Modeling the effects of a log export ban in Indonesia

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Abstract

Because enforcement of forestry law has become extremely difficult in Indonesia, a ban on export of logs has been suggested as a means of controlling over-harvest and illegal logging. A model of a log export ban can help us visualize its effects on the forestry sector. The model consists of simplified overviews of: the wood processing sector, demand—price feedback loops, forest standing stock and log availability, log harvest capacity, and log exports. It examines important feedbacks that must be understood if the potential costs and benefits of a log export ban are to be properly considered. Although some scenarios can help reduce log harvests to sustainable levels, others encourage expansion of small domestic milling capacity leading to increased log harvests. Excess domestic milling capacity added during a log export ban may continue to operate even after a log export ban is lifted. For a log export ban to be an effective tool in combating over-harvest and illegal harvest, limits must also be placed on possible increases in domestic milling and logging capacity. Copyright © 2004 John Wiley & Sons, Ltd

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Indonesia's forestry sector has been in turmoil since the removal of President Soeharto from power in May 1998. A period of weakened legal control followed resulting in substantial increases in illegal logging. The illegal logging situation is well documented (Currey *et al.* 2001; Currey and Ruwindrijarto 2000; Newman *et al.* 2000), and by late 2000 about 40 percent of the timber harvest was believed to be illegal (Scotland *et al.* 2000). In early 2001, a major decentralization of authority, carried out with minimal planning of local natural resources laws and regulations (see review by Resosudarmo and Dermawan 2001), led to a rapid quasi-legalization and intensification of the serious over-harvest by small and medium scale entrepreneurs.[1]

A wide array of other factors also contribute to deforestation in Indonesia, including: expansion of plantation crops (e.g., palm oil, pulp wood, rubber) (Barr 2001a; Casson 2002); fire, including its use for land clearing (Applegate *et al.* 2001); over-harvest on timber concessions (Barr 2001b); and land clearing for agriculture. The illegal and quasi-legal over-logging is occurring within a larger context of many causes of deforestation (Contreras-Hermosilla 2000). Although illegal logging was already a serious problem prior to 1998 (e.g., McCarthy 2000, 2002), extreme increases in illegal forest activity resulted from causes related to the downfall of President Soeharto and resulting political uncertainty (e.g., see Dudley 2002). The overall situation of Indonesian forests has been discussed in a number of reports (e.g., Aden *et al.* 2001; FWI/GFW 2002; Jepson *et al.* 2001; Palmer 2001).

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Political changes, including decentralization, led to the creation of overlapping jurisdictions and laws that blurred the distinction between legal and illegal logging. This situation reinforced the idea that over-logging might be controlled by limiting demand rather than by attempting to use weakened government agencies to enforce confusing laws. Because they believe many illegal logs are exported, concerned agencies and NGOs suggested a ban on log exports to reduce illegal logging. The initial idea was that after several years the ban would be lifted,[2] having allowed time to control over-logging by other means.

An export ban might appear illogical since illegally cut logs could be exported illegally anyway.[3] However, proponents of a log export ban believe that terminating all raw log exports would make an export ban enforceable, as opposed to a partial ban (e.g., banning export of logs stolen from national parks), which could be easily defeated using phony documentation. A total ban, in theory, would make any log leaving the country illegal.

An export ban might affect domestic processing industries by decreasing raw material (log) costs and decreasing competitiveness through over-protection. Also, employment in the logging and wood-processing sectors might decrease—due to a decrease in log harvest, or might increase—due to a stimulation of the domestic wood-processing sector. Importantly, if the export ban stimulated local wood processing, this would defeat the utility of a ban in controlling illegal logging. A previous export ban, in the early 1980s, helped the Indonesian processing industry and led to an overall decrease in log harvest. But that occurred during a period of strong governmental control. The usefulness of log export bans as a means of controlling over-logging or of providing in-country benefits is a subject of debate (Arunanondchai 2001; Goodland and Daly 1996; Manurung and Buongiorno 1997).

Participants from industry, government, academia, NGOs, and donor organizations met to discuss these issues in September 2000.[4] Participants disagreed on 70% of the points discussed, especially those regarding outcomes of a proposed log export ban. Predicting the outcome of actions within such a complex situation without an understandable and agreed upon framework is difficult. This article presents a framework sufficient to allow meaningful thinking about the use of a log export ban as a means of controlling rampant over-logging.

Modeling approach

Ideas for this model evolved from related activities (including those reported in Dudley 2002, 2004). These included interviews[5] with institutional stakeholders (government, business, and non-governmental conservation organizations), examination of literature and colleagues' field reports, and follow-up discussions with these and other colleagues. Interest in the log

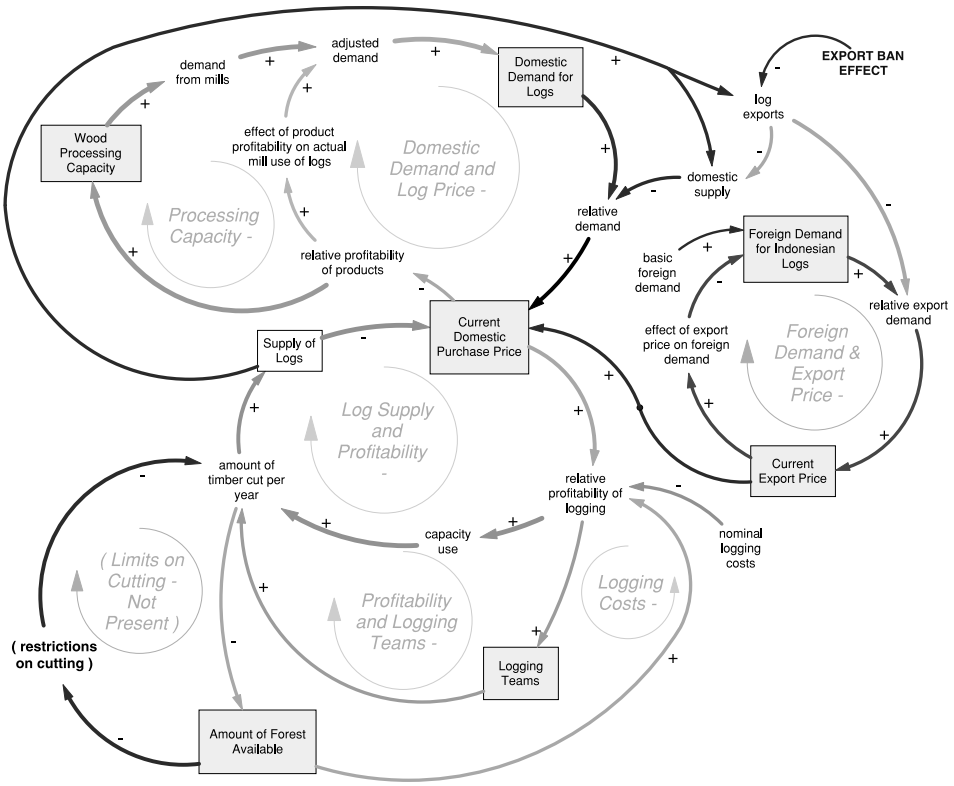
export ban was stimulated by its active consideration by the Indonesian government starting in the latter half of 2001. The model discussed in this paper was developed using Vensim Professional32 version 5.0a (Ventana 2003).

Overall model structure

The model consists of six sectors (Figure 1): wood processing capacity, domestic demand and log price, log supply and the profitability of logging, profitability and the buildup of logging teams,[6] foreign demand and export price, and the effect of logging on logging costs. Also shown in Figure 1 is a feedback loop missing from the Indonesian situation and not included in the model: the relation between the amount of forest remaining and management limits on amount of timber cut per year.

This simplified model considers a one million hectare (ha) forest with associated processing and harvesting capacity. It is initiated with a stable log harvest of 3 million m^3/year (i.e., 3 m^3/ha/year), half exported and half

Fig. 1. The main sectors of the model



processed domestically. Log prices are \$50/m^3 with logging cost half of this. The selling price of wood products is set at \$100/m^3 of raw material used, giving an initial profit margin of \$50/m^3. All prices are expressed in terms of generic raw material. For example, prices of wood products are expressed as \$/m^3 of raw material used.

Milling capacity is viewed as small-scale sawmills, which can be built and brought on-line within a few to several months, considerably less time than would be needed for plywood or pulp mills. This view is based on several field reports (Casson 2000; Casson and Obidzinski 2001; McCarthy 2000; Obidzinski and Suramenggala 2000; Obidzinski. *et al*. 2001; Wadley 2001). An expanded model would include significantly different, parallel, structures for plywood and pulp mills (see Barr 1998, 2001a).

Wood processing, domestic log demand and log price

Domestic processing capacity affects domestic log demand and, consequently, log price. Relative profitability of wood products depends on log price[7] and determines desired mill capacity, which is gradually incorporated into actual wood-processing capacity as mills are built, expanded or improved. Older or obsolete mills and equipment are scrapped. Milling capacity creates the log demand from mills. Because wood-processing capacity is not always fully used, the demand from the mills is modified by the effect of product profitability on the actual mill use of logs. This, in conjunction with the demand from mills, determines an adjusted demand which gradually influences domestic demand for logs.

A comparison of domestic demand for logs with domestic supply will affect the price the mills would like to pay for their logs. This is one of three primary factors affecting the current domestic log price, which in turn will affect the overall profitability of wood products. The other factors are price changes caused by log supply, and price changes caused by foreign demand. A fourth factor, price change caused by alternate sources, acts as a ceiling price on Indonesian logs if log prices escalate drastically.

Logging and log supply

Current domestic log purchase price and logging costs directly affect profits from logging. Log contractors weigh potential profitability against some expected profitability of logging. This relative profitability of logging determines whether they believe it desirable to establish more logging teams to cut trees, and also the extent to which they will use existing teams to full capacity. Logging teams, which represent harvesting capacity (m^3/yr), are built up over time and are not immediately disbanded if profitability drops. However, the extent to which teams are used (e.g., capacity utilization) can vary more rapidly as profitability changes. The use of logging teams determines the

amount of timber cut each year. This yields a supply of logs, which, when compared to typical log supplies in the recent past, provides the second influence on the current domestic log purchase price: the price change caused by log supply.

Foreign demand and export price

Foreign demand for Indonesian logs, when compared to the supply (i.e., log exports) yields a relative export demand, which affects current export log price. Changes in current export log price will in turn moderate foreign log demand. Basic foreign demand for Indonesian logs is ultimately created by foreign processing capacity plus the effect of alternate log sources, and is treated exogenously. If Indonesian logs dominate the market then their removal from it via an export ban will have a significant effect on price. On the other hand, if there are many other sources of logs, then the effect of a decreased supply from Indonesia would be negligible. In recent years the importance of Indonesian logs has increased as other countries in the region have exhausted their forests and placed limits on logging.

Current export log price is the third factor affecting current domestic log price. However, if the export price is high, but exports are strictly banned, then domestic log price would be only minimally affected. The default modeled impact of export log price on domestic log price is determined by the fraction of the log supply actually exported. If export volume is high, then the effect that export prices have on domestic log price will also be high.

We have no information about decision processes used to determine if logs will be exported or sold domestically. The relative proportions are assumed to be a function of the ratio of export to domestic log price. Relative amount exported may follow a direct proportional relationship with the export price ratio; however, it is more likely that the proportion of exports rises more rapidly than the export price ratio.

Effect of harvest on forest available

The effect of logging on the forest is conceptualized as the effect on an average hectare of forest land. Timber volume changes as a result of harvesting and regeneration. Regeneration combines creation of new trees, growth, and deaths of trees, and is a fraction of stock volume already on the land as modified by the ratio between it and the maximum standing stock possible. As the forest becomes more densely stocked, regeneration approaches zero and the number of cubic meters per hectare approaches a constant value.

As forests become degraded the lowered availability of trees for harvest will affect logging costs. It is assumed that, as harvestable trees become scarcer, logging costs rise. This is not necessarily the case, since some harvesting may make access to the forest easier, thereby lowering logging costs. It may also be

the case, under the current situation, that average logging costs are not yet affected by decreasing forest availability.

A major problem for Indonesian forestry is the conversion of forest land to other uses. This is more likely to occur when the forest is already degraded. In the model, hectares of forest land can optionally be treated as a stock with an outflow dependent on the state of forest degradation. Under the model's sustained yield conditions there is no conversion of forest land, but as over-harvesting causes forest stocking densities to drop there is an increasing rate of forest land conversion.

A missing loop—limits on cutting

Shown in Figure 1 is a feedback loop, "limits on cutting," which, in reality, does not exist in the current Indonesian situation. In an ideal world, forestry agencies would monitor forest health and would implement practices, including restrictions on cutting, that would protect the long-term sustainability of the forest. The inability, or unwillingness, of these agencies to do this led the government to attempt to use an export ban as an alternative means of controlling over-harvest.

Model outcomes

Application of a log export ban for five years

If an export ban is instituted, log exports drop and current export price rises causing foreign demand to drop slightly (Figure 2). At first, excess supply forces domestic log prices down, driving up profitability of wood processing, domestic processing capacity, and domestic demand (Figure 3). Loss of the export market initially causes a substantial drop in the amount of timber cut, but this rises significantly as domestic processing is stimulated by lowered log prices. After about 18 months profitability in the logging sector is back near its normal value (Figure 4).

When the export ban ends gradually (ramp implementation over a six-month period), log exports gradually return to pre-ban levels. If the ban is ended suddenly (step implementation), the lingering high export price and limited supply will cause a temporary surge in exports, which will require almost 80 percent of available logs. In either case the resurgence in export demand coupled with a higher domestic demand, which increased during the ban period, now outstrip supplies. This pushes the domestic price temporarily higher creating a significant but temporary rise in logging profitability which stimulates the re-establishment of logging teams and the cutting of timber. Eventually both export and domestic prices drop again as log supplies increase. Within a few years after the ban the system has largely re-stabilized.

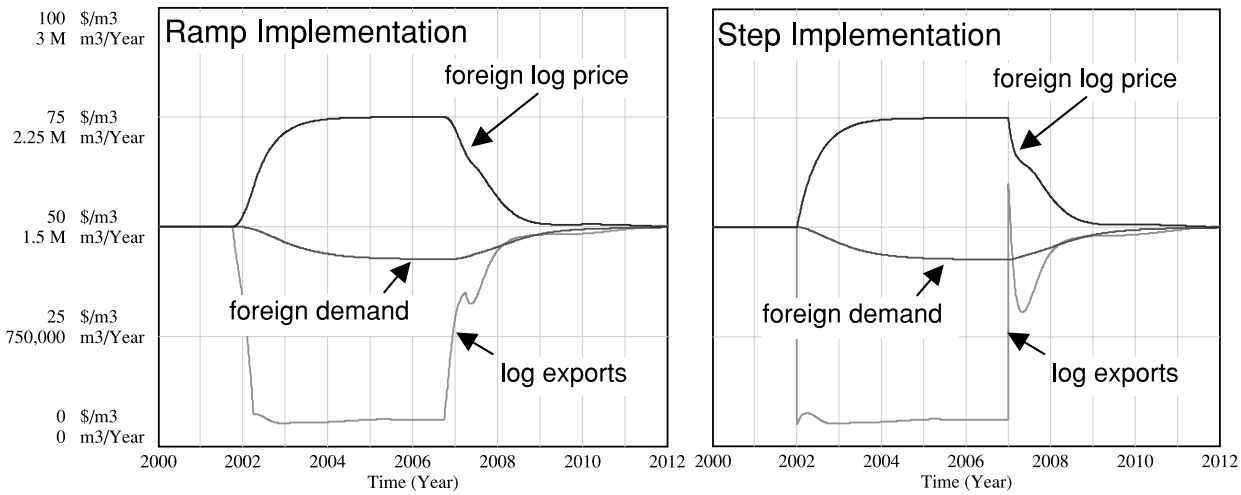
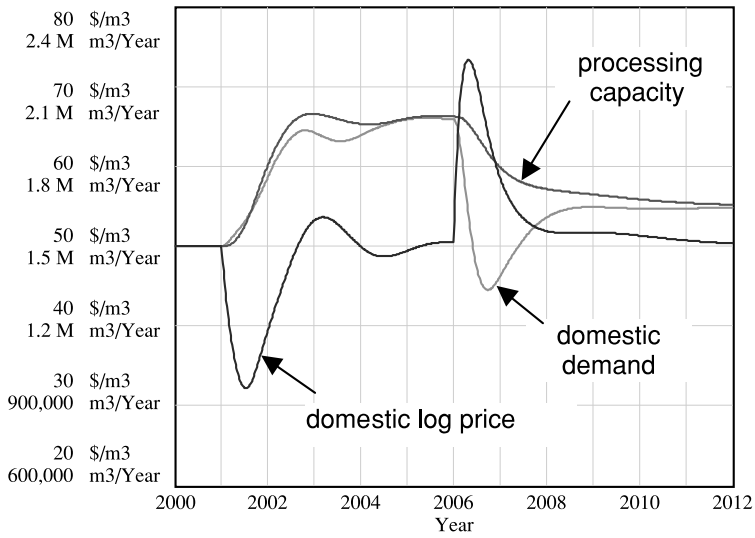


Fig. 2. The effect of a log export ban an export price and foreign demand

Fig. 3. The effect of a log export ban on domestic price and processing



However, the log harvest rate during the post-ban period is dependent both on the lag times used and on mill investment strategies as discussed below; an increased domestic processing capacity compared to pre-ban levels may be maintained. Also with expanded harvest, forests very slowly re-stabilize at a

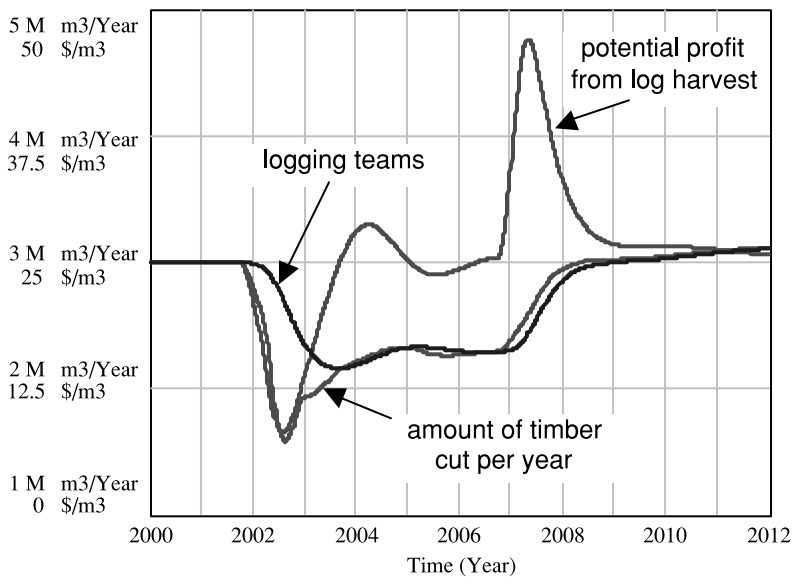


Fig. 4. The effect of a log export ban on timber harvest. Logging teams refer to the harvest capacity of men and equipment employed in cutting trees.

lower standing stock, causing a very gradual rise in harvesting costs, decline in harvest, and slight rise in log price. As indicated below, other factors can greatly accelerate this decline. In the following examples, an export ban is assumed to be 90 percent effective with a six-month ramp implementation at the start and end of the ban unless stated otherwise.

Variations in domestic milling and logging investment response

Investor response to new profit opportunities in domestic wood processing will alter the ultimate outcome of a temporary log export ban. If mill owners aggressively expand operations during periods of high profitability, the outcome will be different than if they invest modestly. This question was investigated by examining different shapes for the function describing the effect of relative product profitability on desired mill capacity (Figure 5). While some mill investment strategies lead to lower harvests after a log export ban, others could significantly increase harvest rates. Entrepreneurial mill owners greatly expand operations when profitability rises, and hold on to investments when profitability drops. This entrepreneurial investment strategy would lead to a 10 percent increase in domestic demand and a 5.5 percent increase in log harvest about three years after the ban is lifted. In the case of a mild investment strategy little change is made as profitability changes. This strategy would lead, post export ban, to a 4 percent decrease in domestic demand and a 2 percent decrease in timber harvested per year (Figures 6 and 7).

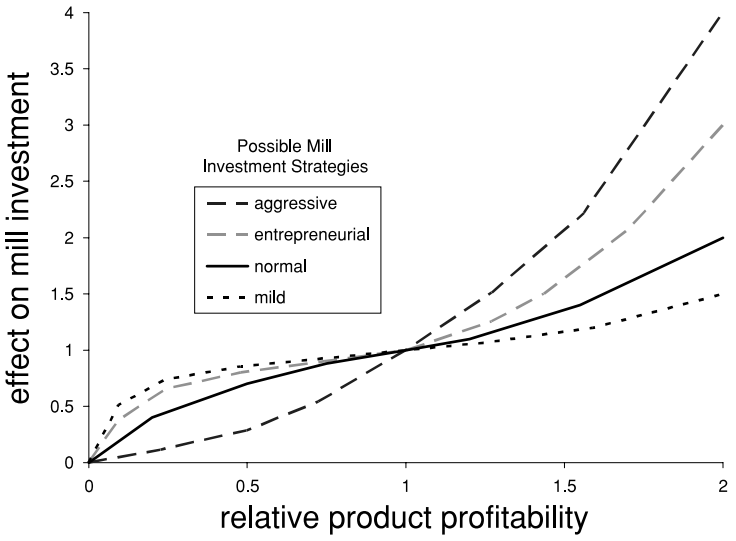


Fig. 5. The effect of relative product profitability on desired mill capacity; possible responses of small-scale mill owners to changes in wood processing profitability

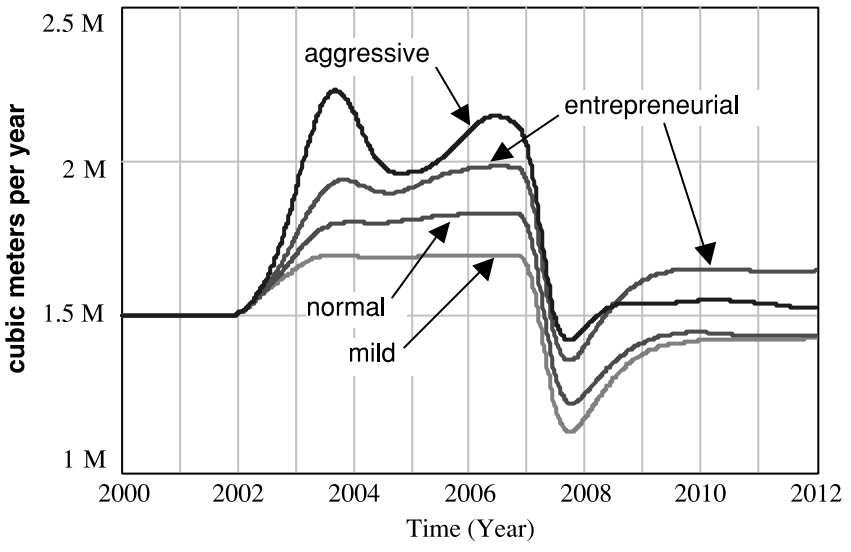


Fig. 6. The effect of mill investment scenario on domestic demand with an export ban

A ban coupled with entrepreneurial investment will result in higher domestic demand after the ban is lifted. Any log ban policy should be coupled with appropriate policies directed at limiting expansion of domestic milling capacity.

The investment strategy of small mill owners can have significant and lasting effects on domestic processing capacity (upper graph in Figure 7) and log harvest (lower graph in Figure 7) both during an export ban and after the ban is

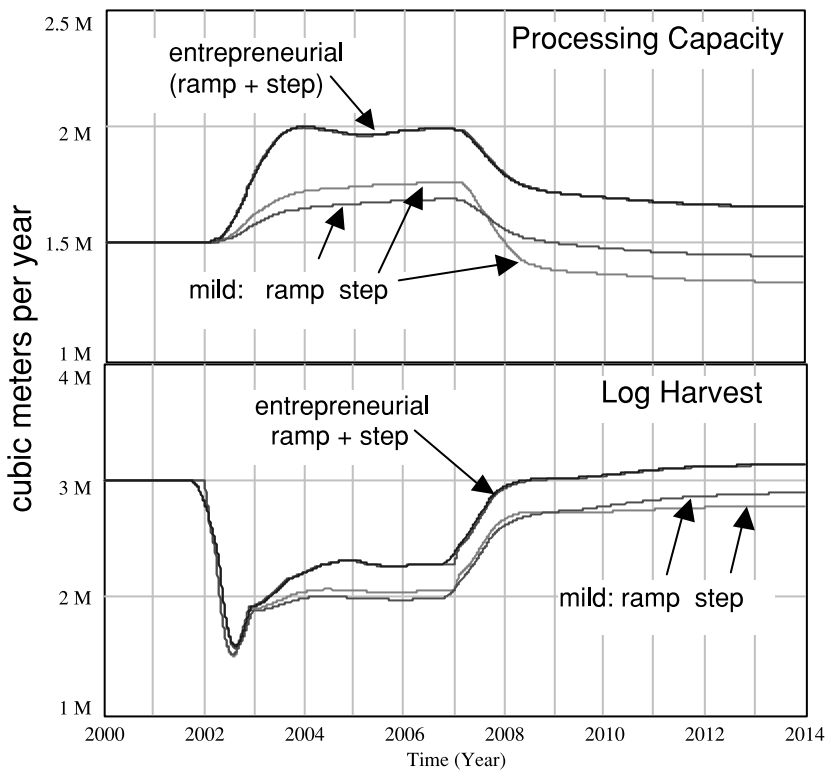


Fig. 7. The effect of mill investment strategy on domestic processing and total log harvest

lifted. Entrepreneurial investment will result in a higher domestic processing capacity and somewhat higher log harvest after an export ban is terminated. The way in which a ban is implemented and lifted (ramp or step) makes little difference to the outcome if entrepreneurial investment occurs. With a mild mill investment strategy a step implementation creates a bigger drop in processing capacity because of a spike in export demand that raises log prices promoting export of logs.

The rapidity with which mill investors make decisions also has important effects. If entrepreneurs quickly decide about, and build, new mills, significant increases in domestic capacity and, ultimately, the amount of logging, will occur. With an entrepreneurial investment strategy and shortened, but realistic, response times for investments, post export ban log harvest will increase to 9 percent above baseline. This change is maintained by a 17 percent increase in domestic processing capacity coupled with a 4.5 percent increase in log exports. Short response times coupled with a mild investment strategy could decrease post-ban log harvest by 3 percent, due to a 5 percent decrease in domestic capacity and a 2 percent decrease in exports.

In general a sudden (step) implementation of an export ban results in patterns very similar to the gradual (ramp) implementation. Also, bans of less effectiveness (e.g., 50 percent effective) yield similar but milder effects compared to a 90 percent effective ban.

The rapidity of investment in logging teams is another problem area for Indonesian forestry, making the relation between potential logging profits and investment in logging teams very important. A relatively entrepreneurial logging team investment approach coupled with the entrepreneurial milling investments (as above) results in a post-log-ban 13 percent increase in log harvest to supply a 25 percent increase in domestic demand and a 6 percent increase in exports.[8]

The above examples reveal that there is no guarantee that a temporary log export ban will reduce harvest pressure on forests. The outcome is dependent, at least in part, on the response of domestic mill owners and logging entrepreneurs to temporary changes in log supplies and log prices, which can be caused by an export ban.

Possible effects on employment

Employment in the forestry sector will be lower during a log export ban, but the post ban effect is dependent on the longer term effects on domestic milling capacity. Using the likely scenario of entrepreneurial investment in mills, and assuming that wood from our hypothetical forest is cut and milled by relatively small scale operations, milling employment would rise almost 30 percent during a five-year-ban, but would remain only about 10 percent higher than pre-ban levels after the ban was lifted. However, logging employment would drop by roughly 24 percent during the ban and, post ban, would return to about 5 percent above pre-ban levels. Combined employment would drop about 13 percent during the ban returning to about 6 percent above pre-ban levels after the ban is lifted. Of course, in the long run, with over logging occurring, the whole system will collapse, drastically reducing all employment in the forest sector.

Changes in export demand

If export demand is gradually rising, as is probably the case in Indonesia,[9] then overall demand increases and log export price gradually rises. Higher export price forces the domestic log price higher, diminishing the opportunities for milling profits and lowering both domestic processing capacity and log demand. Nevertheless, a log export ban instituted during a period of rising demand has an effect similar to that described above: under reasonable assumptions domestic log demand is stimulated. After the ban is lifted this probably results in a higher domestic processing capacity and a higher overall harvest than would occur without a ban.

Over-harvest and illegal logging

A full examination of illegal logging requires different models designed to examine a range of social, economic, legal and political issues (e.g., Dudley 2004). One of these issues is the fact that illegal logging lowers the costs of log harvest.[10] One simple examination of the response of the system to illegal logging can be tested by lowering logging costs by 15 percent over a five-year period. This creates a positive feedback effect, which dominates the system, raising profits of logging operations, stimulating the harvest of more logs, lowering the price of logs, making both wood processing and log exports more profitable.

More realistically, over-logging was already occurring when illegal logging became widespread. Such over-logging can be approximated by doubling the harvest per hectare[11] in addition to lowering logging costs as above. This scenario (Figure 8 and right-most curves in Figure 9) which is similar to the

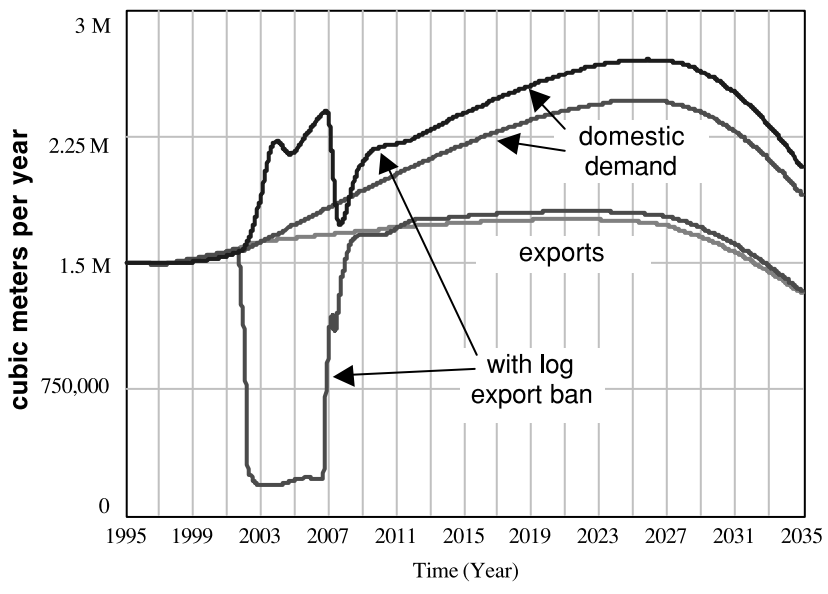


Fig. 8. Illegal logging effects on demand and export with and without a log export ban

situation in current day Indonesia includes logging at an unsustainably high rate coupled with the lowering of logging costs due to illegality and results in increasing over logging until the forest is depleted. In this case a temporary log export ban would likely raise domestic demand and exports unless limits were placed on domestic processing capacity. The ban would not control the trend and would most likely merely stimulate a higher level of logging and a slightly more rapid, but slightly delayed, collapse. Even this dismal view is probably overly optimistic.

In fact, if we assume that degraded forest lands are converted to other uses, then the situation is more like that illustrated by the left-most curves in Figure 9. Conversion of forest not only removes forest from production but also places more harvest pressure on the remaining forest, thereby degrading it faster and making it more susceptible to conversion.

The conversion of forest land to other uses hastens the collapse of the timber industry. In general terms, if illegal logging and over-harvest are common, as in the example in Figure 9, a five-year export ban will have little influence on the overall outcome whether or not conversion of forest land is considered. If conversion of forest land is likely as forests are degraded, then the whole system will collapse much more rapidly.

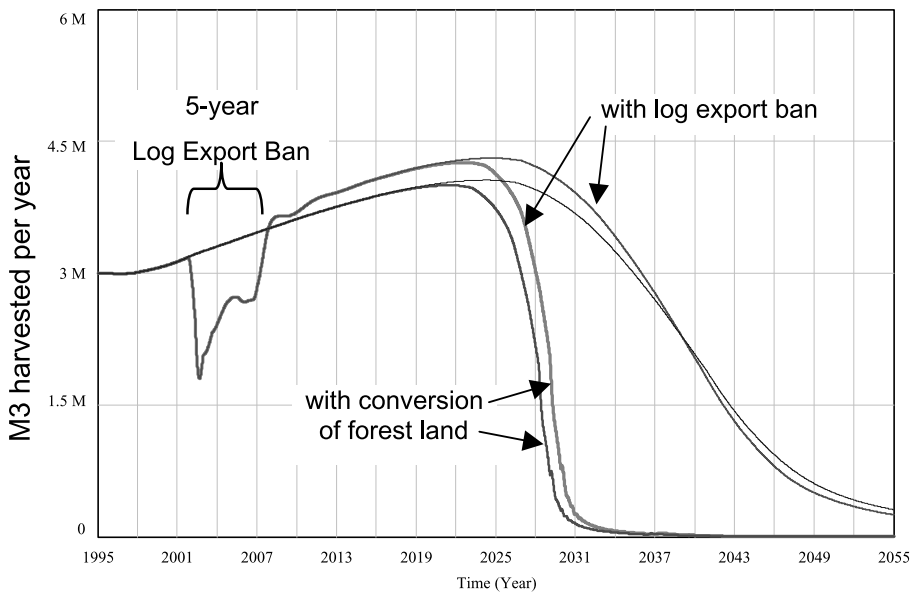


Fig. 9. The effect of loss of forest land on amount of timber cut per year with over-harvest and illegal logging

Discussion

The model allows a general examination of interlinked relationships between demand and price, harvesting capacity, milling capacity, and other factors. Although the exact nature of these relationships is not accurately known, the model provides a reasonable framework for discussing the effects of a log export ban. This model also helps define questions remaining for a more detailed examination of export ban costs and benefits.

The model indicates that different responses by mill owners to changes in log prices can result in very different outcomes. The likely scenario of entrepreneurial investment by small mill owners makes a temporary log ban less beneficial for forest protection than no ban except that, during the export ban, harvests will be lowered. Negative post-ban effects are increased if there is similar entrepreneurial behavior in logging team investment. Importantly, some policymakers supporting a log export ban believe this view and hope that a ban will help the local wood processing industry by lowering log prices and allowing expansion of domestic milling capacity as happened in the past.[12] If the purpose of a log export ban is to stimulate local industry, then the conservation rationale for such a ban, prevention of over-harvest, is not valid. Manurung (1997) found that Indonesia's earlier export ban did limit overall log harvest, but that ban was long term, not temporary. Also that ban was instrumental in creating low log prices, which stimulated a significant overcapacity in the processing sector, in comparison to the sustainable harvest of logs, which is partly to blame for today's problems. Detail regarding the expected response of investors to any log export ban, as well as any government policies that might stimulate, or control, mill investment, should be examined carefully.

A long-term log export ban would limit harvest as long as the ban is in effect, but the decrease in harvest will be less than the amount of banned exports because of expansion of domestic processing. As above, any investigation of a long-term ban would have to examine more closely the intentions and probable responses of the domestic processing industry as well as the long-term effects of any expanded domestic processing capacity and related export of finished products.

The model is a simplified view of the Indonesian situation. In reality there are many interactions between large-scale mills and logging operations, pulp mills, plantations, and small-scale logging and milling operations. Similarly, there are many types of trees, some very valuable, some not, as well as a large variety of wood products. It may be beneficial to examine some of these issues in an expanded model. The model also represents a reality in which no forest policy feedback directly links the predicted long-term availability of trees to timber harvests. Feedback occurs only as timber becomes increasingly scarce. This is the sad reality of Indonesia's forest industry.

In late 2001 the Indonesian government instituted a log export ban. However, its implementation has been very weak and its effectiveness in stopping exports poor. It is certainly conceivable that an effective log export ban, coupled with strong regulation of domestic milling capacity, could assist in controlling over-logging, but neither of these actions is likely under current conditions.

A log export ban attempts to limit harvest by limiting (export) demand for logs. Even if enforced, this might have only limited effectiveness. Lost foreign demand can be replaced by demand from domestic mills, which can then

export wood products. The real challenge is to limit log harvesting so that harvests are balanced by production of trees in the forest. Growth of trees needs to become the limiting factor of the overall system.

Finding solutions to the Indonesian over-logging problem will be difficult. Over-capacity already exists, and virtually any scenario that adequately protects forest resources for future generations will necessarily limit forest-based employment and income in the present. Consistent with current decentralization efforts, one approach that might assist in the search for solutions would be regional and national initiatives to investigate future scenarios for the timber industry similar to that developed for northeastern North America by Jones *et al.* (2002). Although the current situation makes this type of cooperative approach difficult, there is certainly an awareness of the problem at national, regional and local levels, and there are numerous local, national and international agencies and NGOs with a genuine interest in solving this problem. Hopefully, the current political climate will stabilize, allowing meaningful strategic forest planning for Indonesia, a country with some of the world's richest forest resources.

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Notes

1. In the current Indonesian forestry context what is illegal cannot clearly be distinguished from what is legal. One example is the corrupt creation of laws allowing local officials to participate in what had previously been illegal timber harvests. For this reason, controls on log demand rather than enforcement of confusing logging laws was being suggested.
2. The reason for consideration of a temporary, rather than a permanent, export ban was the need to maintain compliance with international trade agreements.
3. Indeed this is exactly what happened. In 2001, the Indonesian government instituted a log export ban. However, its implementation has been very weak and effectiveness in stopping exports poor.
4. Roundtable on Log Export Ban, 27 September 2000, World Bank Office, Jakarta (meeting summary).

5. Interviews were related to illegal logging and related research priorities, but did not specifically address modeling efforts except in a few cases where there was an interest in such modeling.
6. The term, logging team, refers to groups of forest workers with equipment, usually camped in the forest for periods of many weeks. Within the model this is the equivalent of logging capacity, the amount that can be harvested per unit time, and is measured in m^3/yr.
7. Other factors affecting wood product profitability are treated exogenously. This implies that the market for wood products is very strong and that all products produced can be absorbed into the market without any major effect on pricing. A more detailed model could include wood product demand and pricing relationships.
8. Unless stated otherwise, examples assume a "normal" logging team investment and an "entrepreneurial" milling investment strategy.
9. Several countries in the region have placed a moratorium on logging. Here I use a ramp-up of foreign demand by 150,000 m^3/yr, which is 10 percent of the original foreign demand, for 10 years.
10. It is important to stress that any factors that increase logging profitability, in the absence of limits on logging, will lead to over-harvest.
11. Various reports indicate that log harvest exceeds sustainable supply by 30 to 50 percent.
12. In the early 1980s, Indonesia successfully implemented a log export ban that greatly helped the domestic processing industry. By 1990, Indonesia was a major player in the international wood products trade. However, that business empire was centrally controlled by a small political elite, which had almost absolute power to enforce export regulations and to control domestic processing capacity, which it did.

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