AN ECONOMETRIC STUDY OF
INDONESIA'S HARDWOOD LOG MARKET
AND THE IMPACT OF GOVERNMENT INTERVENTION

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ABSTRACT

A simple econometric model of Indonesia's hardwood log market, incorporating both foreign and domestic demand, was developed. Hardwood log demand was modelled as a function of log prices, other input prices, end product prices, GDP, exchange rates and government export policies. Hardwood log supply was modelled as a function of hardwood log prices, inventory, and government harvesting fees. Government export policies designed to encourage domestic end-product production were found to be effective in that log export tariffs and lumber export taxes did not significantly reduce demand for Indonesian logs. Over a planned phase-in period, domestic manufacturers increased production of various end-products and the resultant increase in domestic log demand successfully replaced export demand for Indonesian hardwood logs. The estimated model parameters, when significant, had the predicted signs. Estimated elasticities of supply and demand with respect to price were greater than one.

INTRODUCTION

Indonesia has the world's second largest expanse of tropical rain forests. Based on Indonesia's Forest Land Use Plan, 143.9 million hectares or 74.64 percent of Indonesia's total land area
are classified as forest area¹. Forest land use has been classified into five categories based on function: parks and conservation (13.0%), protection (21.1%), limited production (21.2%), regular production (23.5%), and conversion forests (21.2%).

In the limited and regular production forests, hardwood logs are harvested from plantations and natural forests². Plantations, which were developed in Java hundreds of years ago during the Dutch Colonial era, have been managed and maintained by the Indonesian Government, through a state-owned enterprise called "Perum Perhutani." Teak (Tectona grandis) is produced primarily from 2.37 million hectares of plantation forests. Natural forests, which constitute 73 percent of the evergreen rain forests, are found primarily in Kalimantan, Sumatera, Sulawesi, and Irian Jaya. Commercial hardwood logs from the natural forests are dominated by the Dipterocarpaceae family. Standing commercial timber is estimated to be over 2,700 million m³, with a potential biologically sustainable annual yield of 50 million m³ (Directorate General of Forest Utilization and FAO, 1990).

The intensive harvest of tropical forests in Indonesia began in 1970. Logging operations are carried out by state-owned enterprises³, concession holders⁴, and private companies⁵. Log production rapidly increased from 2.6 million m³ in 1966 to 10.9 million m³ in 1970, and reached 24.9 million m³ in 1973. Production peaked at 25.2 million m³ in 1980 (figure 1). About 93.5 percent of the annual log production is extracted from the natural forests.

A log export ban was introduced in 1980 to stimulate development of the domestic plywood industry, to obtain higher and more stable prices for timber exports, and to provide a constant supply of raw materials for domestic wood industries (Allen et al., 1986). A partial log export ban was phased in over the period 1980

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¹ The Indonesian Government owns all forest land and is responsible for its management.

² Harvest volumes in the natural forests (limited and regular production forests) are based on sustainable yield principles and Indonesia's selective cutting and replanting silvicultural system (TPTI).

³ Two state-owned enterprises are PT. Perhutani, which manages the plantations in Java, and PT. Inhutani, which manages portions of the natural forests outside Java.

⁴ The Ministry of Forestry grants concession holders (HPH) the right to harvest and manage a given area of production forests for 20 years. In 1970, there were 71 concession covering working areas of 5.3 million hectares. In 1990, some 59.4 million hectares forest area were allocated to 583 concession holders.

⁵ Private companies (HPPH) are granted short term rights (one or two years) to harvest timber from land clearings in the conversion forest.
to 1984. Only concession holders who were developing integrated plywood plants were allowed to export logs. Before the ban, logs were utilized domestically or exported. The lumber and plywood industries were the primary domestic markets. Plywood industries in several Eastern countries including Japan, South Korea, Taiwan, and Singapore were the primary export markets. Log exports were completely banned in January 1985.

Indonesia's "timber boom" of the 1970's and 1980's significantly influenced the Asian and world hardwood markets (Gillis, 1988; Ostermeier, 1993). In 1970, 3.8 million m$^3$ of hardwood logs, about 75 percent of total production, were exported. Exports peaked at 19.4 million m$^3$ in 1978, and accounted for over half of world trade in tropical hardwood logs (Allen et al., 1986).

The log export ban policy dramatically accelerated the growth of the domestic plywood industry (figure 2). In 1980, 0.95 million m$^3$ of plywood was produced domestically. By 1985, production had reached 4.3 million m$^3$. Plywood production continued to increase after the ban was fully implemented, reaching 9.1 million m$^3$ by 1992. About 90 percent of the plywood production was exported, accounting for 80 percent of world hardwood plywood trade (Handadhari, 1992).

Total lumber production was relatively stable during the study period, except for the three-year boom period, 1986-1988, resulting from the development of public housing (figure 3). Compared to plywood, Indonesia exported very little lumber prior to 1990.
Figure 2 Indonesian plywood production and log exports, 1975-1992

Approximately 70 percent of lumber production was consumed domestically. The markets for lumber exports were primarily Italy, Singapore, and Japan. The Indonesian Government also intervened in the hardwood lumber market by imposing prohibitive tariffs on lumber exports (Government Regulation No. 1134, 1989; and No. 534, 1992). This policy was designed to stimulate the exports of finished wood products, improve the efficiency of forest-resource utilization, and provide jobs. With the high lumber-export tariff, export-lumber prices were no longer competitive in world markets. Lumber exports in 1990 dropped 90 percent from 1989 levels.

Indonesian hardwood log prices are lower than Asian and other hardwood log prices (Ostermeier, 1993). This low price is partially the result of government policies including: reducing competition by banning exports, requiring logging concessions to be vertically integrated, and charging low forest rents. In addition, lower production costs contribute to the low price.

The hardwood log market in Indonesia is an interesting one. Supply and demand of hardwood logs are influenced not only by producers and consumers, but also by government policies. The purpose of this study is to develop a simple econometric model of the Indonesian hardwood log market which incorporates the effects of government intervention.

A number of previous studies have modelled stumpage, log or lumber markets.
There have been several econometric analyses of aggregate supply and demand for stumpage. Brannlund et al. (1985) modelled Swedish pulpwood demand as a function of lumber price, timber price, and the wage rate in the sawmill industry. They modelled supply as a function of timber price, pulpwood price, and harvesting costs.

Daniels and Hyde (1986) modelled supply of North Carolina softwood and hardwood stumpage as a function of stumpage price and inventory, and modeled demand as a function of stumpage price and wood product prices. Newman (1987) modelled southern solidwood and pulpwood stumpage demand as a function of capital, labor, and raw material (stumpage inputs) prices. His stumpage supply equation, however, was similar to Daniels and Hyde. Newman found stumpage supply and demand for pulpwood and solidwood in the Southern timber market were price inelastic.

Cengel and McKillop (1990) specified the aggregate supply of
stumpage supply and demand for pulpwood and solidwood in the
Southern timber market were price inelastic.

Cengel and McKillop (1990) specified the aggregate supply of
South Sea tropical hardwood logs from a producing country as a
function of the delivered log price, exchange rate, export prices,
and the total economically accessible log volumes in each year.
The quantity of logs demanded by plywood industries, in a
particular exporting country, was specified as a function of the
import price of logs, export and domestic prices of lumber and
plywood, prices of other inputs, productive capacity, and stock of
logs or plywood in that country.

With minor exceptions, these studies found supply and demand
were inelastic with respect to stumpage price changes. These
inelastic results are consistent with economic theory, given that
demand for stumpage is derived from the demand for final wood
products (Gregory, 1987). Other related studies include Jackson

THEORETICAL MODEL

The model's theoretical structure was based on stumpage market
models developed by Brannlund et al. (1985), Johansson and Lofgren
(1985), and Newman (1987). Logs are an input in the production of
wood products such as lumber and plywood. Demand for logs,
therefore, is derived from the demand for these products. The
production function for final wood products can be written as
(Johansson and Lofgren, 1985):

\[ Q_t = F \left( o_t^d, c_t \right) \]  (1)

where \( Q_t \) is the quantity of wood products produced, \( c_t \) is the
quantity of logs, \( o_t^d \) is the quantity of other inputs used in the
production of final wood products, and \( t \) is the period
(\( t=1, \ldots ,T \)).

Assuming that log prices and final wood product prices are
fixed for individual producers in both the domestic and
international markets, the profit function for each producer of
wood products in period \( t \) is:

\[ \pi_t(p_l, p_w, p_o) = \max_{(o_t^d, c_t)} \left( p_w F \left( o_t^d, c_t \right) - p_l c_t - p_o o_t^d \right) \]  (2)

where \( p_l \) is the log price, \( p_w \) is a vector of wood product prices,
and \( p_o \) is a vector of other input prices.
Applying Hotelling's lemma, a firm's demand for logs in the $t^{th}$ period is obtained by differentiating the profit function with respect to log price. This yields

$$\pi_{p_1} = c_t^d (p_w, p_1, p_{od})$$

with the expected signs of the estimated coefficients listed below. The sign for other input prices is uncertain, depending on whether those inputs are complements or substitutes for logs (Newman, 1987).

The aggregate demand for logs ($C_t^D$) can be found by summing the N individual wood industries demand functions:

$$C_t^D = \sum_{j=1}^{N} c_{t_j}^d (p_w, p_1, p_{od}) \quad \text{all } t$$

Aggregate log supply can also be obtained in a similar manner. The log supply for individual loggers is assumed to be a function of the log price and other input prices used in log production. The profit function for an individual logger in period $t$ is:

$$\pi_t(p_1, p_o) = \max_{(o_t^s, c_t)} F(o_t^s, c_t) - p_o o_t^s$$

Differentiating with respect to output price yields the following supply function for an individual logger:

$$\pi_{p_1} = c_t^s (p_1, p_{os})$$

The aggregate supply is the sum of the N individual loggers' supply functions and can be written as:

$$C_t^s = \sum_{j=1}^{N} c_{t_j}^s (p_1, p_{os}) \quad \text{all } t$$

where $C_t^s$ is the total quantity of log supplied in time $t$, $c_{t_j}^s$ is the quantity of log supplied by the $j^{th}$ logger, $p_1$ is the log price, and $p_{os}$ is price of other inputs affecting log production.

The expected sign of the log price variable with respect to the log supply is positive, because, ceteris paribus, an increase in price will increase log supply. The sign for other input prices is negative, because an increase in cost of other inputs will decrease log supply.
In equilibrium, supply equals demand so that:

\[ C_t^D (P_w, P_1, P_{o1}) = C_t^S (P_1, P_{o2}) \quad \text{all } t \quad (8) \]

where \( P_1 \) and \( C_t \) are endogenous variables, simultaneously determined. \( P_w, P_1^D \) and \( P_{o2} \) are exogenous.

In addition to the variables developed in the Johansson and Lofgren model, other factors affect the wood product trade in both national and international markets. The level of domestic economic activity influences domestic demand. As the level of economic activity increases, demand for wood products also increases. The exchange rate influences export demand. In general, as the exchange rate increases, logs and wood products become more affordable abroad.

Another factor that influences timber markets is government policy. Political considerations obviously play an important role in determining the market price of a particular product. Imposing tariffs, restricting imports and exports, subsidizing consumption, and restricting production are examples of government intervention.

In the supply model, other inputs incorporated in the model are inventory and harvesting costs. Previous stumpage studies have found these variables to be significant in influencing the shift in log supply. See, for example, Newman (1987), Daniels and Hyde (1986) and Braunnlund et al. (1985).

The complete theoretical model for hardwood logs in Indonesia developed in this study is:

Demand,

\[ Q_t^D = f(P_1, P_w, P_o, E_t, F_t, G_t) \quad (9) \]

Supply,

\[ Q_t^S = f(P_1, C_t, I_t) \quad (10) \]

where,

- \( Q_t^D \) and \( Q_t^S \) are the quantity of logs demanded and supplied respectively;
- \( P_1, P_w, \) and \( P_o \) are the price of logs, final goods, and other inputs;
- \( E_t, F_t, \) and \( G_t \) are the level of economic activity, foreign demand, and government policies; and
- \( C_t, \) and \( I_t \) are harvesting costs and inventory.
The quantity of logs demanded \( Q^D_t \) and supplied \( Q^S_t \), and log price \( P_t \) are endogenous in this system. Price and quantity interact until an equilibrium is reached. The final good prices \( P_v \), other input prices \( P_o \), the level of economic activity \( E_t \), foreign demand \( F_t \), and government policies \( G_t \) are exogenous variables in the demand equation. Harvesting costs \( C_t \) and inventory \( I_t \) are exogenous variables in the supply equation.

**EMPIRICAL MODEL**

As described in the theoretical model, hardwood log demand is a function of log price, final product prices, other input prices, level of economic activity, foreign exchange rates, and government policies. Hardwood log supply is a function of log price, harvesting costs, and inventory.

The weighted average of domestic and export log price indices is used as a proxy for log price. The lumber and plywood prices in both domestic and export markets are incorporated to represent the final good prices, because the sawmill and plywood industries are the primary markets for hardwood logs. As with log price, the weighted average index price of lumber and plywood are used as final good prices.

Other input prices such as labor, capital, electricity, and other materials in the wood product processes should be included in the model. Unfortunately, because of the difficulty of obtaining the raw data, these variables are not incorporated in this study.

Real Indonesian gross domestic product (IGDP) is included as an indicator of economic activity in Indonesia. As a developing country, the Indonesian economy has expanded tremendously during the last two decades. Starting at a real GDP of $30,409 million (U.S) in 1975, the real Indonesia GDP was $72,423 million (U.S) by 1980, and increased to $194,445 million (U.S) in 1990.

The Indonesian-Japanese exchange rate is used as a proxy for the Indonesian-World exchange rate. Japan is the dominant market for Indonesia's hardwood logs, lumber, and plywood. Prior to 1980, Japan consumed about 51.7 percent of Indonesia's log exports. In the 1980's, Japan was the largest importer of Indonesia's lumber (14.4 percent) and plywood (22.3 percent). The real value of the exchange rate between the Indonesian Rupiah and the Japanese Yen also increased from 2.77 in 1975 to 3.84 in 1980, and reached 9.52 in 1990.

Two government-imposed restrictions on log demand must be accounted for. The first is a log export ban which was phased in over the period 1980 to 1984. By 1985, log exports were completely stopped. The second is a lumber export tax imposed in 1990. To incorporate the impacts of these policies, a lumber export tax variable and variables representing the pre-log ban, post-log ban, and the phase-in periods are included in the demand equation.

A complete empirical model for the demand equation of domestic
and foreign markets can be specified as:

\[ DLOG = f(\text{IPLOG, IPLUM, IPPLY, TAX, IGDP, IJEXR, D80, D81, D82, D83, D84, Dpo84, Dpre80}) \] (11)

where:

- **DLOG** is the quantity of log demanded,
- **IPLOG, IPLUM, and IPPLY** are the weighted average index prices of logs, lumber, and plywood respectively,
- **TAX** is the lumber export tax as an indicator to investigate the effect of the government policy,
- **IGDP** is the Indonesia GDP as an indicator of the level of economic activity,
- **IJEXR** is the Indonesian-Japanese exchange rate as an indicator for the foreign market influence,
- **D80, D81, D82, D83, D84**, are variables representing the years during the partial log export ban period:
  - \( D80 \) equals 1 if year = 1980, and 0 otherwise;
  - \( D81 \) equals 1 if year = 1981, and 0 otherwise;
  - \( D82 \) equals 1 if year = 1982, and 0 otherwise;
  - \( D83 \) equals 1 if year = 1983, and 0 otherwise;
  - \( D84 \) equals 1 if year = 1984, and 0 otherwise,
- **Dpo84** represents the period after the ban is fully implemented and equals 1 after 1984, and 0 otherwise, and
- **Dpre80** represents the pre ban period and is the omitted variable which equals 1 during the years before the export ban was initiated, and 0 otherwise.

In mathematical form, the hardwood log demand model can be written:

\[ DLOG = \alpha_0 + \alpha_1 \text{IPLOG} + \alpha_2 \text{IPLUM} + \alpha_3 \text{IPPLY} + \alpha_4 \text{IGDP} + \alpha_5 \text{IJEXR} + \alpha_6 \text{TAX} + \alpha_7 D80 + \alpha_8 D81 + \alpha_9 D82 + \alpha_{10} D83 + \alpha_{11} D84 + \alpha_{12} Dpo84 \] (12)

A priori expected signs for demand equation are shown in table 1.
<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Expected signs</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPLOG</td>
<td>Negative</td>
<td>Wood industries demand fewer logs as the price increases</td>
</tr>
<tr>
<td>IPLUM</td>
<td>Positive</td>
<td>Increased lumber prices will induce the lumber industry to manufacture more lumber which, in turn, will result in increased log demand.</td>
</tr>
<tr>
<td>IPPLY</td>
<td>Positive</td>
<td>Increased plywood prices will induce the plywood industry to manufacture more plywood which, in turn, will result in increased log demand.</td>
</tr>
<tr>
<td>IGDP</td>
<td>Positive</td>
<td>As economic activity increases, more raw materials, including logs, will be utilized.</td>
</tr>
<tr>
<td>IJEXR</td>
<td>Positive</td>
<td>As the exchange rate increases, Indonesian logs become more affordable abroad.</td>
</tr>
<tr>
<td>TAX</td>
<td>Negative</td>
<td>Decreases the amount of lumber exported and consequently log demand.</td>
</tr>
<tr>
<td>D80, D81, D82, D83, D84, Dpo84</td>
<td>Negative</td>
<td>The log export ban reduces log exports and consequently log demand.</td>
</tr>
</tbody>
</table>

In the supply model, government revenues from forest activities are a cost of harvesting. Two government revenues, forest royalty and reforestation fee, are directly related to log production. Forest royalties are charged per m$^3$ of log production, but vary depending on species, sizes, grades, location, and product prices. Reforestation fees are collected by the government for reforestation and forest rehabilitation activities. In 1980, the charge was $4$ (U.S) per m$^3$, raised to $7$ (U.S) per m$^3$ in 1989, and further raised to $10$ (U.S) per m$^3$ in 1990 (Directorate General of Forest Utilization and FAO, 1990).

The total working area of concession holders is a proxy for inventory. Generally, the larger the working area, the more logs available for harvest. In 1970, there were 71 concession holders covering working areas of 5.3 million hectares with a log
production of 10.4 million m$^3$. In 1980, working areas of 582 concession holders, totalling 48.8 million hectares, yielded 25.2 million m$^3$. In 1990, there were 583 concession holders covering working areas of 59.4 million hectares yielding logs at 25.7 million m$^3$. (Ministry of Forestry, 1975-1991; Directorate General of Forest Utilization and FAO, 1990)

The complete empirical model for the hardwood log supply equation is:

$$SLOG = f(IPLOG, REV, AREA)$$

(13)

In mathematical form, the model can be written as follows:

$$SLOG = \beta_0 + \beta_1 IPLOG + \beta_2 REV + \beta_3 AREA$$

(14)

where:

- $SLOG$ is the quantity of hardwood logs supplied,
- $REV$ is government revenues from log production, and
- $AREA$ is the total working area of concession holders.

A priori expected signs for the supply equation are shown in table 2.

Table 2. Independent variables and sign expectation for hardwood log supply ($SLOG$)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Expected signs</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPLOG</td>
<td>Positive</td>
<td>More logs will be supplied as log price increases.</td>
</tr>
<tr>
<td>REV</td>
<td>Negative</td>
<td>As costs of harvesting increase, log supply will decrease.</td>
</tr>
<tr>
<td>AREA</td>
<td>Positive</td>
<td>As the area of inventory increases, log supply will increase.</td>
</tr>
</tbody>
</table>

Three stage least squares (3SLS) was used to estimate the model.
Time series data for 18 years (1975-1992) were used for this study. Data were collected from: (1) Forestry Statistics of Indonesia, Ministry of Forestry, 1975-1991; (2) The Statistical Yearbook of Indonesia, Central Bureau of Statistic; (3) The International Financial Statistics, International Monetary Fund, 1992-1994; and (4) other sources.

1. **Demand and Supply of Hardwood Logs (DLOG and SLOG)**

Supply of hardwood logs (SLOG) was the annual volume of logs harvested, measured in millions of m$^3$. (Source: Statistics of Indonesia, Ministry of Forestry). Indonesia did not import logs.

2. **Weighted Average Index Price of Hardwood Logs (IPLOG)**

The weighted average index price of hardwood logs (IPLOG) is a weighted average of the domestic and export log price indices. IPLOG is obtained by using the following formula:

\[
IPLOG = \frac{(IP_D \times Q_D) + (IP_S \times Q_S)}{Q_D + Q_S}
\]

Where:

- $IP_D$ = domestic log price index (1985=100),
- $Q_D$ = quantity of domestic log consumption,
- $IP_S$ = export log price index (1985=100),
- $Q_S$ = quantity of log exported.

Domestic log consumption ($Q_D$) was determined by subtracting log exports ($Q_S$) from total log production (Source: the Forestry Statistic of Indonesia, Ministry of Forestry). After log exports were totally banned in 1985, domestic log consumption equalled to log production.

The domestic wholesale price index of logs was obtained from the Statistical Yearbook of Indonesia, Central Bureau of Statistics. During the study period, portions of the price index were reported in three different base years. All portions were converted to base age 1985 and divided by the GDP deflator to express the index in real terms. For detailed descriptions of the indices and conversion procedures, see Arifin (1994).

The export price index of logs ($IP_S$) was obtained from the export log price (U.S. $/m^3$) by dividing the foreign exchange revenues from log exports by the volumes of log exports (Source: The Forestry Statistic of Indonesia, Ministry of Forestry). Export prices were adjusted by the GDP deflator to express prices in real terms.

3. **Weighted Average Index Price of Lumber and Plywood (IPLUM & IPPLY)**

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The weighted average index price of lumber (IPLUM) and plywood (IPPLY) were calculated using the same procedure as IPLOG.

4. **Indonesian Gross Domestic Product (IGDP)**

The nominal values of Indonesian GDP were obtained from the International Financial Statistical Yearbook, International Monetary Fund. Data were reported in billions of Indonesian rupiahs. The real IGDP (in U.S. dollars) was calculated by dividing the nominal IGDP by the exchange rate, and then deflated by the GDP deflator.

5. **Indonesian-Japanese Exchange Rate (IJEXR)**

Because Japan is the major market for Indonesia's timber, the real Indonesian-Japanese exchange rate (Rp/Yen) was used as a measure of world market influence. The consumer price indices (CPI) for both countries were used to calculate the IJEXR. The formula for IJEXR was:

\[
IJEXR = \frac{\text{Indonesian-U.S. Exchange rates} \times \text{Japan's CPI}}{\text{Japanese-U.S. Exchange rates} \times \text{Indonesia's CPI}}
\]

Exchange rate and CPI data for both countries were obtained from the International Financial Statistical Yearbook, International Monetary Fund.

6. **Government Revenues (REV)**

The annual government revenue, which was calculated as forest royalties plus reforestation fees, represents a cost of production to loggers. Both revenues are charged per m³ of logs produced and measured in Indonesian rupiahs. Because these fees are expressed in U.S. dollar terms, all other revenues were converted to U.S dollars. The GDP deflator was used to convert nominal prices to real prices.

7. **Working Areas of Concession Holders (AREA)**

The working areas of concession holders (AREA) were used as a proxy for inventory. This data is reported in the Situation and Outlook of the Forestry Sector in Indonesia, Vol.2: Forest Resource Base, 1990.

8. **Lumber Export Tax (TAX)**

Lumber export tax barrier (TAX) represents government intervention in the lumber export market. The tariff on lumber exports in 1990 and 1991 was increased to U.S. $400 per m³, and increased again by U.S. $1,000 in 1992 (Source: Government Regulation No. 1134, 1989; and No, 534, 1992).
RESULTS

Variance inflation factor (VIF) values and condition indices (CI) were calculated to test for multicollinearity. No multicollinearity was detected among variables in the supply equation. In the demand equation, however, multicollinearity may be a problem as indicated by high VIF and CI values. Consequently, the estimated standard errors are inflated and the statistical significance of some variables may be under-estimated. The system weighted R-square, a measure of goodness of fit, was 0.8412.

All the estimated coefficients in the supply equation had the anticipated signs (table 3). The weighted average index price of

<table>
<thead>
<tr>
<th>Table 3. Estimates of the determinants of Indonesian hardwood log supply.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanatory Variable</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td>IPLOG</td>
</tr>
<tr>
<td>REV</td>
</tr>
<tr>
<td>AREA</td>
</tr>
</tbody>
</table>

* Significantly different from zero at the 0.10 confidence level based on a one-tailed t-test.

** Significantly different from zero at the 0.05 confidence level based on a one-tailed t-test.

logs (IPLOG) and the working areas of concession holders (AREA) in the supply equation were statistically significant at the 0.05 confidence level. The only non-significant parameter in the supply equation was government revenue (REV).

In the demand equation, IPLOG, IPPLY and IJEXR are statistically significant at the 0.05 confidence level (table 4). IPLUM, IGDP and TAX are not statistically significant. Results for the dummy variables representing the years during the export ban phase-in period are mixed. Only D82 and D83 were statistically significant with the predicted sign.

Hardwood log supply and demand are elastic with respect to log price at 1.68 and -2.865, respectively. Log demand is also elastic with respect to hardwood plywood prices at 2.632. The elasticities of supply and demand with respect to other variables are inelastic.

Equilibrium of log supply and demand, calculated at the mean values of data, occurs at an index log price of $121.39 and a quantity of 22.87 million m³ as shown in figure 4. The graph shows
Table 4. Estimates of the determinants of Indonesian hardwood log demand

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Predicted Coefficient</th>
<th>Estimated Coefficient</th>
<th>t-statistic</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>13.3474</td>
<td>0.530</td>
<td></td>
<td>-3.15</td>
</tr>
<tr>
<td>IPLOG</td>
<td>-0.5396</td>
<td>-2.226**</td>
<td>-2.865</td>
<td></td>
</tr>
<tr>
<td>IPLUM</td>
<td>-0.0106</td>
<td>-0.250</td>
<td>-0.006</td>
<td></td>
</tr>
<tr>
<td>IPPLY</td>
<td>0.5104</td>
<td>3.284**</td>
<td>2.632</td>
<td></td>
</tr>
<tr>
<td>IGDP</td>
<td>0.0570</td>
<td>0.443</td>
<td>0.199</td>
<td></td>
</tr>
<tr>
<td>IJEXR</td>
<td>1.9276</td>
<td>2.641**</td>
<td>0.507</td>
<td></td>
</tr>
<tr>
<td>TAX</td>
<td>0.0142</td>
<td>1.622</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D80</td>
<td>14.2611</td>
<td>2.237</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D81</td>
<td>-10.5042</td>
<td>-1.205</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D82</td>
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** Significantly different from zero at the 0.05 confidence level based on a one-tailed t-test.

that the demand curve is relatively flatter than the supply curve, which implies the change in quantity of log demand is greater than that in log supply for an increase in the index log price of one dollar.

DISCUSSION

The price of logs has a statistically significant impact on supply and demand as one would expect, based on economic theory. Both log supply and demand, however, are elastic with respect to price, contrary to a priori assumptions and most previous stumpage studies. Only two studies found elastic price relationships. Cengel and Mckillop (1990), who modeled the South sea tropical hardwood log supply from exporting countries (Indonesia, Malaysia, and Philippines) and demand from importing countries (South Korea, Taiwan, and Japan) in 1960's and 1970's, found that both supply and demand were inelastic with respect to most log prices. However, they did find log supply in Taiwan is elastic with respect to price. Davis and Jensen (1994) found Japanese demand for hardwood lumber from the United States elastic with respect to price.

Compared to previous studies, which focused primarily on stumpage markets in the United States and Europe, the hardwood log market in Indonesia has different characteristics. First, current log production in Indonesia is less than the annual allowable cut.
Figure 4. Supply and Demand equilibrium for the Indonesian hardwood log market

indicating no biological constraints at current log production levels. Consequently, log supply can increase rapidly in response to price increases.

The major buyers of Indonesian hardwood logs, or hardwood products after the ban, are the wood product industries in Japan and several other Eastern countries (Singapore, Taiwan, and South Korea). Because there is little differentiation in logs and intermediate goods such as plywood or lumber, buyers may easily substitute logs and/or wood products from tropical or temperate countries. Consequently, it is not surprising that demand for Indonesian logs is elastic with respect to own price.

Of primary interest in the study are the impacts of government attempts to capture manufacturing jobs by banning log exports and imposing a prohibitive tariff on lumber exports. As shown in figure 1, total log production dipped during the phase-in period but, once the log export ban was fully in place, rebounded to its former level, suggesting that the Indonesian government’s action had no lasting effect on the hardwood log market. The empirical results of this study support this observation. Only during 1982 and 1983 was log production significantly lower than the pre-ban period, given the levels of the other explanatory variables. Most importantly, there is no significant difference between pre and post-ban production levels. Furthermore, it is evident that manufacturing jobs were successfully captured as indicated by a steady increase in plywood production during the phase-in and post-
ban periods.

The export tariff on lumber also does not appear to have influenced hardwood log demand. Lumber exports were virtually eliminated but no statistically significant impact on hardwood log demand occurred as measured by the coefficient on TAX. Lumber production maintained its pre-housing boom levels, suggesting that previously exported quantities are now utilized by domestic producers. Whether this volume is converted to export or domestic goods is not evident from this study.

Based on these observations, it is safe to say that the Indonesian government did not adversely affect the hardwood log market in its attempts to capture manufacturing jobs.

SUMMARY

A simple econometric model of supply and demand relationships developed in this study provides some insight into the behavior of hardwood log markets in Indonesia. All estimated parameters in the supply equation were consistent with underlying economic theory. Log price, as measured by weighted average index price of logs, and inventory, as represented by the working area of concession holders, were found to significantly influence the supply of hardwood logs in Indonesia. Government revenues, consisting of royalties and replanting costs charged to log producers, are harvesting costs but do not significantly influence log supply.

The price of logs, the price of plywood, and the Indonesian-Japanese exchange rate significantly affected log demand. The level of Indonesia’s GNP did not.

Government policies, banning log exports and imposing prohibitive export tariffs on lumber, did not have any lasting effect on the hardwood log market. The estimated coefficients for dummy variables representing the pre-export log ban period, each year of the ban phase-in period, and the post-ban period, indicate that demand was significantly lower during only two of the five years in the phase-in period, and by the post-ban period had returned to pre-ban levels. In addition, the export tariff on hardwood lumber did not have a significant impact on hardwood log demand.

Both price elasticities of supply and demand were found to be elastic which is contrary to most previous studies. However, in light of market condition in Indonesia, the elastic results seem plausible.
REFERENCES


