Policy Options for Conserving Sri Lanka's Natural Forests

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EXECUTIVE SUMMARY

Forest cover in Sri Lanka has declined drastically during the last century. Some of the remaining forests, which are under protection, harbor high levels of biodiversity and endemism. Illegal timber extraction is the most important cause of deforestation at present. The illegal logging now occurring in unprotected forests may extend to protected forests, if necessary policy measures are not implemented.

The main policy currently employed to limit deforestation is a timber permit system. This study assesses that policy and four alternative policy measures: legislative approaches; establishment of forest plantations; improvements in the technical efficiency of saw-milling; and liberalization of the timber market. The study finds that the timber permit system has failed to protect Sri Lanka’s forests. It has instead resulted in higher timber prices for consumers and lower prices for producers, allowing most of the timber rents to be extracted by timber traders. Furthermore, it has not promoted conservation: low producer prices provide a disincentive for growing trees, while high consumer prices encourage illegal timber extraction from natural forests. Despite the profitability of commercial forest plantations, the private sector does not invest in forestry because of the uncertainty created by the excessive regulatory system.

The study found significant technical inefficiencies in sawmills. On average, the current output can be obtained with 28% less of all the inputs. Quality of logs, age of machinery, owner’s management practices and current system charges are the determinants of technical efficiency. With plausible assumptions, the analysis shows that elimination of 50% of the technical inefficiency could prevent deforestation of about 7,390 ha per annum.

Timber market liberalization was analyzed in a static framework, using various assumptions about demand and supply elasticities (i.e. the degree to which producers or consumers respond to changes in prices or incomes). The lowest impact was observed when price elasticity of demand and supply are inelastic. In that case, timber market liberalization would reduce local supply of timber by about 13%, leading to a saving of about 9,569 ha of natural forest annually.

The four policy options were compared using criteria such as short-term and long-term implications, effectiveness, political feasibility and economic efficiency. Timber market liberalization was found to be the most attractive option for protecting natural forests in Sri Lanka.

1.0 INTRODUCTION

Forest lands cover only 30% of the land area in the world. Of the total forested area, 40% are tropical forests and 20% are woodlands. These tropical forests harbor a significantly higher proportion of the world's genetic materials. Sri Lanka contributes to the global wealth of genetic materials and biodiversity by harboring important tropical rainforests (Kotagama et al. 1997). It has a land area of 6.56 million ha, of which, 80% was closed-canopy natural forests at the beginning of the 20^{th} century. This forest cover dwindled to about 18% by 1992 (Ministry of Forestry and Environment - MFE 1995). The annual rate of deforestation between 1956 and 1992 was more than 40,000 ha while the average annual replanting of forest plantations during the same period was only 2,000 ha.

The factors contributing to deforestation and forest degradation are extensive and complex. Some factors which contributed to deforestation are outside the forestry sector. These factors include large agricultural and human settlement projects such as the Mahaweli project, shifting cultivation, excessive timber-harvesting and, harvesting non-timber forest products (NTFP). The potential for a large scale agricultural expansion is already realized in Sri Lanka. There is no room for such projects in the future. Shifting cultivation has been curtailed successfully. NTFP harvesting may or may not contribute to forest degradation depending on the situation. Given the above reasons, timber-harvesting seems to be the most important factor contributing to current deforestation in Sri Lanka.

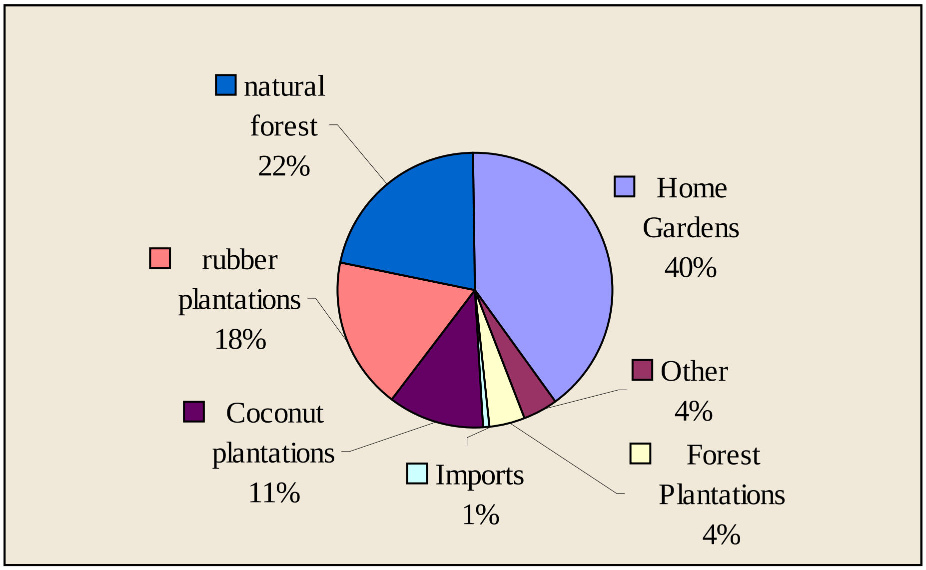
In an agricultural country like Sri Lanka, there is a strong link between population growth and deforestation. More food is needed to feed/support the increasing population and over the years, the agricultural production has been increased mainly by expanding the area under cultivation (MFE 1995). In addition to the demand for food, demand for fuel wood, construction wood and other wood-based products such as paper and pulp, are also increasing with population growth. As a result of the above-described deforestation per capita, forest areas have declined from about 1.3 ha in 1900 to less than 0.1 ha in 1992. Thus, the resource base that provides forest products has reduced significantly. The remaining natural forests are faced with increasing pressure as the population keeps expanding (MFE 1995).

The above-described situation has been aggravated due to unequal distribution of the existing types of natural forests. Distribution of the different types of natural forests in Sri Lanka as of 1995 is given in Table 1. Of the remaining natural high canopy forests, about 85% are dry-zone forest types. Ecologically more important lowland rainforests and montane forests are confined to small patches (Gunatilleke and Gunatilleke 1991). Protecting these two types of forests have become a priority as they contain rich biological diversity and higher level of endemism. The government has declared most of the remaining lowland rainforests and montane forests as protected areas, after having recognized the importance of these forests for biodiversity protection.

Table 1. Distribution of Natural Forests in Sri Lanka 1995

Types of Forest	*Area (million hectares)*
High canopy forests	1.58
Sparse forests	0.46
Mangroves	0.01
Total	2.12

Since natural forests supply a whole range of multiple products and environmental services, the consequences of rapid deforestation can be far-reaching. Population growth, coupled with industrial development, result in increasing demand for forest-based products. Population in Sri Lanka is still growing at an annual rate of 1.1% (Central Bank 1996). Annual sawn-wood consumption per 1,000 persons in 1993 was estimated to be 31 m^3 (MFE 1995). This is relatively lower compared to other countries, for example: Malaysia 216.9 m^3, Thailand 67.4 m^3, Korea 112 m^3, India 20.5 m^3 and USA 485 m^3. Sawn-wood demand is projected to grow from 0.544 million m^3 in 1993 to 0.885 million m^3 in 2020, at a rate of 12,600 m^3/year. Demand for plywood and other wood-based panels, respectively, will increase at the rates of 2.8% and 3.5% per year (MFE 1995).

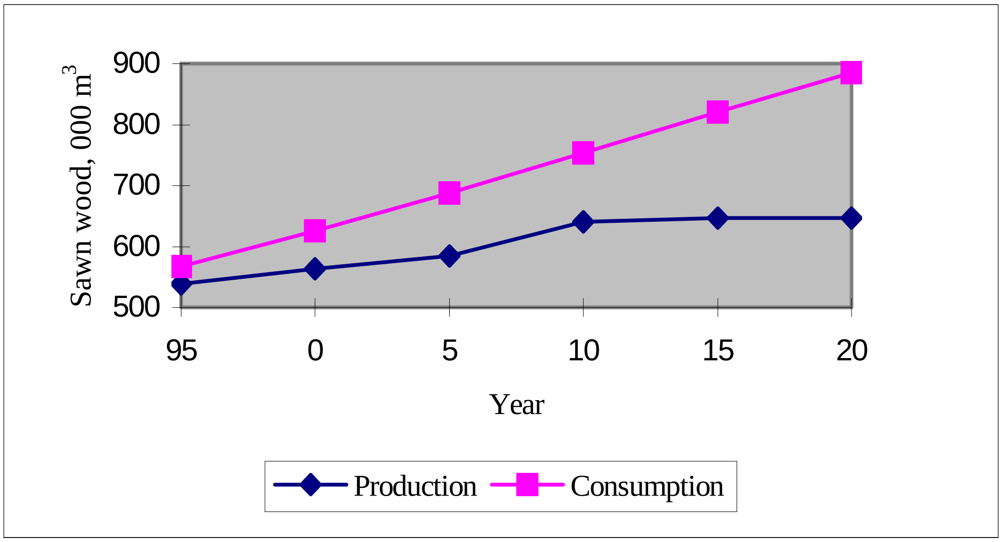


Source: MFE 1995

Figure 1. Estimated Shares of Saw Log Supply

Currently, non-forest lands such as home gardens, coconut and rubber plantations etc. supply a major portion of saw logs in Sri Lanka (see Figure 1). According to the estimation made in late 1980, natural forests supply only about 22% of the timber while home gardens supply over 40% (MFE 1995). These figures should be read with some care as illegally extracted timber from natural forests is also recorded under the home garden category. Contribution to timber supply from natural forests may be much higher than indicated in the figure when illegal timber is included. Having reviewed the future supply and demand scenario, MFE (1995) has forecasted a shortage in timber supply if the current trends are allowed to continue (see Figure 2). Figure 2 clearly shows the widening gap between saw log production and consumption.

Timber extraction rights from natural forests in Sri Lanka are exclusively assigned to the State Timber Corporation. Even though timber extraction from natural forest by non-state entities is legally banned, illegal timber extraction takes place on a large scale. The number of forest offences recorded in 1997 had increased by 3% to 5,158 from 5,014 in 1996 and the value of illegal timber confiscated was Rupees 35.7 million (USD 383,871) (Central Bank 1997). These records represent only a fraction of the illegal activities. Thus, illegal logging has been a major problem in managing natural forests in Sri Lanka. Given the above background, one of the major challenges the country would be facing in the immediate future is supplying forest-based products, especially timber, without compromising the need for conserving the remaining natural forests with high biodiversity values.



Source: MFE 1995

Figure 2. Predicted Sawn-wood Production and Consumption for Sri Lanka

Recent evidence shows the existence of a severe wood shortage as predicted by the MFE (1995). Utilization of forest products and protection of natural forest are interdependent. This means that the shortage of wood raises sawn-wood prices and higher prices provide incentives for illegal logging from natural forests. At the same time, higher prices lead to the planting of more trees by smallholders and that makes timber available at lower prices. This will in turn reduce the incentive for illegal logging and the need to harvest timber from natural forests. However, as explained later in this report, there are other distortions which prevent provision of price incentives for tree planting. Illegal logging activities are currently taking place mainly in unprotected natural forests. A persistent wood shortage may extend the illegal activities to protected forests too. Therefore, a sustainable management of forest product industry is necessary for forest protection. There are several ways to handle this problem. Among the conventional measures taken in many countries are: the establishment of forest plantations, policy reform to promote wood imports and removal of policy distortions that inhibit the local saw log production.

Apart from the above measures, efficient utilization of the logs produced in the country may be another way to relieve the pressure on natural forests. For example, Hyde (1980) suggests an alternative way to approach forest conservation through the re-organization of the wood products processing and application industries. With this alternative view in mind, this research focuses on the technical efficiency of saw-milling in Sri Lanka, in addition to timber market liberalization, profitability of forest plantations and legislative reforms. Presently, there is a significant wastage in saw-milling. The wood industry in Sri Lanka is dominated by sawmills producing sawn-timber for the domestic market and for usage in factories making furniture and other wood products. The saw-milling sector consists of more than 4,000 sawmills including pit-sawing units. This study, however, indicates that pit-sawing units are no longer in operation due to higher labor costs. The breakdown of mill types is given in Table 2. The furniture factories indicated in the table have their own sawmills. Note that the data in Table 2 covers only part of the country, excluding six Northern and Eastern districts which are Ampara, Batticaloa, Jaffna, Vawnia, Wanni, and Trincomale.

Table 2. Types of Sawmills and Their Distribution

Types	*Number*
Major sawmills	380
Minor, multi-purpose sawmills	500
Furniture factories	680
Total	1,560

Sawmills in Sri Lanka are, in general, small and labor intensive. They have old and mostly worn-out machinery. The total output of sawn-wood in 1993 is estimated at 515,000 m^3. The capacity of sawmills range from a few m^3/year to 7,000 m^3/year. The average output of the major sawmills is about 750 m^3/year. (In Thailand the average is 7,000 m^3/year and in Indonesia it is 30,000 m^3/year). Thus, the average output of a sawmill in Sri Lanka is lower than that of other Asian countries. The sawmills in Sri Lanka are old and the average age of a surveyed 50 mills is 18 years (MFE 1995). The oldest mills have been established in the early 1950s and many had not undergone major improvements. The technology employed is simple and labor intensive and the old mills still use the originally imported equipment while some of the new mills have locally made replicas of the old imported machinery (MFE 1995). Primary cutting machines are dominated by circular saws and some larger mills have horizontal reciprocating head rings (band saws). Higher recovery of wood in the latter rather than former is due to the relatively narrow saw blade. Small size, labor intensiveness, old and mostly worn-out machinery as well as poor layout, poor saw-doctoring and feeding systems are the cause for the heavy losses during milling. The average recovery rate is only about 40% (Malaysia 55% and Indonesia 50%).

The above description of the saw-milling industry in Sri Lanka indicates that there is an on-going wastage and lack of efficiency in the sector. There may be possibilities of improving the efficiency in this sector to make saw-milling more profitable. Consumers will be able to purchase sawn-timber at a lower price if the efficiency is improved. More importantly, improving the efficiency in this sector could play a vital role in the conservation of natural forests. If there is inefficiency, eliminating it would save saw log inputs and relieve extra pressure for logs. Thus, improving the technical efficiency of saw-milling could have a significant positive impact on forest conservation in Sri Lanka, in addition to direct producer and consumer benefits. Therefore, this study was carried out to test the hypothesis that there is a notable inefficiency in the saw-milling sector in Sri Lanka. Recognizing the existence of inefficiency is not adequate to solve the problem. One needs to know what factors determine the inefficiency in order to eliminate it. Therefore, the research was extended to find the factors determining the technical efficiency.

From a broader policy perspective, technical efficiency improvement is only one policy option to promote forest conservation. In addition to this, the other policy options are legislative reforms, establishment of forest plantations and timber market liberalization. Some of them may be complementary to technical efficiency improvement while others may be substitutes. Moreover, some of the policy options can be implemented immediately for short run impacts while other policy measures may take a longer time to produce results. This is very important, given that forestry has a long gestation period. Therefore, this study analyzed the above-mentioned alternative policies in comparison to technical efficiency improvement. Towards the end, these policies were assessed in terms of effectiveness, short and long-term impacts, economic efficiency and political feasibility.

In order to achieve the above-mentioned objectives, the following activities were undertaken. A survey was carried out to gather primary information required for the technical efficiency analysis. A total of 180 sawmills, selected using a stratified random sampling procedure, were surveyed with a structured questionnaire. In addition to gathering information for the analysis, a situational assessment of the saw-milling industry was also carried out with the survey. A review on the impact of existing legislative measures for forest protection was carried out using available secondary information i.e., the Forestry Sector Master Plan and various amendments to the Forest Ordinance. This analysis was supplemented with limited fieldwork for supportive empirical evidence. The available data was used to assess the financial profitability of selected species of forest plantations. A simple, static, partial equilibrium market model was developed to assess the impact of timber market liberalization. This model was simulated assuming the elimination of various distortions existing at present.

Organisation of the Report

Chapter 1 is an introduction on policy options for conserving natural forests in Sri Lanka. Chapter 2 presents the results of the survey. Chapter 3 discusses the impact of legislative approaches on forest protection in Sri Lanka. The reasons for the private sector's lack of involvement in the establishment of forest plantations are explained at the end of this chapter. Chapter 4 presents the results of the technical efficiency analysis and its determining factors. This chapter includes results from the Stochastic Frontier model and Data Envelopment Analysis model. Chapter 5 presents the impact of timber market liberalization on forest conservation. Chapter 6 presents the summary and policy implications of the study.

2.0 SURVEY RESULTS

This chapter describes the general results obtained through the survey conducted on the sawmills. The first section of the chapter describes the sample. The second section describes the mill owners/managers' characteristics. Section three provides details of the sawmills surveyed while section four discusses the mill owners' perceptions regarding the shortage of wood. The fifth section presents the results of entrepreneurship assessment. The final section presents the mill owners' perceptions on problems and suggestions for improvement of the industry.

2.1 Sample

The original sampling framework and the distribution of the final sample are given in Table 3. As planned in the proposal stage, an attempt was made to conduct the survey in two stages. In the first stage of the survey, information on general aspects of the sawmills was collected and an input-output sheet was given to the mill manager. At the first stage, except for a few managers, others agreed to fill the input-output sheet. However, we found that almost all managers had not filled the input-output sheets when we visited the mills to collect them. They informed us that they were too busy and did not have the time to fill the forms.

Table 3. Sampling Framework

	Climatic Zones			*Geographical Zones*			*District*			
Total Sample Size 200	*Climatic Zones*	*Number of Millers*	*Sample Size*	*Geographical Zones*	*Number of Millers*	*Sample Size*	*District*	*Number of Millers*	*Sample Size 165*	*Actual Sample 4*
	Wet Zone	846	100	North Wet Zone Low Land	366	37	Gampaha	209	16	14
							Kegalle	23	5	5
							Kuruneagale	113	11	9
							Matale	21	5	4
				South Wet Zone Low Land	353	33	Kalutara	117	11	10
							Galle	164	15	14
							Matara	39	4	4
							Ratnapura	33	3	3
				Up Country	127	30	Kandy	117	23	20
							N. Eliya	4	3	2
							Badulla	6	4	4
	Dry Zone	203	50	South Eastern Dry Zone	110	29	Hambantota	32	14	12
							Moneragala	4	2	2
							Ampara	51	11	-
							Batticaloa	23	2	-
				Central Dry Zone	93	21	Anuradhapura	13	11	9
							Trincomalee	8	-	-
							Puttalam	72	10	10
	Highly Urban	198	50	Colombo	198	50	Colombo	198	50	47

With this disappointing experience, we decided to visit the mills again to have the forms filled. Data would have been very accurate had the mill managers filled the forms as inputs came in and soon after milling the logs. The data gathered at the end were based on the memory of the mill managers in most cases, as they did not keep proper records.

In the original sampling framework, 13 mills have been allocated for Ampara and Batticaloa Districts. Due to security reasons, these 13 mills could not be visited again. About eight questionnaires were excluded from the sample taken from the other districts due to inconsistencies found in the answers. One of the problems found in these questionnaires is the higher sawn-wood output compared to the log input. Another 11 mills were excluded from the sample due to the mill owners' reluctance to provide information on log inputs and outputs. Throughout the second stage of the survey, we felt that mill owners were hesitant to reveal any information. There are three possible reasons for this behavior.

First, the saw-milling industry in Sri Lanka is a highly regulated industry and every year the mill owners have to renew their licenses. Any information which proves that they mill timber without permits may lead to loss of licenses and heavy fines. Second, mill owners, like many other businesses, generally maintain two sets of records: one genuine and the other forged, for tax purposes. If there is a mismatch in what they tell us and what is in the records, it may lead to some investigation, according to their perception. Although efforts were made to convince them that the information collected will not be revealed to the forest authorities or tax authorities, some mill owners were still suspicious. Third, some of the mill owners/managers may have felt that this research might lead to policy implications that are disadvantageous to them. The last 11 mills excluded were due to either a complete lack of information or some unreliable information provided due to the above-mentioned reasons. The final analysis was conducted for 148 sawmills.

2.2 Ownership Information

Most of the mills are owner managed as shown in Table 4. Few questions were asked about the incentives given to hired managers who run the mill. Managers are generally paid a salary of Rupees 5,000-10,000 per month (USD 57.37 – 114.74) (Table 5). Besides the salary, no other incentives are given to the managers based on their performances. Managers are not relatives of the owners in most cases, as 31 (72%) out of 43 hired managers are non-relatives. Most of the owners/managers are males. Females manage only four out of the148 mills.

Table 4. Types of Management in Sawmills

Types of Management	*No. Responded*	*Percentage*
Owner	105	71
Manager	43	29
Total No. Responded	148	100

Table 5. Distribution of Manager's Salary

Salary, Rs[a] per Month	*No. Responded*	*Percentage*
< 5,000	8	26
5,000 – 7,500	19	61
7,501 – 10,000	4	13
Total No. Responded	31[b]	100

[a] 93 Rupees = 1 USD

[b] Some managers did not reveal their salary

Table 6 shows the details of the managers'/owners' special training in the saw-milling industry and business administration. The results show that only a few managers have undergone any special training in saw-milling and related work. Similar results were observed regarding general business administration. Only five out of 146 mill managers/owners have undergone special training in business administration. About 40% of the mill owners indicated that saw-milling is their traditional business and their families have been doing it for generations. Table 7 shows the distribution of the years of experience of the sawmill owners/managers. As shown in the table, managers/owners are quite experienced in the saw-milling industry. Over 88% of the mill owners/managers have more than five years experience in saw-milling.

Table 6. Training Received by Managers/Owners

	Saw-milling Industry		*Business Administration*	
	No. Responded	*Percentage*	*No. Responded*	*Percentage*
Training	2	1	5	3
No training	144	99	141	97
Total No. Responded	146	100	146	100

Table 7. Manager's/Owner's Working Experience in Saw-Milling Industry

Years of experience	*No. Responded*	*Percentage*
<5	18	12
5-10	48	33
11-15	34	23
16-20	19	13
21-30	19	13
31-60	8	6
Total No. Responded	146	100

2.3 Characteristics of Sawmills

Most of the sawmills in Sri Lanka are small compared to those in the other countries of the region. Most of the mills have capacities between 1,000-6,000 ft^3 per month (see Table 8) with an average of 3,627 ft^3 per month. As shown in Table 9, most of the mills use manual labor for moving logs. Only about 15% of the mills use machines for this purpose. Table 10 shows the floor area of the surveyed mills. As shown in the table, most of the mills have less than 0.5 ha floor area with an average of 0.26 ha. Table 11 shows the circumference of the logs, which can be handled by the machines in the mills. Most of the mills are designed to handle logs with the circumference of 5 to 10 ft. Our informal discussions with mill owners/managers indicated that most of the logs that are brought to their mills have smaller circumference than required due to severe wood shortage.

Table 8. Capacity of Sawmills

Capacity (ft^3 per Month)	*No. Responded*	*Percentage*
< 1,000	13	9
1,000 – 3,000	72	49
3,100 – 6,000	45	30
6,100 – 10,000	14	9
10,100 – 30,000	4	3
Total No. Responded	148	100

Table 9. Timber Feeding System

Timber Feeding System	*No. Responded*	*Percentage*
Manual	124	84
Machinery	19	13
Both Systems	5	3
Total No. Responded	148	100

Table 10. Floor Area (hectares) of the Sawmill

Mill Area (Hectares)	*No. Responded*	*Percentage*
0.025 – 0.1	56	38
0.11 – 0.2	47	32
0.21 – 1.2	45	30
Total No. Responded	148	100

Table 11. Circumference of Logs Required by Machines

Circumference (Feet)	*No. Responded*	*Percentage*
< 5	12	8
5 – 10	120	84
11 – 15	11	8
Total No. Responded	143	100

Table 12 shows the distribution of the different types of machines. Over 85% of the mills have aged circular saws. These machines provide lower recovery rate of sawn-wood. Only 20 mills have band saws, which minimize wastage in milling. Table 13 shows the distribution of age of the machines. As shown in the table, most of the machines are old with an average age of 12 years. About 60% of the machines are older than 11 years. Only about 15% of the machines were purchased within the last five years. Most of the newly purchased machines are locally produced replicas of the old machine types imported earlier. Informal discussions with mill owners/managers about the lack of new investments in their mills indicated that the uncertainty of future log supplies and heavy regulatory measures discouraged investments in the industry. Moreover, high cost of new machines and lack of credit and other incentives also lead to the continuation of their operations with the old machines. Only 47 (32%) out of the 148 mills surveyed have undergone major renovation after establishing the mills.

Table 12. Types of Machines

Types of Machines	*No. Responded*	*Percentage*
Circular Saw	108	73
Band Saw	3	2
Frame Saw	16	11
Circular Saw + Band Saw	17	11
Band Saw + Frame Saw	0	0
Circular Saw + Frame Saw	4	3
Total No. Responded	148	100

Table 13. Age of Machines

Age (Years)	*No. Responded*	*Percentage*
< 5	22	15
5 – 10	33	22
11 – 30	68	46
31 – 40	22	15
40 <	3	2
Total No. Responded	148	100

Table 14 describes the condition of the floors in the sawmills. Only about a fourth of the mills have cemented floors. Other mills have either sawdust compacted and gravel compacted floors or a combination of them. The sawdust compacted mills increase the possibilities of pest attacks on logs. Frequent power cuts and various other reasons lead to logs being kept longer in the mills and that results in attacks by wood borers. About 36% of the mills surveyed reported attacks by wood borers.

Table 14. Conditions of the Floor

Floor Conditions	*No. Responded*	*Percentage*
Cemented	38	26
Saw Dust Compacted	43	29
Gravel	4	3
Saw Dust and Gravel	63	42
Total No. Responded	148	100

2.4 Wood Shortage

As described in the introductory chapter, most of the logs were harvested from natural forests before the 1970s. As the forest cover was reduced to very low levels and existing forests became severely degraded, harvesting timber from the natural forest was banned. Following this ban, most of the wood for milling came from the home gardens and other non-forest sources. Illegal logging from natural forests also contributes significantly to the current log supplies, although proper records are not available. Since wood shortage is a very significant factor in deciding the performance of the saw-milling industry, mill owners/managers were asked to rank the shortage of wood supplies. Table 15 shows the responses of mill owners to this question.

Table 15. Shortage in Supply of Logs

Categories	*No. Responded*	*Percentage*
No Shortage	25	17
Slight Shortage	14	10
Shortage	43	29
Severe Shortage	48	32
Very Severe Shortage	18	12
Total No. Responded	148	100

About 17% of the mill managers reported not having had experienced any wood shortage. Given the background, this was a bit surprising. However, further investigations of the mills which reported that they did not face any wood shortage, indicated that most of them specialized in softwood milling. Since there are no or very few regulations for felling and transporting softwood types, softwood milling firms do not face wood shortages. About 83% of the mills reported that they faced some wood shortage while over 45% of the mills reported facing severe wood shortage. The mill owners/managers were also asked to rank the quality of the logs received during the month considered in this study. A summary of their responses are given in Table 16. Only less than 20% of the mills reported that they obtained logs with satisfactory quality.

Table 16. Quality of Wood

Categories	*No. Responded*	*Percentage*
Extremely Poor	14	10
Poor	48	32
Moderate	58	39
Good	20	14
Very Good	8	5
Total No. Responded	148	100

2.5 Entrepreneurship

Entrepreneurship was assumed to have an impact on technical efficiency. Six characteristics were qualitatively assessed in this study to rank the entrepreneurship of the mill manager. These characteristics included risk perception, employee welfare (symbiosism), technology adoption, diversification to other businesses other than saw-milling (in order to spread out the risks), development of contacts and networks and sustainability. Managers/mill owners were asked a few questions on each of these aspects. Based on the answers to these questions, they were assigned a rank (from 1 to 5), 1 representing very poor entrepreneurship and 5 representing very good entrepreneurship. Table 17 shows the distribution of the ranks given under each category. There is no unique pattern of distribution of the ranks. For example, technology adoption and diversification show poor ranks for many mills while other attributes concentrate on the middle ranks.

Table 17. Distribution of the Ranks on Entrepreneurship

	Risk Perception		*Technology Adoption*		*Diversifi- cation)*		*Contacts*		*Employee Welfare*		*Environmental Awareness*	
	No. Responded	*Percentage*	*No. Responded*	*Percentage*	*No. Responded*	*Percentage*	*No. Responded*	*Percentage*	*No. Responded*	*Percentage*	*No. Responded*	*Percentage*
1	18	12	65	44	62	42	17	12	27	19	17	12
2	45	31	48	32	33	22	34	23	21	15	11	8
3	34	24	17	12	39	27	52	35	48	33	56	38
4	42	29	16	11	11	8	39	27	36	25	61	41
5	6	4	2	1	2	1	4	3	11	8	2	1
Total No. Respon -ded	145	100	148	100	147	100	146	100	143	100	147	100

2.6 Constraints and Suggestions for Improvement

Respondents were asked an open-ended question regarding their views on reasons for poor performance of the industry. Their responses are given in Table 18. Mill managers'/owners' responses indicate that old machinery, poor condition of the benches, and poor quality of logs are the major constraints faced by the industry. In addition, poor saw-doctoring, shortage of skilled labor, and discontinuous supply of logs have also been identified as the constraints.

Table 18. Constraints for the Efficiency Loss

Constraints	*No. Responded*	*Percentage* [a]
Old Machinery	72	49
Poor Saw-doctoring	33	22
Poor Condition of Benches	48	32
Poor Stocking	11	7
Labor Shortage (skilled)	22	15
Mill Layout	2	1
Poor Quality Logs	51	34
Discontinuous Log Supply	32	22

[a] Multiple Responses

Similarly, the respondents were asked an open-ended question on their suggestions to improve the industry. Many did not respond to this question. The responses are given in Table 19. The number of responses for this question were fewer than that of the previous question. Use of better machines and removal of strict regulations on felling and transporting of logs were the suggestions made by a large number of mill owners/managers. Providing training for workers, better storage facilities, contract labor hiring system, and new technology are the other important suggestions made by them. Surprisingly, very few suggested that the quality of the logs need to be improved. One reason for this may be the knowledge of the mill managers that wood quality improvement cannot be achieved in the short-term. This may also be due to the respondents' fatigue after answering many questions. It was observed that the respondents were quite busy and wanted to finish the interview quickly. Since the questionnaire was lengthy, respondents wanted to finish the discussion by the end of the interview.

Table 19. Suggestions for Overcoming Constraints

Suggestions	*No. Responds*	*Percentage* [a]
Provision for Training of Workers	17	23
Use of Better Machines	37	25
Improving the Efficiency of the Mill	5	3
Provision of Good Storage Facilities	18	12
Contract Labor Hiring System	12	8
Removal of Strict Regulations	33	22
New Technology	13	9
Human Relation Management	5	3
Repair Machines	4	3
Improve Quality of Logs	5	3

[a] Multiple responses

3.0 LEGISLATIVE APPROACHES FOR FOREST PROTECTION

In this Chapter, we review the Sri Lankan experience of using legislative approaches for forest protection. In the ancient times, the king owned all the forestlands. However, if a forest is not designated as a protected forest (as a wildlife sanctuary or due to military reasons) usufruct right, such as rights for hunting, shifting cultivation, and gathering activities, were granted to the people. The British rulers changed this situation by introducing the first legislation, the Timber Ordinance No. 2 of 1822, which dealt with the harvesting of timber. This act prohibited cutting timber from crown lands and jack trees on private lands without a license (MFE 1995). Jack tree was given special treatment due to food security reasons. At that time, jack fruit was a substitute for the staple food, rice. Later, the British government introduced Forest Ordinance (FO) No. 10 of 1885. This Ordinance made a provision for the declaration of reserved forests, but emphasis was given to the control, felling and transport of timber. The Forest Ordinance No. 16 of 1907 is the basis of the present law relating to forest and plant protection. The main objective of all this legislation is to transfer the usufruct rights enjoyed by the people to the colonial government and to appropriate the rents from the forest and wildlife from the periphery to the center, under colonialism. Since its enactment, the Ordinance has been amended many times, but its original structure remains unchanged (MFE 1995).

After the enactment of the FO in 1907, several amendments were made to it and that resulted in the current regulations regarding timber harvesting from natural forests. The regulations are very restrictive as a large number of forestry activities are described as punishable (MFE 1995). Under this legislation, forests cannot be utilized unless a permit is obtained. With the amendments, private individuals were not allowed to harvest timber from natural forests completely. A government monopoly, State Timber Corporation, was created in 1968 and it was assigned with the power to harvest timber from natural forests.

Gradually, the legislation was expanded through various amendments to restrict timber harvesting from privately owned lands. Eventually, the legal system resulted in an extremely restrictive permit system for felling and transporting timber in Sri Lanka. However, one should acknowledge that the protection of fauna and flora within forest reserves and particularly the protection of listed tree species occurred as a by-product of this legislation.

With the introduction of various amendments, the timber permit system became very complicated. The specific details of the system are too complex for present discussion. Therefore, an attempt is made to provide only the basic features of the permit system. For the purpose of issuing permits, trees are divided into two groups. It is sufficient to get only a transport permit for the tree species in the first group while it is required to obtain both felling and transport permits for the second category, which includes three species of trees grown in private lands. Transport permit should be obtained before felling trees for both categories. According to the circulars of 17/96 dated 25 March, 1996, 18/96 dated 6 December, 1996 and 04/91 dated 27 July, 1991 issued by the Ministry of Agriculture, Lands and Forestry, permits to cut down trees in the second category will only be given for prescribed reasons. For example, jack trees can be cut down only if the agricultural officer certifies that a tree does not bear fruits anymore, or has become an obstacle for other agricultural activities or has the potential to fall on to a building.

For the purpose of issuing transport permits, trees were categorized as softwood and hardwood species. Softwood species are generally exempted from the requirement of transport permits. The hardwood species are categorized into three main groups such as Class A, B and C. In all the cases, a tedious procedure has to be followed in order to obtain felling and transport permits.

Two main government agencies, the Ministry of Public Administration (MPA) and the Department of Forest Conservation (DFC) are vested with the authority of issuing permits. The authorization of the Department of Agriculture is necessary for issuing permits for some types of trees in addition to the above-mentioned two agencies. An application form has to be obtained from the Gramaseva Niladhari (GSN) as the first step in obtaining a permit. The duly filled application with a copy of deed and plan (with specific location of the trees in the land) should be submitted to the Divisional Secretary (DS). These two officers belong to MPA. DS instructs the GSN and Range Forest Officer (RFO) to report about the trees, their locations and sizes. RFO instructs Beat Forest Officer (BFO) to report about the trees. These two officers belong to DFC.

Both GSN and BFO visit the site separately to inspect the locations and measure the circumference of the trees. BFO’s report should be approved by RFO before it goes to the DS while GSN’s report goes directly to the DS. If the RFO is not satisfied about something, he will visit the site for re-inspection. If the DS is not happy about the reports, he can re-inspect the site by himself or through one of his agents. If some problems are detected, the permit-issuing procedure will be terminated at this stage.

After all these inspection and re-inspection, if there is no disparity about the measurements, locations, ownership etc., the first hurdle of obtaining a permit is over. There are several reasons to reject an application. For example, if the private land is located close to a forest reserve, the request will be turned down at this stage. Given the scope of the powers vested with the relevant officers, they can always find a reason to reject a request for a permit. There is no proper appeal procedure if the applicant is unhappy with the decision.

If a permit application is successfully completed at this stage, then the felling permit will be issued to the applicant. This permit will be approved by a committee (Timber Committee) that includes the DS, RFO, and at least two other government officers who are not from the Forest Department or Public Administration. This committee meets once in two months and approves the felling and transport permits. If trees are cut during the day, the GSN and BFO should be present at the site. After the trees are cut, the GSN and the BFO should give another report, separately to the DS. This report is known as a log report. Here again, the BFO’s report should go through the RFO to the DS while the GSN's report will go directly to the DS. The log report should give the details of the number of log pieces obtained from each tree with the lengths and circumferences. The main objective of the log report is to avoid adding trees to the lot by cutting trees from other lands or natural forests. If the log reports from the two officers are identical, then the transport permit will be written.

The permit, which will be issued for 12 hours, includes the details of all the log pieces and the vehicle. On the day the logs are transported, both the GSN and BFO should go to the site and place their emblem on each piece of log and inspect the loading of approved logs. Only then can the timber be transported.

Certain additional routes need to be taken in the case of jack trees and some of the tree species that grow only in the natural forests. In the case of jack trees, the DS forwards the application after the first stage to the District Secretary, who is his superior. If necessary, the District Secretary will send a team of his own to inspect the site. For some of the very rare timber species grown naturally in forests, the applications will be sent to the Forest Department head office following the RFO’s approval. Note that this type of species sometimes grow in home gardens. If they are in natural forests, they cannot be harvested, as there is a moratorium on harvesting timber from natural forests since the late 1970’s.

The above-described tedious procedure to obtain permits to cut down and transport timber from private lands has become a very serious constraint in the development of private timber supply in the country. It has become extremely difficult for an ordinary person to obtain a timber permit due to the following reasons:

There are large numbers of government officers who have the authority to approve timber permit documents at various stages of the procedure. If one of the officers uses his discretion against the application, the permit will not be issued. Even if the decision is unfair, the applicant cannot appeal to change the outcome.

The initial documentary requirements include a deed and a plan of the land indicating the location of the trees. Many poor smallholders do not have the titles for the land and their trees cannot be sold. Even if the smallholder has the deed, it is costly to get a plan for the land.

One has to visit the offices of the GSN, DS and RFO and in cases of special timber categories, the District Secretary's office and Forest Department head office, many times. It is very time-consuming and expensive for a permit applicant to go and wait in the queues to meet the necessary government officers. Given that, these officers also do field visits and are responsible for numerous tasks other than issuing timber permits. There are situations where applicants visit their offices, wait a long time and come back without meeting the officers.

Most of the government officers have many duties other than issuing timber permits. Moreover, there are no incentives such as promotion or incentive payments linked to forest conservation activities.

Generally, government officers are poorly paid and many are frustrated with the quality of life they have, particularly in comparison to the private sectors and semi-government sectors like banks.

This very restrictive regulation of felling and transporting timber, together with the above-described characteristics of the government service, have created an artificial scarcity of timber with high prices and consequently an implicit understanding between timber traders and government officers. These high prices together with the government officers' cooperation have provided opportunities for some of the timber traders to make excessive profits.

The local level timber trade has evolved together with the restrictive regulations in a very specific manner. In many situations, timber traders are either government servants themselves or their relatives and friends who have developed a network among the government officers involved in issuing permits. When there is some mature timber in a private land, these timber traders negotiate a price with the landowner and arrange for the felling and transporting permits under the tree owner's name. Their networking reduces the time cost for obtaining the permits. In order to facilitate the permit procedure, they usually bribe all the officers involved in issuing the permit. In essence, the situation has created a cartel of timber traders and government officers. For every truckload of timber, there are different payments made to all the officers involved. Given this system, the officers know the traders who pay the bribes and consciously facilitate issuing permits to such traders while discouraging others from applying for timber permits.

If an ordinary person applies for a timber permit, the system becomes extremely bureaucratic. Many of the ordinary applicants are denied the permit or their documents are kept for a very long time, causing them to give up on the procedure. Thus, it has become extremely difficult for an ordinary person to obtain timber permits. Given that this system is in operation, timber owners know that their trees have no value without a permit and the permit cannot be obtained easily. In the meantime, the traders know that they have the capability of going through the hurdle of obtaining the timber permit. This situation puts the tree owner in a very disadvantageous position when they bargain for the stumpage price. Thus, it allows timber traders to purchase trees at very low prices, obtain the timber permit and sell the timber at very high prices. Eventually, both consumers and producers of timber are adversely affected by the existing regulatory measures.

In the above section, we described the impact of regulation on producers and consumers of timber. Now let us look at some of the empirical evidence to further support the above-described theoretical exposition. In order to understand the impact of heavy regulations on timber felling and transport, a study was undertaken (Senaviratne and Gunatilake 2001) and timber owners and traders were interviewed in a selected district of Sri Lanka. Based on the information gathered, a profile of prices and costs starting from the stumpage price up to the final market price was constructed for selected species. In addition to the usual costs of felling, cutting, de-barking, loading and transporting, the unofficial transaction cost (UTC) was estimated. The UTC has two components: bribes paid to government officers and the opportunity cost of time. Table 20 shows the amounts paid as bribes to the government officers at various stages of obtaining a permit. The data in the table clearly shows that all the officers involved in issuing a permit received bribes.

Table 20. Distribution of Unofficial Transaction Cost

Category	*Average UTC Rs[a]. per Cuft(ft^3) (% on Total)*	*Minimum*	*Maximum*	*Standard Error*
Basic Documents	5.53 (9%)	3.33		0.67
GSN	3.07 (5%)	1.67	5.00	0.23
DS	21.40 (35%)	13.33	33.33	1.12
RFO	5.73 (9%)	3.33	10.00	0.27
BFO	4.58 (8%)	3.33	10.00	0.47
Head Office	16.07 (27%)	10.00	33.33	0.99
Other	4.53 (7%)	3.33	6.67	0.25
Total	60.91 (100%)			

[a] 93 Rupees = 1 USD

It is clearly evident from Table 20 that bribery is an accepted transaction in obtaining the timber permits. Table 21 and Table 22 show the formation of cost and final price of timber. There are three major important points that need further discussion from the data in the two tables. First, the UTC, (only the bribery component) is about 7.35% of the final price of timber. Although this amount does not look very significant, one should realize that these figures were obtained from the timber traders who were very reluctant to reveal the information. They have incentives to provide under-estimated figures as they are beneficiaries of the existing system. Moreover, the opportunity cost of time for the timber traders who are part of the cartel is very low, as officers try to minimize the time requirement for those who pay bribes. For an ordinary person, the time cost will be much greater. Once the profit is excluded, the bribery cost is about 18.5%. Second, the average profit margin is about 60% of the final price.

Table 21. Cost Structure of Timber Marketing

Average Cost Structure	*Satin Wood (Rs.)*	*Jack (Rs.)*	*Teak (Rs.)*	*Kolon (Rs.)*	*Average*	*Percentage*
Owners price	224.97	100.00	136.88	128.19	147.51	56
Pruning of branches	3.81	3.82	3.81	3.81	3.81	1
Cutting & logging	10.33	10.33	10.33	10.33	10.33	4
Depot	5.96	6.58	5.96	5.96	6.12	2
Loading	10.33	10.33	10.33	10.33	10.33	4
Transport	38.20	38.20	36.67	36.67	37.44	14
U.T.C.	60.91	44.85	44.85	44.85	48.87	19
Total Cost	354.51	214.11	248.83	240.14	264.40	100

93 Rupees = 1 USD

Table 22. Formation of the Market Price of Timber

Average Cost Structure	*Satin wood (Rs.)*	*Jack (Rs.)*	*Teak (Rs.)*	*Kolon (Rs.)*	*Average*	*Percentage*
Owners Price	224.97	100.00	136.88	128.19	147.51	22
Pruning of branches	3.81	3.82	3.81	3.81	3.81	1
Cutting & Logging	10.33	10.33	10.33	10.33	10.33	2
Depot	5.96	6.58	5.96	5.96	6.12	1
Loading	10.33	10.33	10.33	10.33	10.33	2
Transport	38.20	38.20	36.67	36.67	37.44	6
U.T.C.	60.91	44.85	44.85	44.85	48.87	7
Profit Margin	425.49	486.52	451.17	218.00	395.30	59
Final Price	800.00	700.00	700.00	458.00	664.50	100

93 Rupees = 1 USD

This clearly indicates that the excessive bargaining power given to the timber traders enables them to extract most of the value of timber. In the end, the timber owners get only about 22% of the final price as the stumpage value. So, the regulatory system and the associated marketing mechanism have resulted in high-priced timber for consumers and a very low price for producers. This works as a disincentive to grow timber in private lands.

There are two cases which corroborate the above-described findings further. First, in the year 2000, the timber permit system for jack tree was temporarily suspended. During the suspension period, there was no need to obtain permits to cut down and transport jack trees. At this time, the final price of jack timber decreased by about 50%. Note that none of the factors affecting timber prices other than the suspension of the timber permit system changed during this period. This clearly shows the impact of strict regulation on timber prices.

In the second case, a very high-ranking officer of the Ministry of Forestry and Environment, who owned eight satin timber trees, experienced the impact of regulation on timber prices. He wanted to sell these trees and the timber traders (about ten traders visited the site) offered less than Rupees 100,000 (USD 1,075.27) for the trees. Having known the high value of the trees, this officer decided to obtain a permit to sell the trees. Although he is an influential officer in the ministry itself, he found it very difficult to obtain a permit. After a struggle, he finally obtained the permit and once the permit was issued, the same timber traders offered him Rupees 700,000 (USD 7,526.88) for the same number of trees. He finally transported the trees to Colombo and sold them for about Rupees 1,100,000 (USD 11,827.96). This case study also shows that the uncertainty of obtaining a permit and the tediousness of the procedure allow timber traders to make excessive profits while timber owners get only a small fraction of the final value.

From consumers' and producers' points of view, the timber permit system has not had any positive impact as described above. Has the regulatory system benefited the forest conservation? The answer, unfortunately, is no. After imposing the moratorium on timber harvesting from natural forests in late 1970, private lands, especially, home gardens, became the most important source of timber supply. For a while, these lands were supplying timber.

During this period, the regulation on timber harvesting became tougher. Timber became scarce in private lands too. At present, part of the timber, if not most, designated as coming from home gardens, are actually coming from natural forests. Timber traders, with the help of relevant officers, harvest trees from nearby natural forests, bring them to private lands and obtain permits as if the trees were harvested from private lands. Since all the officers are gaining from this arrangement, they do not take any action against these illicit activities.

During the study on timber permits, one of the researchers personally visited the natural forests near the villages and found that most of the immatured valuable timber trees had been harvested. Since these trees could not be transported without a permit, somebody had taken a permit indicating that the trees were harvested from private lands. Thus, the existing heavy regulatory system has, in fact, promoted illegal harvesting.

On one hand, the excessively high price prevails (due to heavy regulations) promotes illegal activities; on the other hand, very low stumpage prices received by growers and the uncertainty about harvesting timber created by the regulation, severely discourage growing timber trees in rural areas where lots of suitable lands are available. This further increases the wood scarcity, creating a vicious cycle. Thus, the existing timber permit system is an excellent example of government or policy failures.

3.1 Forest Plantations

The establishment of forest plantations can increase the timber supply and reduce the pressure on natural forests. Forest plantations were established and managed by the Forest Department in Sri Lanka. The private sector does not play any significant role in forest plantations at present. The first forest plantation was established in the 1870s in Sri Lanka. However, most of the plantations were established after 1950.

Currently, about 89,000 ha of forest plantations exist in various parts of the country. Only 5,000 ha of these forest plantations are owned by the private sector. Teak, eucalyptus and pinus are the main species established by the Forest Department. In addition, some limited extents of jack tree and mahogany plantations have also been established in the intermediate zone areas.

Like in many parts of the world, forest plantations have been established with excessive costs and they are poorly managed by the Forest Department. Most of the plantations are overstocked and proper silvicultural management practices have not been used. As a result, expected yields are comparatively poor. There are many reasons for the poor management of forest plantations. A lengthy discussion on the various reasons for poor management and the excessive cost of establishing forest plantations is beyond the scope of this report. The Sri Lanka Forestry Sector Master Plan (MFE 1995) has recognized that the institutional environment of the Forest Department does not support financially self-sustaining forest plantation development. Therefore, the Master Plan recommends the involvement of the private sector in future developments of forest plantations.

Participation of the private sector in forest plantation depends on the profitability of the venture. Analysis carried out on the profitability of forest plantations show that forest plantations are financially feasible although not very attractive compared to other investment opportunities. Table 23 shows the financial returns of different forest plantations for the private sector. Note that the Internal Rates of Return (IRR) given in the table are derived considering only the direct financial benefits. Since forest plantations may provide other environmental services and community benefits, the social IRR will be much higher than the figures in the table. Since the other benefits are realized by the society, it is feasible to provide some assistance and subsidies to develop the private sector forest plantations. In fact, it has been found that providing lands, technical assistance and plants for forest plantations are more cost effective than having the Forest Department establish them. However, the attempts taken to develop this sector have been unsuccessful mainly due to heavy regulatory measures existing in the country.

Table 23. Financial Feasibility of Forest Plantations

Timber species	*IRR (%)*
Teak (*T. grandis*)	12.4
Eucalyptus (*E. tereticornis*)	11.6
Eucalyptus (*E. grandis*)	14.2
Pinus (*P. caribaea*)	11.9

Source: MFE 1995

4.0 TECHNICAL EFFICIENCY OF SAW-MILLING

This chapter presents the results of the technical efficiency analysis. The present study estimates the technical efficiency of saw-milling using both stochastic frontier and data envelopment analysis (DEA) approaches. The first section presents the stochastic production frontier results and the DEA results follow that. Towards the end of the chapter, a comparison of the results will be made.

4.1 Stochastic Production Frontier Analysis

4.1.1 Theory

Traditionally, the economic efficiency at the firm level is measured by single factor productivity. This approach is, however, not very accurate as other factors should be held constant in measuring factor productivity. Farrel (1957) developed better, but simple measures of efficiency. He defined two measures of efficiency: technical efficiency and allocative efficiency. Of these, technical efficiency reflects the ability of a firm to obtain maximum output from a given set of input or to obtain a given level of output from a minimum level of input. The allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, given their prices (Coelli 1995). These two efficiency measures are combined to estimate the economic efficiency.

Efficiency, in general terms, refers to getting more output using the same input or getting the same output using less input. In essence, achieving efficiency requires savings of input or augmentation of output. In economics, the term "efficiency" is used with very different meanings under different context. For example, Pareto efficiency refers to overall efficiency in an economy that includes efficiency in production, consumption and exchange. In this analysis, efficiency is narrowly defined and it only refers to the efficiency that can be gained by re-organizing the production process. Therefore, efficiency can be understood as attempts to improve and produce the same quantity of goods using smaller quantity of input.

For example, assume a sawmill uses 100 m^3 of logs to produce 50 m^3 of sawn-wood at the beginning. Then the mill owner sends the workers for a training on how to operate machines. After the training, workers acquire skills as to how the wastage can be minimized so that now the mill can produce 50 m^3 of sawn-wood with 90 m^3 of logs. That is an efficiency improvement. The following description of efficiency measures is precise and technical in nature.

Farrel's technical, allocative and economic efficiency can be further elaborated using the concept of unit isoquant (Figure 3). Consider a firm producing output Y from inputs X_1 and X_2 with the production function (frontier) $Y = f(X_1, X_2)$. Assuming constant returns to scale, the frontier technology can be represented by the unit isoquant, $1 = f(X_1/Y, X_2/Y)$, *QQ'*. Let *WW'* represent the ratio of input prices. Farrell defines a firm producing at point A as technically inefficient and the ratio OB/OA gives Farrell's measure of technical efficiency. Point B is technically efficient but allocatively inefficient and the ratio OD/OB is Farrell's measure of allocative efficiency. Finally, the ratio OD/OA measures total efficiency. Note that total efficiency is equal to the product of technical and allocative efficiencies.

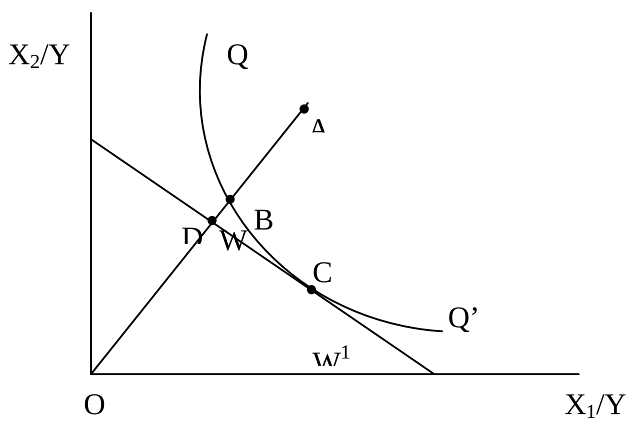


Figure 3. Efficiency Measurements

Often, firm level input-output relationships are examined with production functions that are estimated using the regression analysis. Since the regression line is fitted through the means of the data set, such analysis provides only an average relationship (Alauddin et al. 1993). In contrast, the frontier production function corresponds to the formal definition of a production function, which refers to the maximum output obtainable from a given set of input and technology. The basic difference of a stochastic frontier, compared to the average production function, lies in the formulation of the residual term of the regression equation. Here, the error term is separated into symmetric and asymmetric components. The symmetric component represents the usual random variations, measurement errors and statistical noise. The asymmetric (one-sided) term captures the technical efficiency of the firm (Kumbhakar et al. 1991; Bravo-Ureta and Pinheiro, 1993; Coelli 1995). The major weaknesses of the stochastic frontier method include arbitrary specification of the distributional form of the one-sided error term, selection of the functional form, and difficulties involved when multiple outputs are present.

Following the standard assumption of Zellner et al. (1966) that mill owners maximize expected profits, the single equation Cob-Douglas stochastic production model (Aigner et al. 1977; Meeusen and van den Broeck 1977) is specified as:

$$Lny_i = Ln\beta_0 + \sum_{k=1}^{5} \beta_{ik} Lnx_{ik} + v_i - u_i$$

Where

y_i is the index of sawn-wood output, ft^3/month

x_1 is index of log inputs, ft^3/month

x_2 is units of energy used, KWh/month

x_3 is Capital expenditure of the mill,

x_4 is Skilled labor, man days/ month

x_5 is Unskilled labor, man days/month

β_k (k =1,2,…5) are the parameters

v_i is random variable (iid ~N(0, σ^2v)

u_i is non-negative random variable that represents technical inefficiency.

The two error terms make the difference between an average production function and frontier production function. Using Battese and Coelli (1992) parametric specification, the maximum likelihood estimation of equation 1 provides estimators for β, $\sigma^2 = \sigma^2_v + \sigma^2_u$ and $\gamma = \sigma^2_u + \sigma^2$. The prediction of a firm's technical efficiency is based on conditional expectation of u_i (Exp(-u_i)), given the value of random variable $\varepsilon i = v_i - u_i$. Subtracting exp(-vi) from both sides of the above equation we obtain:

$$Lny_i^* = Lny_i - u_i$$

Where y_i* = is the ith firms observed output adjusted for statistical noise. The above equation forms the basis for the technical efficiency of the firm.

4.1.2 Data and Measurements

The primary data for estimating the above production function was collected using a structured questionnaire. As mentioned earlier, a complete set of data was available for only 148 sawmills due to practical difficulties in obtaining accurate information on inputs and outputs. One of the problems encountered in estimating equation 1 is the presence of a number of different outputs. For example, a sawmill produces door and window frames, flanks with different thickness, rafters, wall plates and many other different sized and shaped products. These are different outputs with very different values per m^3. The stochastic frontier technique can be used only for single output firms. Therefore, the different outputs were aggregated to a single output index using the following formula.

$$y_j = \frac{\sum_{r=1}^{s} p_{rj} q_{rj}}{\sum_{j=1}^{n} \bar{P} / N}$$

Where y_j is the normalized output for the jth firm, s denotes the number of differentiated products, p_{rj} denotes the price of the rth product for the jth firm, q_{rj} denotes the amount of rth product for the jth firm. The average price in the denominator is defined as:

$$\bar{p} = \sum_{r=1}^{s} p_{rj} q_{rj} / q_j , \; q_j = \sum_{r=1}^{s} q_{rj}$$

A similar problem was encountered in measuring the log inputs. The log inputs were broadly categorized into softwood and hardwood. Then they were also aggregated using the above formula. The number of units of energy used during the month under consideration were directly obtained from the electricity bills. An attempt was made to get an accurate information on the capital expenditure of the sawmills. However, during the pre-testing stage, it was felt that mill owners/managers were not willing to reveal true information on capital expenditures, probably due to tax evasive strategies. Therefore, a proxy, the capacity of the mill, was used in place of capital expenditure. Table 24 shows the descriptive statistics of the variables used in estimating the production frontier.

Table 24. Descriptive Statistics of the Variables

	Output Index	*Input Index*	*Energy (KWh)*	*Capacity of the mill (ft^3/month)*	*Labor 1*	*Labor 2*
Mean	2,832.76	4,031.90	1,581.45	3,626.69	90.08	61.99
Standard Error	546.66	724.52	117.37	315.53	4.36	2.93
Median	1,104.94	1,806.83	1,165	2,875	88	44
Mode	2,626.44	2,427.38	1,000	1,500	88	44
Standard Deviation	6,650.40	8,814.21	1,427.87	3,838.60	53.05	35.65
Range	43,771.11	60,544.83	8,820	29,775	264	154
Minimum	2.89	139.69	180	225	22	22
Maximum	43,774.01	60,684.52	9,000	30,000	286	176
Count	148	148	148	148	148	148

An initial estimate of the technical efficiency scores were made and these scores were plotted against possible variables that determine the technical efficiency. The initial run indicates that on average, the sawmills are 65% efficient. Based on the plots, the following variables (Table 25) were selected for the second stage regression in order to determine what causes the inefficiency in saw-milling.

Table 25. Determinants of Technical Efficiency

Variables	*Determinants*	*Hypothesized relationship to technical efficiency*
X_1	Ln Age of the manager/owner	Positive
X_2	Ln Quality of log inputs	Positive
X_3	Charges based on log input =1, Others 0	Negative
X_4	Owner managed mills = 1, Others 0	Positive
X_5	Ln Education of the manager/ owner	Positive
X_6	Ln Entrepreneurship	Positive
X_7	Ln Capacity of the mill	Negative
X_8	Source of energy, only public Electricity =1, public electricity and other = 0	Negative
X_9	Ln Age of the machines	Negative

The owner's age was considered for X_1 when the mill was managed by himself. Otherwise, the hired manager's age was considered. Log quality was ranked from 1 to 5: 1 representing the poorest quality and 5 representing the best quality. Some mills buy logs and do the milling operation. These mills then sell the output at the mill. Other mills only provide milling services. These second type of mills charge a fee based on the ft^3 of the log inputs. The X_3 variable assigns 1 for the second type of mills and 0 for the other mills. The X_4 variable assigns 1 for the owner managed mills and 0 for the mills managed by hired managers.

As described earlier, entrepreneurship was assessed based on six characteristics and the average rank was initially used as X_6. Since the results were inconsistent with the postulated hypothesis, a step-wise procedure was followed to find the best single category that provides the expected result. Business contacts provided the best results and therefore this variable was used in the analysis. X_7 measures the scale of the operation by considering the capacity of the mill. If the source of energy in a mill is only electricity, that mill was assigned 1 and mills with diesel-operated machines and a combination of electricity and diesel were assigned 0.

In the early studies, a two-stage procedure was followed to analyze the determinants of technical efficiency. In the two-stage procedure, first the technical efficiency scores were estimated and then a second stage regression was estimated to find the determinants of technical efficiency. As shown by Kumbhakar et al. (1991) this procedure has two problems. First, technical efficiency may be correlated with inputs causing inconsistent estimates of the parameters and technical efficiency scores. Second, the standard OLS estimators are inappropriate because the technical efficiency scores – the dependent variable in the second stage regression - are one sided. Kumbhakar et al. (1991) suggest a one-step formulation in order to overcome these problems. We used this procedure in the present analysis to obtain the technical efficiency scores and their determinants simultaneously using the Frontier (Version 4.1) program.

4.1.3 Results

Table 26 shows the results of the production function analysis. Only the log input in the production function is statistically significant. Energy inputs, and both labor inputs are insignificant. The results reveal that the log input is the limiting factor of production in saw-milling. Most of the mills are operating below their full capacity due to severe shortage of logs. Labor is paid per month and regardless of whether the mill is operated or not (due mainly to availability of logs), laborers are paid. This is due to the scarcity of skilled labor in this sector. There is no proper training for skilled labor. They start their career as unskilled workers and over time acquire the skills to operate the machines. If the skilled labor is laid off, finding a replacement is not easy and training a manual worker takes time. Therefore, mill owners keep the skilled laborers even when the mill is not in operation. That may be the reason for the insignificant relationship between output and both skilled and unskilled labor.

Energy is also insignificant in the model, perhaps, due to the use of energy for purposes other than milling. We obtained the units of energy from the electricity bill. The data on energy does not provide any breakdown between energy used for milling and other purposes such as lighting, fans, air-conditioning etc. Further, the mills with their own electricity generation capacity have not kept proper records. The data only uses the energy obtained from the public electricity supply. This measurement error may also have contributed to the insignificant result with respect to energy.

Table 26. Production Function of the Saw-milling Industry

Variables	*Coefficient*	*Standard Error*	*t-ratio*
Intercept	-0.50	0.22	-2.21 [a]
Log input	1.02	0.03	39.48 [a]
Energy	0.01	0.03	0.34
Capacity of the mill	0.02	0.02	0.98
Unskilled labor	0.03	0.03	1.08
Skilled labor	-0.05	0.03	-1.61

[a] Significant at 0.05 level

The distribution of the technical efficiency scores are given in Figure 4 and the descriptive statistics of the efficiency scores are given in Table 27. The average technical efficiency is 0.72. This indicates that on average, the sawmills can save about 28% of all the inputs while producing the same outputs. Note that the technical efficiency score is defined with respect to the best mill/mills in the sample. From an output orientation, the results suggest that on average, 28% more sawn-wood can be produced with the current level of inputs. Thus, the overall results indicate that there is a considerable inefficiency in the saw-milling industry.

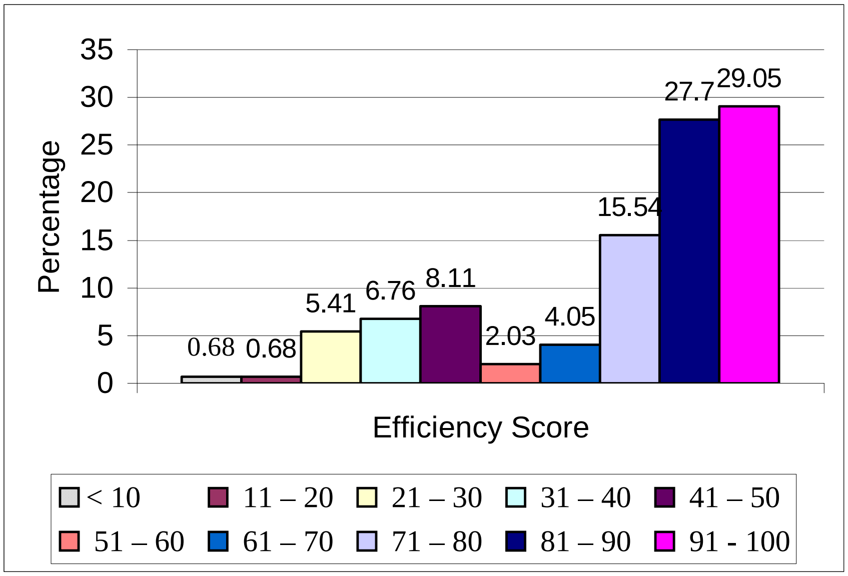


Figure 4. Distribution of Technical Efficiency

Table 27. Descriptive Statistics of Efficiency Scores

Mean	0.72
Standard Error	0.02
Median	0.85
Standard Deviation	0.23
Sample Variance	0.05
Kurtosis	-0.01
Skew	-1.13
Range	0.88
Minimum	0.10
Maximum	0.98
Sum	109.80
Count	148

Table 28 shows the factors influencing the technical efficiency in the saw-milling industry. Age of the manager/owner shows a statistically insignificant impact on technical efficiency. Quality of the log input shows a statistically significant positive impact on the technical efficiency as expected. As many mill managers/owners have indicated, the quality of logs coming to the mills are rapidly declining with the shortage of wood. Most of the tree species currently being sent to the mills are not meant for wood production. They are multi-purpose tree species harvested from non-forest lands such as home gardens. Most of these trees have not been subjected to silvicultural practices. The stems are not straight and matured enough and this leads to heavy losses. Moreover, the trees are cut before they reach the optimal age due to wood scarcity. This also results in lower yields of wood.

Table 28. Factors Influencing the Technical Efficiency (Stochastic Frontier)

Variables	*Coefficient*	*Standard error*	*t- ratio*
Intercept	-0.40	1.58	-0.25
Age of Manager/Owner	0.04	0.05	0.75
Quality of Logs	0.35	0.03	10.43 [a]
Charges	-0.48	0.06	-7.45 [a]
Owner Managed Mill	0.21	0.03	7.13 [a]
Education of Manager/Owner	-0.22	0.03	-7.88 [a]
Entrepreneurship	0.11	0.03	3.68 [a]
Capacity of the Mill	-0.09	0.01	-5.69 [a]
Energy	0.16	0.12	1.42
Age of the Machine	-0.29	0.07	-3.90 [a]

[a] Significant at 0.05 level

It was hypothesized that mills which are only milling and charging based on the log input are inefficient because there is no incentive for such mills to improve technical efficiency. As hypothesized, the expected negative relationship was observed with statistical significance. As discussed earlier, mill managers are not provided with any incentives based on the performance of the mill. Therefore, we expect owner-managed mills to be technically more efficient. The expected relationship was observed with statistical significance. Education of the owner/manager was expected to positively affect the technical efficiency. This relationship was not observed. The statistically significant negative impact may be due to the lack of formal education in business management. Entrepreneurship (business contacts) was expected to positively affect the technical efficiency. The results show the expected impact with statistical significance. Since the saw-milling industry is highly regulated, mill owners who have a network with government officers may get consistent supplies of timber, making their mills more efficient.

Capacity of the mill was expected to have a positive impact on technical efficiency. This expectation was due to the economies of scale of the larger mills. However, the results show that there is a negative relationship between capacity of the mill and technical efficiency. Given the scarcity of saw logs, big mills operate at too low a level of output. Most of the fixed factors in larger mills are under utilized and therefore, large mills seem to be more inefficient. Some mills have their own power generation capacity. Since there are frequent power-cuts, it was hypothesized that mills which are completely dependent on public power supply are technically inefficient.

However, results indicate that there is no statistically significant relationship between source of energy and technical efficiency. As indicated earlier, most of the machinery in the saw-milling industry are old and as machines get older their performance becomes poor, leading to technical inefficiency. As shown by the results, age of the machine negatively influences technical efficiency.

4.2 Data Envelopment Analysis

4.2.1 Theory

This section presents the details of the deterministic frontier model. The deterministic model uses mathematical programming techniques to estimate the production frontier. The technique used in estimating the deterministic frontier is known as the data envelopment analysis (DEA). The essential characteristic of the DEA model is the reduction of the multiple-output multiple-input situation for each decision-making unit (DMU) to that of a single "virtual" input and output. The ratio of this single virtual output to single virtual input of each DMU provides the measure of efficiency.

Charnes et al. (1978) generalized the DEA to a linear programming (LP) problem. The main advantage of the DEA method is its ability to estimate a production frontier when multiple outputs are present. Moreover, the DEA methodology also avoids the difficulties involved in selecting a suitable functional form and suitable distributional form for the one-sided error term (Battese 1992). Further, the DEA method avoids the simultaneity bias problem in estimating the second stage regression using efficiency score to identify the factors affecting efficiency.

The major weakness of the DEA methodology is that it does not take into account the measurement errors and other statistical noise in the data. However, saw-milling industry is not subjected to natural uncertainties such as weather changes. Therefore, this weakness may not be a serious limitation[1].

[1] Although the saw-milling industry does not face natural uncertainty, the data used in this study may have some measurement errors as explained in Chapter 2.

The basic DEA model embodies a constant returns to scale (CRS) assumption. Variable returns to scale (VRS) DEA models were developed by Banker et al. (1984). Constant returns to scale, variable returns to scale and non-increasing returns to scale are illustrated in Figure 5. Under CRS, any DMUs lying on the ray, OCR, are efficient and those lying below it are inefficient. Because variable returns to scale allows both increasing and decreasing returns, the VRS frontier may include scale-inefficient DMUs that may be technically efficient for a given scale, resulting in the piecewise linear frontier ABCDE in Figure 5.

In general, the CRS efficiency comparison gives a poorer performance because a DMU has to be both technical and scale efficient to be efficient. Under VRS, technology dominance is weaker, in the sense that scale inefficient production may qualify as a "best practice" if it is technically efficient. VRS efficiency is also known as pure technical efficiency to distinguish it from CRS efficiency, which involves both technical and scale components in performance.

For DMU "K" in the figure, it can be easily seen that technical efficiency under constant returns to scale is equal to or less than that under variable returns to scale, i.e., $TE_{K,CRS} < TE_{K,VRS}$. This relationship is used to estimate the scale efficiency for the K^{th} DMU as $SEK = TE_{K,CRS} / TE_{K,VRS}$. Scale inefficiency is due to increasing or decreasing returns to scale, which can be determined by comparing the VRS technical efficiency score with that estimated under non-increasing returns to scale (NIRS).

The input-oriented and output-oriented efficiency scores under constant returns to scale (TE_{CRS}) and variable returns to scale (TE_{VRS}), and resultant scale efficiency (SE) of the K^{th} DMU can easily be derived from the figure and presented in the Table given below (Table 29).

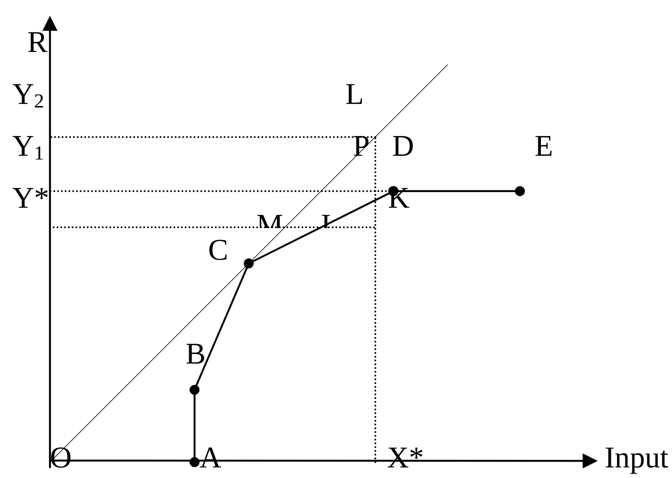


Figure 5. Technical Efficiency under Variable Returns to Scale Output

OCR : Constant returns to scale

ABCDE : Variable returns to scale

OCDE : Non-increasing returns to scale

An inefficient firm can reach the frontier by reducing its input (input orientation). The input reduction/output augmentation is achieved in two stages. Input-orientation models yield input-oriented projections and output-oriented models yield output-oriented projections of efficiency. The input-oriented models seek to maximize the proportional decrease in all inputs until one of the input excesses is reduced to zero. The maximal proportional decrease is achieved in the first-stage problem. The resulting intermediate point is employed in the second-stage problem to obtain the projected point. Output-oriented models maximize the proportional increase in the output vector while remaining within the envelopment surface. A proportional increase in all outputs is possible until at least one of the output slacks is reduced to zero.

Table 29. Efficiency for Input-oriented and Output-oriented DEA Surfaces

Efficiency	*Input-oriented surface*	*Output-oriented surface*
Overall technical efficiency (TE_{crs})	Y*M/Y*K	X*K/X*L
Pure technical efficiency (TE_{vrs})	Y*I/Y*K	X*K/X*P
Scale efficiency (TE_{crs}/TE_{vrs})	Y*M/Y*I	X*P/X*L

The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. For a simple example of an industry where one output is produced using two inputs, it can be visualized as a number of intersecting planes forming a tight fitting cover over a scatter of points in three-dimensional space. Assume there is data on K inputs and M outputs on each of N firms. The vectors x_i and y_j, respectively, represent these. The KX x N input matrix, **X**, and the MY x N output matrix, **Y**, represent the data of all N firms. With the constant returns to scale (CRS) assumption, and using the duality in linear programming, the envelopment problem can be represented as:

$$\text{Min}_{\theta\lambda}\ \theta,$$

$$\text{St:}\quad -y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$\lambda \geq 0$$

Where θ is a scalar and λ is a Nx1 vector of constants. The value of θ obtained will be the efficiency score for the i-th firm. It will satisfy $\theta \leq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient firm, according to the Farrel (1957) definition. The linear programming problem must be solved N times, once for each firm in the sample, to obtain θ for each firm. The above programming problem can be modified to accommodate variable returns to scale.

4.2.2 Data and Measurements

The same data used for the stochastic frontier was used for DEA. The output was measured as one index following the method described above. In doing so, the multiple output advantage was foregone in order to facilitate the comparison of the results of the two frontier models. The measurements of data is similar to that of stochastic frontier. Since the primary objective of the study is to analyze forest conservation through input savings, the input orientation approach was followed. Both CRS and VRS models were used in estimating the technical efficiency. However, the CRS technical efficiency scores were used to analyze the determinants of the technical efficiency.

4.2.3 Results

Table 30 shows the descriptive statistics of the CRS efficiency scores. Figures 6 and 7 show the distribution of technical efficiency under CRS and VRS technologies, respectively. CRS technology assumes that all decision-making units (DMU's) are operating at an optimal scale. A close examination of the distribution of technical efficiency obtained from the stochastic frontier model and CRS DEA model show that average technical efficiencies are close. A t-test however, indicates that the means of the two efficiency scores are statistically different (see Table 31). Individual efficiency scores are also quite different as indicated by their distribution. These differences are due to the methodological differences in the two frontier models. Literature does not provide satisfactory explanation for such differences. Most of the researchers specialize in one of the techniques and continue to work with that. The sole purpose of using the DEA model is to check how robust the result of the determinants of technical efficiency is with different methods.

Table 30. Descriptive Statistics of DEA (CRS) Efficiency Score

Mean	0.65
Standard Error	0.02
Median	0.85
Standard Deviation	0.23
Sample Variance	0.05
Kurtosis	-0.01
Skew	-1.13
Range	0.88
Minimum	0.10
Maximum	0.98
Sum	109.80
Count	148

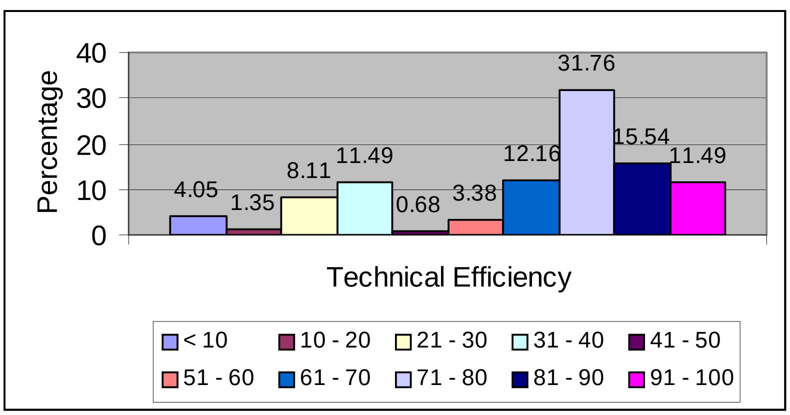


Figure 6. Distribution of Technical Efficiency with CRS Technology

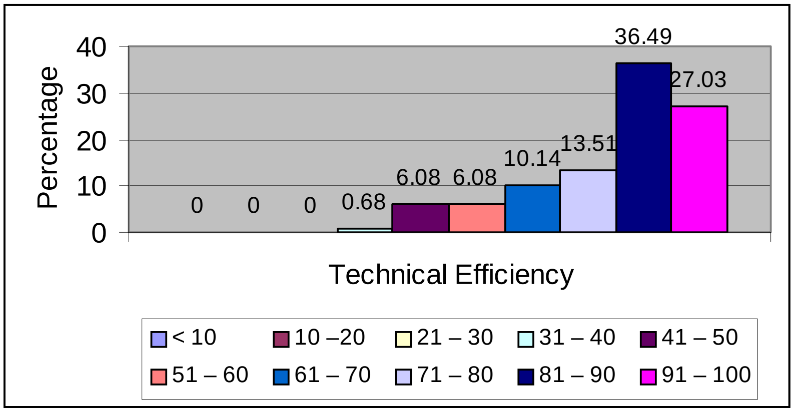


Figure 7. Distribution of Technical Efficiency with VRS Technology

Table 31. Average Technical Efficiencies under Different Technologies

Type of technology	*Average Efficiency*	*Paired t-statistics*
CRS (stochastic frontier) (a)	0.72	5.47 (a-b)[a]
CRS (DEA), (b)	0.65	9.10 (b-c) [a]
VRS (c)	0.81	-7.38 (a-c) [a]
Scale efficiency	0.80	-

[a] Significant at 0.05 level.

The use of CRS specification under inappropriate circumstances will result in measures of technical efficiencies, which are compounded by scale inefficiencies. The VRS specification allows calculation of technical efficiency scores without scale inefficiencies. Therefore, the VRS technical efficiency scores are generally higher than or equal to those of CRS. With the VRS assumption, technical efficiency scores can be separated into two categories: pure technical efficiency and scale efficiency. This is accomplished by conducting CRS and VRS DEA for the same data. If there is a difference in efficiency scores under the CRS and VRS DEA, it indicates that there is scale inefficiency. The difference between the technical efficiency scores is used to calculate the scale efficiency. Figure 8 shows the distribution of the scale efficiency scores.

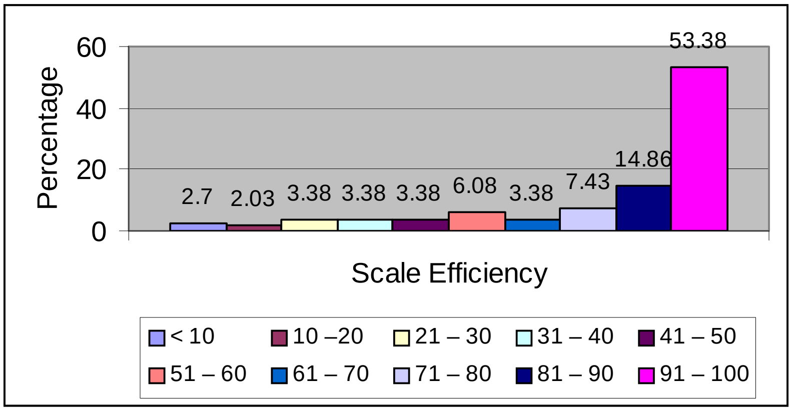


Figure 8. Distribution of Scale Efficiency

One shortcoming of the scale efficiency measure is that it does not indicate whether the DMU is operating under the increasing returns to scale or decreasing returns to scale. This can be determined by running an additional DEA problem with non-increasing returns to scale assumption (NIRS). If the NIRS efficiency score is unequal to the VRS efficiency score, then increasing returns to scale exists for that DMU. If the two scores are equal, then decreasing returns to scale exists. Table 32 shows the description of the existing technology of the saw-milling industry. As seen in the table, more than 90% of the mills surveyed show increasing returns to scale. When one combines this results with existing scale inefficiencies and production function results, it is clear that severe wood shortage (which is the limiting factor in production) forces under-utilization of other resources of the saw-mills.

Table 32. Description of the Technology

Categories	*Number of mills*	*Percentage*
Technically efficient mills	9	6
Increasing returns to scale	135	91
Decreasing returns to scale	4	3

CRS technical efficiency scores were regressed with the same variables used in the frontier model to assess the determinants of the technical efficiency. Preliminary run of OLS regression provided 0.39 R^2 value with a significant F value for the overall goodness of fit. Durbin Watson statistics for autocorrelation was 1.76, which falls in the inconclusive region. However, the diagnostic tests on heteroscedasticity rejected the homoscedasticity null hypothesis. Both Glejser and Bruice-Pegan-Godfry tests provided highly significant Chi-square values. Therefore, a heteroscedastic model was run using the HET command in the Shazam program. Final results are given in Table 33.

As shown in the results, age of the owner/ manager is not statistically significant in the model. Quality of the log input shows a statistically significant positive relationship to technical efficiency. Mills that hire out their machines to others show statistically significant negative impact on technical efficiency. As expected, owner-managed mills show higher technical efficiency compared to others. Education of the mill manager/owner shows a statistically significant positive impact on technical efficiency. Entrepreneurship measured by business contacts shows a positive relationship to technical efficiency. This relationship is however, not statistically significant. Capacity of the mill and source of energy do not show a statistically significant relationship to technical efficiency. Age of the machines shows a statistically significant negative relationship to technical efficiency.

Table 33. Determinants of Technical Efficiency (DEA)

Variables	*Coefficient*	*Standard Error*	*t-ratio*	*P-Value*
Age of the owner/manager	0.06	0.07	0.85	0.40
Quality of the log input	0.17	0.05	3.69 [a]	0.00
Mills that hire their machines	-0.13	0.03	-3.83 [a]	0.00
Owner managed mills	0.07	0.03	2.12 [a]	0.03
Education of the owner/manager	0.07	0.03	2.45 [a]	0.00
Entrepreneurship	0.01	0.03	0.11	0.91
Capacity of the mill	-0.01	0.01	-0.35	0.73
Source of energy	-0.01	0.06	-0.35	0.73
Age of the machines	-0.09	0.04	-2.54 [a]	0.02
Constant	0.36	0.27	1.35	0.18

[a] Significant at 0.05 level.

In comparison to the determinants of technical efficiency obtained from the stochastic frontier model (model 1), the DEA results (model 2) show some similarities as well as differences. Among the differences, education of the owner shows a statistically significant negative impact in model 1 and statistically significant positive impact in model 2. This is the major difference found in the two models. Entrepreneurship shows expected positive impact on technical efficiency but the effect is statistically significant only in model 1. Similarly, capacity of the mill is negatively related to technical efficiency in both models but significant only in model 1. Source of energy shows opposite impacts in the two models. However, this variable is not significant in both models. These differences are due to variations in the two methods adopted to obtain technical efficiencies. However, the theory does not provide clear guidelines to select one approach over the other.

Although there are some differences in the results of the two frontier models, the similarities are remarkable. For example, positive impact of log quality, negative impact of charging system for milling, positive impact of owner's management, and the negative impact of age of the machines are common to the two models, and these variables are statistically significant. Education is the only variable that changes sign and is significant in the two models. Other variables are either statistically non-significant or significant only in one model. Entrepreneurship of the manager is also an important determinant of technical efficiency although not corroborated in both models. The results that are corroborated by both models are important in policy formulation as will be discussed below.

Analysis on technical efficiency presented in this chapter show that a considerable inefficiency exists in the saw-milling industry. On average, 35% (based on the DEA model) and 28% (based on the Stochastic frontier model) inefficiency have been found. From an input orientation, this indicates that the current output can be obtained with a 28% to 35% reduction of all the inputs. From a forest conservation point of view, this reduction of log inputs can be considered as one measure that relieves the undue pressure on natural forests in the country. However, what measures could be taken to improve technical efficiency in the saw-milling industry is not very straight-forward as many factors affect the technical efficiency. Among the results, the impact of log quality, age of the machinery, type of operation and type of management repeatedly show their importance as the determinants of technical efficiency.

About six efficient mills were visited to find the specific reasons for their efficiency. The informal discussions we had with the managers indicate that a few factors are common to these mills. First, these mills are mostly milling the softwood types, which do not need transport permits. So these mills get a fairly regular supply of logs. Second, most of them have recently purchased band saws. Third, the owners themselves managed many of these mills. Finally, all efficient mills purchase logs from the market, they mill the logs, and sell the final product.

Based on statistical results and field visits, old machinery is one of the main factors that determine the technical efficiency. The saw-milling industry needs some major investment on new machinery if the technical efficiency is to be improved. Only very few mills have band saws which provide a higher rate of recovery. A major re-structuring of the industry can be accomplished by replacing the existing old and worn-out machinery. One reason that might explain why mills are not investing in the machinery is the high tariff rates on imported machinery. This was recognized a few years ago. The budget in the year 2000 reduced the tariff on imported machinery from 45% to 30%. The impact of this reduction is yet to be seen.

Lack of investments are not only due to high tariff rates. Given the current situation with regards to heavy regulations, the saw-milling industry faces a huge uncertainty. The majority of the mill owners and managers believe that they cannot continue in this business due to persistent wood shortage. Heavy regulatory measures have added to the physical wood shortage by providing disincentives for private sector investments as explained in Chapter 3. As indicated by many mill owners, continuation of the saw-milling industry with necessary investments on machinery, require a major policy reform that encourages such investments. In addition to reduction in tariff, a conducive business environment without unnecessary restrictive regulations may be required to promote investments on machinery.

One question that arises in the above analysis is whether the saw-milling industry is a naturally dying industry. As we explained in the previous chapter, overly restrictive regulations and associated reasons have made the saw-milling industry unattractive. If the inappropriate policy distortions are removed, the private sector may become involved in the cultivation of timber species. With a continuous supply of timber, the industry may survive.

However, changing timber supply situation is a long-term phenomenon. Therefore, the number of mills may decline until the local wood supply increases. If the changes in the size of the industry are due to the terms dictated by the market, no interventions are necessary. Some of the efficient mills will remain in the industry and more firms will enter as the supply situation improves. Moreover, as shown in the next chapter, market liberalization may increase timber imports. However, only about a third of the total timber requirement will be imported under the most favorable circumstance for imports. Therefore, a complete collapse of this industry is less likely to happen. These reasons show that the saw-milling industry has a potentially important role to play in the forestry sector in Sri Lanka.

Technical efficiency is determined by the log quality. Improving log quality is also a long-term measure that needs some changes in the overall forestry industry. Currently, majority of the logs coming to the mills are immature and of low quality. These trees have not been subjected to silvicultural practices that produce straight logs with high recovery percentages. Home gardens are expected to produce a considerable portion of logs in the future, given that natural forests are allocated for conservation needs. As shown in the previous chapter, existing heavy regulations on felling and transporting timber discourages people from growing trees in their home gardens. Removal of these permit requirements, provision for training on necessary silvicultural practices and provision for good quality planting materials are some of the measures that can be taken to ensure continuous supply of good quality logs from the smallholders.

The technical efficiency is measured as the maximum rate, compared to the best mill in the sample, at which the use of all the inputs can be reduced without decreasing the outputs. It can also be measured as the rate at which the outputs can be increased with the same level of inputs (Kumbhakar 1996; Seiford 1996). As shown in the results, there is a significant inefficiency in the saw-milling sector in Sri Lanka. Given the differences observed in the efficiency scores obtained through the two methods, it is reasonable to conclude that the current output can be obtained with about 27% cut down of all the inputs. Such an improvement will relieve pressure on the overall wood supply sector.

However, protected forests will have the greatest impact of the log inputs savings. As basic forest economics suggests, there is a cost gradient for illegal harvesting from different types of forests. The least cost types will always be harvested first and the highest cost types will be harvested last. Private lands such as home gardens are the least cost sources while protected forests are the highest cost sources[2].

Other natural forests may be in between these categories. If the current trends continue, scarcity will raise the prices, providing the incentive for illegal extraction even from highest cost protected forests.

Thus, theoretically, any efficiency improvement should provide its greatest impact, in terms of prevention of deforestation, on protected forests followed by other natural forests. In order to highlight the magnitude of forest savings due to efficiency improvements, saved logs can be converted to hectares of natural forests under some plausible assumptions. The following assumptions were made in converting the saved logs to natural forests. The data used in this calculation was taken from MFE (1995).

1) On average, the different types of natural forests provide the following wood volumes:

Lowland rainforests -126 m^3/ha

Dry monsoon forests - 21 m^3/ha

Moist monsoon forests – 39 m^3/ha

Of these forest types, lowland rainforests are confined to a few patches and they are protected. Wood harvest from this forest is not possible. Moist monsoon forests are also limited to small areas. Only dry monsoon forests remain in large areas. Therefore, the saved forests are calculated assuming a weighted average of 25.5 m^3 of wood can be harvested from one ha of forests. In the calculation, the dry monsoon forests were assigned a weight of 3 and moist monsoon forests were assigned 1.

2) As technical efficiency improves, the demand for logs decreases, as less is needed to produce a given supply of sawn timber. Figure 9 illustrates the impact of a reduction in demand for saw logs. The technical efficiency improvement allows production of the extra quantity without extra log inputs. This has two effects. First, the price decrease improves welfare as consumer surplus increases and it also reduces the incentives for illegal logging. Second, it can help save the source of logs and forest lands.

3) Total round wood consumption in the country was 1,396,000 m^3 per year in the year 2000. Of this volume of logs, it was assumed that 27% could be saved annually if technical inefficiency is completely eliminated.

4) Complete elimination of existing inefficiency is unlikely, given that some of the factors affecting the inefficiency are not easy to change. It would be a great

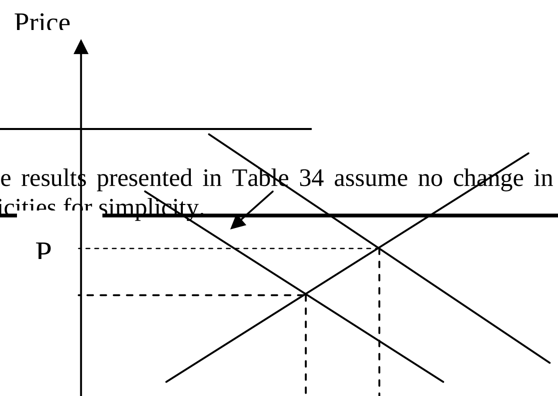
[2] In general, protected natural forests are the least disturbed forests and historically they remained intact due to the high cost of timber extraction. In addition to the location related high cost of harvesting protected forests, there are additional costs of being caught and punished for illegal logging. Such costs are highest for the protected forests.

achievement if the inefficiency is reduced by about 50%. Therefore, the saved natural forest area was calculated assuming that technical inefficiency can be eliminated by 25%, 50% and 75%.

Table 34 presents the possible saving of natural forests due to technical efficiency improvement under the above- mentioned assumptions[3].

Table 34. Efficiency Improvements and Prevented Deforestation

Efficiency Improvement (%)	*Prevented Annual Deforestation (Hectares)*
25	3,695.29
50	7,390.58
75	11,085.88



[3] The results presented in Table 34 assume no change in the demand and supply for sawn-wood and elasticities for simplicity.

Figure 9. Impact of Efficiency Improvement

5.0 TIMBER MARKET LIBERALIZATION

In the previous chapter, improvement of technical efficiency was considered as a means to reduce deforestation. Log input savings due to improvement of technical efficiency was the key in that analysis. Alternative ways to relieve the pressure on natural forests include timber market liberalization, establishment of more forest plantations and correction of existing policy distortions. All these alternatives were analyzed in the previous chapters except for the timber market liberalization. This chapter examines the impact of timber market liberalization on social welfare and forest conservation. Currently tariff (10%), Goods and Service Tax (12.5%) and Defense Levy (7.5%) distort the timber market. The objective of this chapter is to examine the impact of removal of the above- mentioned distortions on social welfare and forest conservation.

5.1 Theory

A simple partial equilibrium framework for a small open economy is used in this analysis. Existence of perfectly competitive markets is assumed. Demand for sawn-wood is given by, $D=f(P_d)$ where D is demand and P_d is domestic price. Supply of sawn-wood is given by, $S=g(P_d)$ where S is local supply. Excess demand is fulfilled by imports; imports=D-S. World market price of sawn-wood (P_w) is different from the domestic price as there are border chargers such as tariff, goods and services tax (GST) and national defense levy (NDL), surcharges and uplifts.

$$P_d= P_w + \text{Tariff}+\text{GST}+\text{NDL} \quad (1)$$

$$Tariff=.\ P_w * tariff\% \quad (2)$$

$$GST=(P_w+ (1+surcharge\%*Tariff)*GST\% \quad (3)$$

$$NDL=(P_w+(1+surcharge\%*Tariff)*uplift\%*NDL\% \quad (4)$$

Equation (1) shows how domestic price is determined. Equations (2), (3) and (4) show how per unit tariff, GST and NDL levels are calculated (Sri Lanka Customs 2001). Import tariffs are charged based on the c.i.f. price (cost insurance freight) of timber. Equation (2) shows how per unit import tariff is calculated. GST per unit of product is based on c.i.f. price of timber and per unit tariff. A surcharge is also charged on the tariff collected. Equation (3) shows how GST per unit is calculated. Per unit rate of NDL is based on a number of factors and equation (4) explains how it is calculated. An uplift is charged in addition to surcharge.

Conceptually, the demand function D=f(P), supply function S=g(P), trade identity, import=D-S, and price linkage identity P_d=P_w+Tariff+GST+NDL form the structure of the model. The D, S, Imp. and Pd variables in the above system of equations are endogenous variables. The exogenous variables Tariff@, GST@, NDL@, uplift@ and surcharge@, c.i.f. price of timber, Pw, and the coefficient of the supply and demand functions determine the values of endogenous variables.

Impact of liberalization of border charges and other local taxes can be analyzed by examining the changes in D, S, Imp. and Pw due to changes in the values of border charges and taxes. Hereafter we call all the distortions (border charges and taxes) “border charges”. Figure 10 shows the impacts due to the reduction of border charges. With the reduction of border charges, domestic price will go down from P_d to P_d’, and depending upon the elasticities of demand and supply, quantity demanded will increase from D to D’ and local supply will decrease from S to S’. Imports will increase from (D-S) to (D’-S’).

As a result of the changes in quantity demanded, quantity supplied and prices, benefits and costs to different market participants will change. In this simple framework the social welfare is measured in terms of changes in consumer and producer surplus. We do not attempt to calculate the theoretically correct welfare measures; compensated variation and equivalent variation here. We assume Willig's (1976) bounds are applicable and consumer and producer surpluses approximate welfare changes adequately. (Consumer surplus is not a true welfare measure since it does not directly represent utility changes. In his seminal article, Willig (1976) showed that for a range on income elasticity values, consumer surplus adequately approximates for compensated variation and equivalent variation, which are considered as the correct welfare measures). Removal of border charges will change the government revenue too.

However, here it is assumed that the government revenue from timber trade is distributed as lump-sum transfers and therefore, has no net impact on social welfare. With the removal of the border charges, consumer surplus will increase by an area ($a+b+c+d$) and producer surplus will decrease by an area a. Compared to the initial higher border charges situation, the government revenue will decrease by an area c. In the mean time, removal of border charges expands the imports from SD to S’D’. Therefore, the government revenue will increase by an area $e+f$. If one disregards the net change in the government revenue, the area ($b+d$) represents the net welfare gain due to removal of border charges.

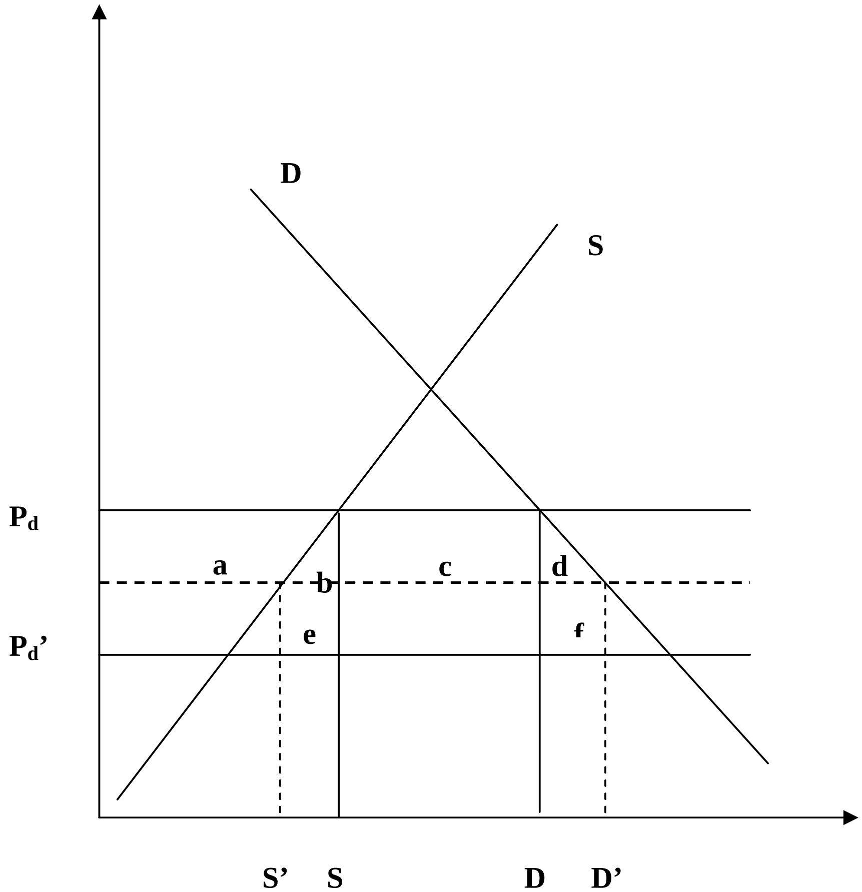


Figure 10. Effect of Timber Market Liberalization

5.2 Empirical Model

One of the problems encountered in simulating the above model was data limitation on demand for sawn-wood. A thorough literature survey indicates that demand estimates for Sri Lanka are not available. Time series data required to estimate the demand and supply functions were also unavailable. Further searches indicated that similar estimates for South Asian Countries are not available either. Appendix 1 shows some of the available elasticities. These elasticities are not indicative as to what range of values are appropriate for Sri Lanka. Therefore, the above model was calibrated using baseline data set for year 1999 for three different sets of elasticities: elastic, unitary elastic and inelastic demand and supply. Baseline data and elasticity values used are given in Tables 35 and 36 respectively.

First the equilibrium in year 1999 was reproduced. Linear demand and supply curves were assumed and intercepted and slope of the demand and supply functions were generated using baseline values reported in Table 35 and elasticity values reported in Table 36. Then import tariff, goods and services tax and national defense levy were eliminated to observe the counterfactual equilibrium with elimination of all border charges.

Welfare measures such as consumer surplus and producer surplus were calculated using the changes in demand, supply, price and import quantity. Government revenue in the forms of tariff, GST and NDL were also calculated. Total social welfare was obtained by adding consumer surplus and producer surplus.

Table 35. Baseline Data Set

Variables	*Units*	*Value (Rs.)*
Demand	Cubic meters	613,700
Supply	Cubic meters	558,400
Domestic Price	Rs/cubic meter	22,473
Border charges %		
Import Tariff	10.0	
Goods and Services Tax	12.5	
National Defense Levy	7.5	
Surcharge	10.0	
Uplift	12.5	

93 Rupees = 1 USD

Table 36. Price Elasticity of Demand and Supply

Response Categories	*Supply*	*Demand*
Elastic	1.25	-1.25

Unitary elastic	1.0	-1.0
Inelastic	0.5	-0.5

5.3 Results and Discussion

Table 37 presents the impacts of eliminating import tariff, GST and NDL under the assumption of elastic price response. In Table 37, GOVT, CS, PS and SW refer to government revenue, consumer surplus, producer surplus and social welfare. GOVT is calculated by summing up the revenue from import tariff, GST and NDL. SW is calculated by adding CS and PS. Results for inelastic demand and supply, unitary demand and supply and other combinations are given in Appendix 2, 3, 4 and 5. As predicted by the theory model, the results show that in all the cases, liberalization of border charges will lead to increase in demand and social welfare, and decrease in local supply and prices. The magnitude of the changes, however, depends on the elasticity.

Table 38 shows the summary results of simulations. The highest social welfare increase of Rupees 1,073 million (USD 11.537 million) was observed in the case of elastic demand and supply while the lowest Rupees 429 million (USD 4.613 million) was observed for the inelastic demand and supply. The results thus show that actual magnitudes of the social welfare changes heavily depending on the elasticity values. Recall that we did not use very high elasticity (absolute) values in our simulations. Had such values been used, one would have observed much higher welfare changes.

Table 37. Impact of Removal of All Border Charges under Elastic Demand and Supply

Categories	*Base Case*	*Removal of All Border Charges*	*Percentage Change*
Demand, M^3	613,700	809,542	31.91
Supply, M^3	558,400	380,204	-31.91
Imports, M^3	55,300	429,338	676.38
Price Rs./ M^3	22,473	16,735	-25.52
Tariff, Rs. million	92.54	0	-100
GST, Rs. Million	128.41	0	-100
NDL Rs. Million	96.30	0	-100
GOVT, Rs. Million	317.26	0	-100
CS, Rs. Million	5,516.67	9,599.41	74.00
PS, Rs. Million	4,705.85	2,013.35	-57.21
SW, Rs. Million	10,539.80	11,612.80	10.18

93 Rupees = 1 USD

Table 38. Welfare Changes due to Timber Market Liberalization under Different Elasticity Scenario.

Case	*Price (Rs./M^3)*	*Local Supply, (M^3)*	*Social Welfare (Rs. Million)*
Inelastic demand & supply:			
Base	22,473	558,400	23,520
Counterfactual	16,735(-25.52%)	487,121 (-12.76%)	23,949 (+1.82%)
Unitary elastic demand & supply:			
Base	22,473	558,400	13,487.60
Counterfactual	16,735(-25.52%)	415,843(-25.52%)	14,345.00(+6.36%)
Elastic demand & supply:			
Base	22,643	558,400	10,539.80
Counterfactual	16,735(-25.52%)	380,204 (-31.91%)	11,612.80(+10.18%)
Elastic demand & inelastic supply:			
Base	22,643	558,400	15,245
Counterfactual	16,735(-25.52%)	487,121(-12.76%)	16,011(+5.02%)
Inelastic demand & elastic supply			
Base	22,643	558,400	18,814
Counterfactual	16,735(-25.52%)	380,024 (-31.91%)	19,550(+3.91%)

93 Rupees = 1 USD

Policy changes, often, results in gainers and losers. As the results show, the removal of distortions contributes to lower prices which in turn increases consumer surplus. Thus, consumers are gainers of the timber market liberalization. The same lower prices will reduce the local supply and producer surplus. Thus, timber producers are the losers in timber market liberalization. Overall, consumers' gains are higher than producers' losses. Therefore, this policy experiment passes potential compensation test.

However, it is necessary to look at the losers more carefully and analyze their situation from the equity point of view. In the present case of timber market liberalization, however, there is no organized timber producing sector. Some of the multi-purpose trees harvested from the home gardens supply part of the timber. The remaining timber supply comes to the market from natural forests and this timber is harvested through various illegal activities.

As explained in Chapter 3, there are no resource rents paid to the government in the case of timber harvested from natural forests. The way this timber is harvested does not allow collection of any royalties. In the case of private lands like the home gardens, timber producers are gaining minimum returns (see Table 22). As explained by Senaviratne and Gunatilake (2001), most of the resource rents are dissipated as timber traders' profits and unofficial transaction cost. Given this situation, the producer surplus losses due to timber market liberalization is not a true cost to the timber producers.

The political feasibility of the timber market liberalization depends on how significant the revenue loss is for the government. As the base case scenario shows, the current revenue from all the charges is about Rupees 317 million (USD 3.408 million). Given the total revenue of the government in the year 2000 as Rupees 242 billion (USD 2.602 billion), the possible revenue loss will only be 0.13%. These numbers clearly show that revenue loss due to timber trade liberalization is not significant and the political feasibility of the market liberalization policy may not be influenced by the revenue loss.

From the perspective of the protection of natural forests, there are two major impacts of timber market liberalization. First, it will reduce the local timber price significantly. As shown in the Appendices, price will drop by about 25%. Such a price drop will certainly reduce incentives for illegal logging. Illegal loggers will then consider the expected cost of being caught and punished against the expected benefits. Price drop reduces the expected benefits and depending on the degree of risk averseness, some of the illegal loggers' expected cost will exceed the expected benefit as timber price drops with liberalization. Although we were unable to quantify the impact, potential price drop will eventually reduce the illegal logging.

The other impact of timber market liberalization on forest comes through reduction in local supply. As evident from the results, timber market liberalization reduces local supply of sawn-wood by 31.91%, 25.52% and 12.76% under the elastic, unitary elastic and inelastic demands. In order to highlight the impact of reduction in local supply, these supply reduction figures were converted to hectare of natural forest saved under the same assumptions made for the case of efficiency improvement. Results are presented in Table 39.

Table 39. Market Liberalization and Prevented Deforestation

Demand Elasticity	*Prevented Deforestation (ha/ annum)*

Inelastic	9,569.4
Unitary Elastic	12,761.1
Elastic	15,952.7

As shown by this simple analysis, timber market liberalization seems to be a superior option compared to the improvement of technical efficiency, in terms of avoiding deforestation in Sri Lanka. As the numbers indicate, market liberalization can save more forests compared to that under efficiency improvement. Further, as the analysis on determinants of technical efficiency show, there are many factors affecting efficiency, and manipulating them to reduce inefficiency is not easy. Moreover, market liberalization improves social welfare while eliminating inefficiency may or may not increase social welfare depending on the costs and benefits involved. For example, if the old machines are replaced with costly new machines, the benefits of efficiency improvements have to be weighed against the cost. Given these reasons, timber market liberalization is an attractive option in reducing deforestation in Sri Lanka, compared to technical efficiency improvement.

An important aspect in comparing the alternative policies for forest protection is the time factor. As discussed earlier, lack of continuous supply of quality logs is a major factor that causes inefficiency in saw-milling. If required policy measures are implemented now to improve local wood production, it will take at least 20 years to realize the effects. Note here that current timber imports to Sri Lanka are sawn-wood rather than saw logs. If Sri Lanka imports good quality saw logs, technical efficiency can be improved quickly.

However, many timber-exporting countries do not allow exporting saw logs. Policies in these countries favor export of sawn-wood since milling industries in these countries will suffer adverse consequences if the policies favor saw log exports. Given this situation, it is unlikely that Sri Lanka will be able to import good quality saw logs. Therefore, certain measures that improve technical efficiency are effective only in the long run. In comparison to such long-term measures, timber market liberalization is a measure that will provide results in the short run.

However, certain services provided by the forests, such as biodiversity, are globally important. From a global perspective, the wood imports have to come from somewhere. If the exporting country has a well-managed, sustainable wood harvesting system with minimum impact on biodiversity and other forest services, timber market liberalization will be an acceptable option. On the other hand, if the exporting country has an unsustainable forest industry, market liberalization would be only transferring the environmental impact from one country to the other. In this case, efficiency improvement seems a better alternative. Certain countries in Scandinavia use timber certificate system to make sure that timber is coming from a sustainable source. It is necessary to study this system and adopt it, if suitable, in order to avoid the adverse environmental impacts of timber market liberalization.

6.0 SUMMARY AND POLICY IMPLICATIONS

Sri Lanka underwent a rapid phase of deforestation during the last century. As a result of this, the forest resource base declined significantly and the government has allocated reasonable amount of forestlands for conservation. Many factors which caused deforestation are no longer in operation and illegal extraction of timber seems to be the most important factor currently causing deforestation. Private lands and unprotected forests (through illegal activities) currently supply the timber requirement of the country. These different sources are interdependent and continuation of the current trends may eventually extend the illegal logging to the protected forests when the scarcity and prices are sufficiently high. This study assesses the alternative policy measures for forest protection such as legislative approach, establishment of forest plantations, technical improvement of saw- milling and timber market liberalization.

Forest protection through a timber permit system in Sri Lanka has proved to be a failure. The existing regulatory system has created an artificial scarcity of timber with very high consumer prices and very low stumpage prices. Timber traders and government officers who are involved in issuing timber permits extract most of the value of the timber. The high final prices encourage illegal logging from natural forests while lower stumpage prices and uncertainty regarding obtaining a permit to sell timber discourages private sector and small landholders' involvement in timber tree cultivation. This situation has resulted in timber scarcity in the country and consequently affected the technical efficiency of saw-milling. Among the available remedial measures for protection of natural forests is the establishment of forest plantations. However, establishment of forest plantations by the government is not cost effective. The private sector has to play a major role here. Removal of existing regulations is a pre-condition to creating a conducive business environment for the private sector to invest in forest plantations. In addition to the removal of overly restrictive regulations, it is timely to study other incentives necessary for the smallholders and medium scale timber tree growers.

Technical efficiency of the saw-milling industry in Sri Lanka was examined with the objective of assessing the impact of technical efficiency improvement on protection of natural forests. A total of 180 sawmills were selected for the study using a stratified random sampling procedure. A structured questionnaire was used to collect data from the sawmills. Thirty-two questionnaires were discarded due to inability to obtain information on inputs and outputs, incomplete information and inconsistent answers. Final analysis was carried out for 148 sawmills.

The production function analysis using the stochastic frontier approach shows that only log input significantly affects the output. This result indicates that a severe log shortage, which was evident from the survey result, is acting as a limiting factor in the production process and the other inputs such as capital, labor and energy are being wasted. Technical efficiency (TE) and the determinants of the TE were simultaneously estimated using the Frontier 4.1 program[4]. Results indicate that sawmills are, on average, technically inefficient by about 28% compared to the best mills in the sample.

[4] Frontier 4.1 is a computer software package that can be used to estimate frontier production functions

The result indicates that current output can be obtained with a 28% cut down of all the inputs. The same set of data was used to measure TE with the DEA approach. The objective of using the two methods was to obtain robust results on determinants of technical efficiency and to compare the efficiency scores. The results show that average technical inefficiencies with constant returns to scale (CRS), and increasing returns to scale (IRS) are 35% and 19% respectively. On average, the mills show about 20% scale inefficiency. Of the 148 mills surveyed, nine mills are technically fully efficient. A total of 135 mills show increasing returns to scale while only four mills exhibit decreasing returns to scale. The rest are on the frontier. Description of the technology of the mill further elaborates that many mills are operating under their capacity due to wood shortage.

Corroborated results from both the models on determinants of TE show that quality of logs and owners' management positively affect the TE. Age of the machines negatively affect the TE. The effect of the system of charging is also consistent in the two models. Entrepreneurship shows the expected positive impact in both models, however statistically significant only in one model. Similarly, capacity of the mills negatively affect the TE in both models but is statistically significant only in the stochastic frontier model. The impact of formal education on TE shows inconsistent results in the two models. Thus, although there are differences, consistent results are prominent and these corroborated results are considered in discussing policy implications.

Given the differences in the TE scores in the two models, and the differences attributed to the assumption on CRS and IRS technologies, on average about 27% of the log input can be saved if the technical inefficiency can be eliminated completely. With some plausible assumptions, saw logs savings due to technical efficiency improvement was converted to area of natural forests saved annually. According to the results, 3,695, 7,390 and 11,085 ha of forests can be saved if the technical inefficiency is eliminated by 25%, 50% and 75%, respectively.

In order to assess the effect of timber market liberalization on forest protection, a static market simulation model was used. Removal of existing distortions such as tariff, goods and service tax, defense levy and other border charges can cut down the local supply of saw logs significantly. Similar to the analysis on the elimination of efficiency, the annual savings of natural forest were calculated. With the more conservative assumption of inelastic demand, timber market liberalization can save about 9,569 ha of forest annually. If the demand is elastic, this savings can increase up to 15,952 ha per annum. Compared to the technical efficiency improvement, timber market liberalization seems to be more effective in protecting natural forests.

Major policy implications of the study can be categorized under three measures; removal of timber permit system, technical efficiency improvement and timber market liberalization. Effectiveness, political feasibility and social welfare implications should be considered in discussing forestry policies. In addition, whether the policy implications are realized in the short run or long run is important. This requirement is unique in forestry because forestry cycles are long and results of many policy changes are realized after 20-40 years depending on the forest species. For example, the effect of any incentive program for smallholder tree growers will be observed only after 20-40 years. Table 40 presents a summary of the policy implications of the study.

Table 40. Summary of Policy Alternatives

Policy	*Effect* *Short Run*	*Long Run*	*Effectiveness*	*Political Feasibility*	*Remarks*
Removal of permit system	Low sawn-wood price		High	Moderate	Economically efficient, No losers
	Incentives for tree growing	Supply of high quality logs			
	Conducive business environment for milling	Incentives for investment in mills			
	Incentives for private sector tree growing				
Technical efficiency Improvement Investment on machinery	Saw logs savings		Moderate	High	Cost effectiveness need to be studied
Supply of quality logs		Saw logs savings			
Mill level measures	Saw logs savings	Saw logs savings			
Timber Market liberalization	Low sawn-wood prices Reduction of local supply		High	Moderate	Economically efficient
Removal of tariff on machinery	Higher technical efficiency		Moderate	High	Economically efficient

Removal of timber permit system for trees grown in private lands such as jack tree, teak and mahogany will reduce timber prices and consequently reduce incentives for illegal logging. In addition, it will provide conducive business environment for milling and may promote investments in the saw-milling industry. This measure will also provide incentives for the private sector and smallholders to grow timber trees. Thus, it will enhance long-term supply of quality saw logs, which is necessary for technical efficiency improvement. This policy will be highly effective as shown by the case studies presented in the text. Its political feasibility is ranked as moderate because the beneficiaries of the existing system are politically powerful to some extent. The donor community, especially the Asian Development Bank, has been trying to implement this policy for a couple of years and it has approved a loan to the forestry sector conditional upon implementing this policy. This incident clearly shows the strength of the groups backing the status quo policy. Since the unnecessary interventions are removed and market is allowed to play its role, this policy is economically efficient. There are no true losers in this case because currently a small group of timber traders and government officers appropriate most of the rents in the timber sector.

Technical efficiency improvement will have both short and long-term effects. Replacing the old machinery with new machines is a measure that can be taken in the short-term. Uninterrupted supply of quality logs is required to improve technical efficiency. This is however a long-term measure that can be achieved through removal of restrictive regulations and provision of necessary incentives. Incentives for tree-growing should be further studied, as this study did not focus on that aspect. In addition, certain changes can be made at the mill level to improve efficiency. These measures include converting the hiring-type mills to milling businesses, providing performance-based incentives for mill managers and making the mill managers aware about their own technical efficiency levels with possible ways to improve technical efficiency. The effectiveness of improvement of technical efficiency is ranked as moderate because manipulation of the determinants of technical efficiency is not easy. Trade liberalization has a considerable opposition in developing countries. However, developing entrepreneurial ability of mill managers or provision of low interest loans to purchase new machines will not have such an opposition from the society. Therefore, technical efficiency measures are politically more feasible. The effects of technical efficiency improvement on social welfare are not very clear as most of the steps taken incur costs. Therefore, the measures should be subjected to cost benefit analysis.

Timber market liberalization is a short run measure that can effectively reduce sawn-wood prices and consequently decrease the incentives for illegal logging. Also, it will reduce the local saw log supply and effectively lessen the pressure on natural forests. Political feasibility of timber market liberalization is moderate as there is a general resentment about open market policies in Sri Lanka.

As shown in the analysis, timber market liberalization improves welfare. Generally, open market policies benefit certain groups in the society and adversely affect certain other groups. In this case, the consumers are gainers and producers are losers. One unique characteristic of the current forestry sector in Sri Lanka is that there are no organized supply sector. Part of the timber is supplied from home gardens and other non-forest lands as a by-product. The rest is illegally extracted from natural forests. Timber traders and a small number of government officers, in both the cases, appropriate most of the rents. Therefore, the producer surplus loss is non-existing and there are no true losers in the case of timber market liberalization. Removal of tariff on imported machines is already taking place. It is included in the table for the sake of completeness.

Since certain effects are realized in the long run, the above-described three major policy measures should be implemented simultaneously. However, market liberalization will reduce local timber supply and may negatively affect the saw-milling sector. Consequently, it may negatively affect certain re-structuring required to improve technical efficiency in the saw-milling industry. In the face of declining local production due to market liberalization, mill owners may hesitate to invest on new machines etc. Since the market liberalization will replace only about a third of the local supply, under most favorable circumstances, the negative impact of market liberalization will be felt only at the beginning. Once the saw-milling industry is stable, this negative impact may gradually fade away.

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Appendix 1

Price Elasticities of Demand for Timber

Source	*Period*	*Countries*	*Products*	*Elasticities*
Bourke	1988	Japanese import from developing countries	Sawn timber ; Veneer and Plywood	-1.3 -1.8
Brooks	1971-91	United States imports	Hardwood	-1.2
Cardellichio et al.	1965-87	N.America/W.Europe Japan Korea N.America/W.Europe Japan Korea United States Japan Korea	Non-coniferous sawn-wood Coniferous sawn-wood Non-coniferous plywood	-0.5 -2.42 -1.06 -0.3 -0.67 -1.51 -0.5 -0.55 -0.85
ECE/FAO	1964-81	Group one countries France Germany Netherlands Switzerland United Kingdom	Sawn-wood	 -.046 -0.28 -0.34 -1.07 -0.49
Kallio et al.	1987	Countries with per capita income above USD 3,000	Non-coniferous sawn-wood. Coniferous sawn-wood Veneer and Plywood	-1.2 -0.5 -0.4

Continued

Appendix 1 continued

Meyer	1952-75	Switzerland	Industrial wood	-1.4
NEI	1961-81	17W-European countries	Tropical timber	-0.34
Slangen	1963-81	Netherlands	Coniferous sawn-wood	-0.78
Wibe	1970-79	60 countries with per capita income above USD 2,500 in 1975	Non-coniferous sawn-wood. Coniferous sawn-wood Wood panels	-1.19 -0.54 -0.18

Source: Herath (2000)

Appendix 2

Impact of Removal of All Border Charges under Inelastic Demand and Supply

	Base Case	*Removal of all border charges*	*Percentage Change*
Demand, M^3	613,700	692,037	12.76
Supply, M^3	558,400	487,121	-12.76
Imports, M^3	55,300	204,915	270.55
Price Rs./ M^3	22,473	16,735	-25.52
Tariff, Rs. million	92.54	0	-100
GST, Rs. million	128.41	0	-100
NDL Rs. million	96.30	0	-100
GOVT, Rs. million	317.26	0	-100
CS, Rs. million	13,791	17,537	27.15
PS, Rs. million	9,411	6,412	-31.86
SW, Rs. million	23,520	23,949	1.82

93 Rupees = 1 USD

Appendix 3

Impact of Removal of All Border Charges under Unitary Elastic Demand and Supply

	Base Case	*Removal of all border charges*	*Percentage Change*
Demand, M^3	613,700	770,374	25.52
Supply, M^3	558,400	415,843	-25.52
Imports, M^3	55,300	354,530	541.10
Price Rs./ M^3	22,473	16,735	-25.52
Tariff, Rs. million	92.54	0	-100
GST, Rs. million	128.41	0	-100
NDL Rs. million	96.30	0	-100
GOVT, Rs. million	317.26	0	-100
CS, Rs. million	6,895.84	10,866.62	57.57
PS, Rs. million	6,274.46	3,479.30	-44.54
SW, Rs. million	13,487.60	14,345.00	6.36

93 Rupees = 1 USD

Appendix 4

Impact of Removal of All Border Charges under Elastic Demand and Inelastic Supply

	Base Case	*Removal of all border charges*	*Percentage Change*
Demand, M^3	613,700	809,542	31.91
Supply, M^3	558,400	487,121	-12.76
Imports, M^3	55,300	322,420	483.03
Price Rs./ M^3	22,473	16,735	-25.52
Tariff, Rs. million	92.54	0	-100
GST, Rs. million	128.41	0	-100
NDL Rs. million	96.30	0	-100
GOVT, Rs. million	317.26	0	-100
CS, Rs. million	5,516	9,599	74.00
PS, Rs. million	9,411	6,412	-31.86
SW, Rs. million	15,245	16,011	5.02

93 Rupees = 1 USD

Appendix 5

Impact of Removal of All Border Charges under Inelastic Demand and Elastic Supply

	Base Case	*Removal of all border charges*	*Percentage Change*
Demand, M^3	613,700	692,037	12.76
Supply, M^3	558,400	380,024	-31.91
Imports, M^3	55,300	311,832	463.89
Price Rs./ M^3	22,473	16,735	-25.52
Tariff, Rs. million	92.54	0	-100
GST, Rs. million	128.41	0	-100
NDL Rs. million	96.30	0	-100
GOVT, Rs. million	317.26	0	-100
CS, Rs. million	13,791	17,537	27.15
PS, Rs. million	4,705	2,013	-57.21
SW, Rs. million	18,814	19,550	3.91

93 Rupees = 1 USD

Appendix 6

Acronyms and Glossary

Acronyms

MFE	Ministry of Forestry and Environment
NTFP	Non-timber Forest Products
FO	Forest Ordinance
MPA	Ministry of Public Administration
DFC	Department of Forest Conservation
GSN	Grama Seva Niladhari
DS	Divisional Secretary
RFO	Range Forest Officer
BFO	Beat Forest Officer
IRR	Internal Rate of Return

Glossary

Technical efficiency	Reflects the ability of a firm to obtain maximum output from a given set of inputs.
Stochastic frontier analysis	Econometric technique to estimate technical efficiency.
Data envelopment analysis	Mathematical programming technique to estimate technical efficiency.
Factor productivity	Ratio between total output and quantity of a factor.
Production function	Mathematical relationship between outputs and inputs.
Endemic	Species that are found only locally.
Elasticity	Percentage change in one variable as a result of a change in another variable by one percent.