)
	DGDPCAP	Annual change in GDP per capita	Million Rupiah	IMF (processed)
	GDPGR	The real growth of GDP	Percent	IMF (processed)
	EXDEBT	Total External Debt	Billion USD	WB
	DEXDEBT	Annual change in total external debt	Billion USD	
	RER	Real Exchange Rate	Rupiah per 1 USD	IMF (processed)
	DRER	Annual change in RER	Rupiah per 1 USD	IMF (processed)
	JAPGDP	Total GDP of Japan (1995 prices)	Billion USD	IMF(processed)
Demography	TPOP	Total Population	Millions	WB
	DPOP	Annual change in total population	Millions	WB
	POPGR	Annual population growth	Percent	WB

Estimation Models and Methods

The recursive system in this model is estimated using two-stage methods. In the first stage, all the five endogenous variables in second-level systems are regressed to their respective explanatory variables using ordinary least squares (OLS) to obtain these estimated values. In the second-stage, these estimated values now act as the instrument variables to be used in the least squares regression of the final endogenous variable. By doing this two-stage method, the estimation of the recursive model using least squares will be consistent and efficient, based on the important assumptions that cov(Y1, U1)=0 and cov(U1, Ui)=0 where i=2,3,4,5, and 6 (Greene 2003: 397). The complete equations are expressed in the estimation models as follow.

<u>The First-Stage Estimation Models:</u>

(1) $\{1-\sum_{1}^{2} a(L)\}RWCON_t = a1 + a2,3,4,5 \sum_{0}^{3} b(L)$ TGDPt + a6 TPOPt + u2

(2) FOREXPt = b1 + b2 EXPRt + b3 JAPGDPt + b4 EDEBTt + b5 RERt + $\sum_{6}^{9} b(L)$ + u3

(3) DCERLt = c1 + c2 DCERINDt + c3 DGDPCAPt + c4 POPGR + u4

(4) DPALMLt = d1+ d2 DCPOPt + d3 DICPOPRt + d4 DEXDEBTt + d5 DRERt + d6 GDPCAPt
+d7 DEXDEBTt-1 + u5

(5) DRUBLt = e1 + e2 DRUBPt + e3 DIRUBPRt + e4 GDPGR + e5 EEXDEBTt +
e6 DRUBPt + $\sum_{7}^{8} b(L)$ + u6

<u>The Second-stage estimation models:</u>

(1) DEFt = a1 RWCON_HATt + a2 FOREXP_HATt + a3 DCERL_HATt
+ a4 DPALML_HATt + DRUBL_HATt + u1

In the first-stage estimations, there is a high probability of error terms being correlated as common problems in time series analysis. In the presence of serial correlation, the

OLS estimates are unbiased and consistent, but inefficient (Gujarati 1995: 410). As a result, inference based on OLS estimates might be misleading. To overcome this problem, lag operators for dependent and (or) explanatory variables will be introduced to capture dynamic patterns of the model. Then, the LM Breusch-Godfrey tests for autocorrelations on residuals will be conducted to check the presence of autocorrelation in the equations (Greene 2003: 271). Due to the use of a small sample in our case, the robustness of the standard errors to the presence of heteroskedasticity then is checked using the white tests (Wooldridge 2001: 399)[5]. All estimations and tests are conducted with help of the econometric package Eviews ver.4.1.

Results and Discussion

The results of the six equations are presented next in terms of the estimated coefficients, t-value and the long-run multiplier when necessary. The significance of impact multiplier is tested using normal procedure of individual tests when for long-run multiplier using the wald restriction tests. The results of serial correlation tests and heteroskedasticity tests are given in Appendix.

<u>Roundwood Consumption</u>

The results of the roundwood consumption equation are as in Table 3. The estimated impact multiplier of national income appears to have a correct sign but it is not statistically different from zero at the critical value of 5 percent.

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[5] Although the major problem in time series regression models is the presence of autocorrelation, heteroskedasticity might also occur in time series analysis, especially in the small sample case.

In the long run, national income also has no effect on roundwood consumption[6]. The insignificancy of national income to affect domestic round-wood consumption may be explained by the fact that logging concession holders, who produce roundwood, and the investors in timber industry being at the same hands. As a result, the consumption of roundwood is likely to be vertically determined by investment in timber industry instead of the effect of aggregate income level.

The estimated coefficients of the impact and long-run multipliers of the population are positive and statistically significant[7]. Population has a cumulative effect on roundwood consumption, which is relatively small in the short-run, that is, 0.139, but which becomes substantially larger in the long-run, that is, 2.152. This indicates that growing population causes a persistent and increasing consumption of roundwood.

Table 3 **Regression results of roundwood consumption equation**

Endogenous variable = RWCONt			
Variable	Coefficient	t-value	LR-multiplier
INTERCEPT**	-13.70812	-2.034687	
TGDPt	0.008341	0.735743	
TPOPt**	0.139272	2.179387	2.1519
$\sum_{1}^{3} b(L)$ TGDP	-0.020871		
$1 - \sum_{1}^{2} a(L)$	0.06472		

R2 = 0.98; ** : significant at 5% (one tail t test).

[6] Under the null hypothesis of no long run effect of the national income variable, the wald test statistic is 4.1052 where the relevant critical value of the F distribution at 5% significance is 4.185. Here our observed TS is smaller than CV so we fail to reject the null hypothesis and conclude that national income have no long run effect on roundwood consumption

[7] Since population has no lagged variables, the individual test using t- distribution is sufficient to test the significance of both short and long-run multipliers, which are statistically significant at 5 percent.

Forest Product Exports

The results of the forest product exports equation are given in Table 4. All coefficients have the correct expected signs but only two that are statistically significant different from zero. The exports are affected positively by the Japanese income and negatively by their prices.

The coefficient of external debt and real exchange rate are not statistically significant. The external debt seems to have null effect on forest product exports because the investment in timber industry in Indonesia dominated by private sectors. Therefore, the revenue from forest product exports that flows to the government will be less important than those from oil and mining sectors. The real exchange rate also fails to explain the variation in forest product exports probably due to the fact that during the period of study Indonesia had adopted various exchange rate systems.

Table 4 **Regression results of forest product exports equation**

Endogenous variable = FOREXPt			
Variable	Coefficient	t-value	LR-multiplier
INTERCEPT	-2.932074	-1.108236	
JAPGDPt**	0.002957	1.994608	0.008896
EXPR**	-0.026478	-1.946430	-0.064246
EXDEBT	0.021354	0.602785	
RER	-0.000275	-0.803858	
$1-\sum_{1}^{4} a(L)$	0.332376		

R2= 0.89; ** = significant at 5% (one tail t-test)

Change in Cereal Cropland

The results of the change in the cereal cropland equation are given in Table 5. The change in the cereal cropland is attributable to the change in its production index and the change in income per capita.

The growth rate in cereal land use is in line with the growth rate in production. This may indicate that efficiency level in terms of land uses for cereal production had relatively unchanged during the period of examination. At the same time, growth in income per capita had negative impact on growth in the cereal cropland. This may suggests that a better income per capita discourage the expansion of cereal cropland.

However population growth is not an important factor explaining the land change use for cereal crops. This situation may exhibit that the growth in population does not necessarily induce the cereal cropland expansions because less young people are willing to work in subsistence agriculture producing staple foods like paddy and maize. High input prices and low output prices are several factors behind the unattractiveness of the cereal crops sub-sector.

Table 5 **Regression results of the change in cereal cropland equation**

Endogenous variable = DCERL		
Variable	Coefficient	t-value
Intercept	-187.3610	-0.438682
DCERINDt***	235.8968	7.523468
DGDPCAPt**	-788.9943	-1.724892
POPGRt	-0.303630	-0.111767

$R2= 0.62$; **: significant at 5%; ***: at 1% (one tail t-test)

Change in Oil-Palm Cropland

The results of the change in the oil-palm cropland equation are given in Table 6. Five variables is statistically significant in explaining the variation in land use change for palm oil sub-sector. The expansion in the cropland is along with the expansion in production but not with its international output prices.

The factor that much matters in context of international trade in this case is the real exchange rate. The Rupiah devaluation policy or depreciation made Indonesia's products cheaper internationally. As a result, the demand for palm-oil increases, which in turn inducing land expansion for palm-oil plantations.

The effect of external debt is lagged one period to influence the change in oil-palm cropland. This may suggest that substantial investment in oil-palm sub-sector is come from overseas, which then increases the international liabilities in the following period.

The change in income per capita contributed positively to the change in oil-palm cropland. This indicates that higher income increases demand for CPO as the raw materials for most cooking oil in Indonesia.

Table 6 **Regresssion results of change in oil-palm cropland equation**

Endogenous variable = DPALMLt		
Variable	Coefficient	t-value
Intercept	-13.81905	-1.657791
DCPOPt***	0.018124	2.085043
DICPOPRt**	-0.224319	-2.079911
DEXDEBTt	0.191859	0.152381
DRERt***	0.048829	4.080188
DGDPCAPt***	226.2067	3.013606
DEXDEBTt-1**	2.858095	2.615255

R2= 0.62; **: significant at 5%; ***: at 1% (one tail t-test)

Note: Newey-West HAC Standard errors (lag truncation of 3) is applied here since the white heteroskedasticity indicate the presence of hetreoskedasticity in the equation

Change in Rubber Cropland

The results of the change in the rubber cropland equation are given in Table 7. The variation in the change in the rubber cropland equation is explained by the change its international prices and the rate growth of GDP.

In contrast to the assumption of demand-driven approach, here, the coefficient of the international prices is positive. That implies that supply side approach to prices is more reasonable in the case of rubber. However, the outputs variable is not significant in affecting the change of land under rubber crops. As a consequence, the change in prices is linked to the change in the lands directly without resort to the change in the outputs. The more satisfactory explanation is given by Barbier (1998) who argues that agricultural policy in Indonesia has resulted in the expansion of its main agricultural export croplands including rubber, regardless the trend in the world prices.

The effect of economic growth to the land use change for rubber crops is positive as expected. It is interesting to notice that long-run multipliers of the prices and economic growth are half of those in the short runs. This could indicate that response of change in land to the change in international prices and economic growth being adjusted in the opposite direction in the following periods.

Table 7 **Regresssion results of change in rubber cropland equation**

Endogenous variable = DRUBLt			
Variable	Coefficient	t-value	LR multiplier
Intercept	-2.581869	-0.151864	
DRUBP	0.120776	0.428123	
DIRUBPR**	0.756208	2.005540	0.3742
GDPGR***	0.082875	2.684398	0.0410
DEXDEBT	0.094130	0.048421	
$1-\sum_{1}^{2} a(L)$	2.02083		

R2= 0.47; **: significant at 5%; ***: at 1% (one tail t-test)

<u>Deforestation</u>

The results of the regression of deforestation on the estimated values of five explanatory variables that determined in the second-stage system are given in Table 8. The deforestation is significantly explained by the forest product exports and the change in cereal cropland at 5 percent of significance. The other two variables are not statistically significant in affecting the deforestation.

The coefficient of forest product exports suggests that an annual increase of one million cubic metres of quantity exported contributes to the annual forest cover loss of 24 thousand hectares. The coefficient of change in cereal cropland is 0.3, which is far away from one-to-one relationship between the amount of forest decline and the amount increase in the land under cereal productions.

In general, this model gives a poor estimates as shown by the extremely low of the goodness of fit (R^2) in which only fourteen percent variation in deforestation may be attributed to the variations in its explanatory variables. The main problem with the deforestation model is due to data reliability, which is in this study is derived form FAOSTAT. The technique of data collection by FAO is through the answer of questionnaire distributed by FAO to the reporting countries. The participant's governments in fill the questionnaires may have incentives to underrate the extent of deforestation to avoid the reputation damage.

Table 8 **Regression results of the deforestation equation**

Endogenous variable = DEFt		
Variable	Coefficient	t-value
RWCON_HAT	-1.633690	-0.162652
FOREXP_HAT**	24.91054	1.873048
DCERL_HAT**	0.300320	1.920256
DPALML_HAT	3.476668	1.030126
DRUBL_HAT	0.345862	0.132951

R2= 0.14 ; **: significant at 5% (one-tail t test)

Impact of underlying causes on deforestation

Based on the two variables that significantly determining deforestation, only income per capita is identified as one of factors extensively discussed as underlying causes of deforestation. However, the effect is to ease the rate of deforestation because an increase in income per-capita is suggested to reduce the land expansion for cereal crops. This conclusion is along with the observation Lombardini (1994) in case study of deforestation in Thailand as it is found that the income per capita negatively affected the forest cover.

The others indirect causes are come form international market pressures on forest products in forms of the importer's income and the international prices. The Japanese income is meant to be indirect cases of deforestation in Indonesia through the forest product exports equation.

Conclusions

This study has attempted to develop an economic model for deforestation in Indonesia by using time series data form 1961 to 2000. The results of the model are definitely subject to the limitation of data. Nevertheless, it can be shown that the exportation of forest products from Indonesia to meet the growing demand of international community has resulted in the substantial decline in forest cover. Another pressure comes form the need of land conversions for cereal productions. However, the impact of the change in land uses under cereal crops appears to be much lower than the expectation of one to one relationship. The most frequently discussed underlying variables have been discussed, but the low goodness of fit of our deforestation model prevents us to draw some policy recommendation based on this study.

APPENDIX

Summary of first order serial correlation tests

Roundwood consumption

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.256371	Probability	0.616588
Obs*R-squared	0.335702	Probability	0.562321

Decision: No first order serial correalation

Forest product exports

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.752832	Probability	0.393519
Obs*R-squared	1.013050	Probability	0.314173

Decision: No first order serial correalation

Change in cereal land

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.699152	Probability	0.109620
Obs*R-squared	2.868375	Probability	0.090336

Decision: No first order serial correalation

Change in palm land

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.211971	Probability	0.648547
Obs*R-squared	0.266613	Probability	0.605613

Decision: No first order serial correalation

Change in rubber land

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.202399	Probability	0.656137
Obs*R-squared	0.256443	Probability	0.612574

Decision: No first order serial correalation

Deforestation

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.947934	Probability	0.173405
Obs*R-squared	2.265922	Probability	0.132247

Decision: No first order serial correalation

Summary of White Heteroskedasticity Test

Roundwood consumption

White Heteroskedasticity Test:

F-statistic	0.585695	Probability	0.848054
Obs*R-squared	10.04612	Probability	0.758804

Decision: No heteroskedasticity

Forest product exports

White Heteroskedasticity Test:

F-statistic	0.861954	Probability	0.614313
Obs*R-squared	15.14078	Probability	0.514353

Decision: No heteroskedasticity

Change in cereal land

White Heteroskedasticity Test:

F-statistic	0.715179	Probability	0.640076
Obs*R-squared	4.611378	Probability	0.594531

Decision: No heteroskedasticity

Change in palm land

White Heteroskedasticity Test:

F-statistic	14.94934	Probability	0.000000
Obs*R-squared	33.35207	Probability	0.000853

Decision: there is heteroskedasticity

Note: The problem has been fixed using The Newey-West HAC Standard errors (lag truncation of 3) as appear in Table 6.

Change in rubber land

White Heteroskedasticity Test:

F-statistic	0.732005	Probability	0.707962
Obs*R-squared	9.913666	Probability	0.623535

Decision: No heteroskedasticity

Deforestation

White Heteroskedasticity Test:

F-statistic	0.752814	Probability	0.670363
Obs*R-squared	8.331647	Probability	0.596477

Decision: No heteroskedasticity

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