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Forest Products Trade Policy in Southeast Asia: An Empirical and Theoretical Analysis

By

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Thesis submitted in partial fulfilment of the requirements for the degree in Doctor of Philosophy in Economics.

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February 23, 2003.

To my parents

Sunthorn and Araya

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Acknowledgements

I am grateful to the Economy and Environment Programme for Southeast Asia (EEPSEA), Singapore, who provided funding for Part I of my thesis under the Graduate Research Grant # 97-8002-20. Part of the funding was also provided through a research assistantship at the Centre for the Study of Globalisation and Regionalisation (CSGR), University of Warwick. I am grateful to my supervisor John Whalley for alerting me to the funding opportunity at EEPSEA, his comments on my research proposal to them, and for his generosity during the period I was employed as a research assistant to the research project on "World Environmental Organisation" at CSGR.

I am indebted to my second supervisor Carlo Perroni for his invaluable comments and insights into economic research; his guidance in many aspects of academic life; and most of all his patience whenever I encounter problems (which is all too often) - his generosity with time and willingness to communicate until a point is understood.

I would like to thank all the applied general equilibrium modellers who have been at the Department of Economics at various times, particularly Lisandro Abrego and Christina Dawkins. Both of them have been bombarded with pedantic questions during early stages of my research and have been extremely kind in initiating me into the use of GAMS package. Of course, all the remaining errors are my responsibility alone.

I would also like to thank my parents for their emotional and financial support during my years of study in the UK. Both of them have instilled the value of education in all their children from an early age and had to sacrifice many things to send us all to be educated abroad.

My friends have been relied upon for emotional support during most of my time at Warwick - those I go to meditation with, those in economics, in biology and others disciplines - I cannot express sufficient gratitude towards them.

Declaration

This dissertation is my own work. It has not been submitted for a degree at another university.

The material in Part I of this thesis is based on my research report to EEPSEA, titled "Trade policy and the welfare of Southeast Asian timber exporters: Some implications on forest resources" (2001). Unlike the research report, Part I of the thesis contains a more detailed account of patterns of forest product trade and includes a section on how to construct a micro-consistent data set.

An earlier version of Chapter 6 in Part II of the thesis appears as a Warwick Economic Research Paper # 619 (2001).

Summary

In this thesis, we examine the impact of forest products trade policy in Southeast Asia using two different approaches: applied competitive equilibrium trade modelling and strategic trade policy theory. These approaches make up Part I and II of the thesis respectively.

In Part I, an applied general equilibrium trade model is built to analyse the impact of the 1994 Uruguay Round on the forest and agricultural sector. Forest products trade in previous Uruguay Round models has been subsumed with agricultural and/or mineral commodities, making it difficult to discern the impact on forest products trade per se. Moreover, previous large scale forest sector trade models have tended to focus on developed countries, such as the USA and Canada. Here a general equilibrium trade model of forest and agricultural products is built with a focus on major Southeast Asian exporters, namely Malaysia and Indonesia. Unlike partial equilibrium models, a general equilibrium model such as ours takes into account the terms of trade effect that arises from the sizable market share owned by Malaysia and Indonesia in tropical log, sawnwood and plywood. The impact of the Uruguay Round on welfare and harvesting activities in these countries are highlighted. In addition to this, two separate counterfactual simulations are performed using the same model. The first counterfactual analysis ascertains the impact of widespread use of log export barriers amongst developing countries. In the second counterfactual analysis, optimal forest products trade policies for Indonesia and Malaysia are derived with and without trade policy retaliation by other regions.

Three key results emerge from our study: (i) trade liberalisation does not necessarily lead to increased log production since the real producer price does not always rise; (ii) the Uruguay Round tariff changes may make forestry a less attractive form of land use when compared with agriculture; (iii) the proliferation of log export barriers amongst tropical countries has a cartel-like effect, thus the elimination of these barriers is detrimental to tropical log exporters. In addition, the removal of log export barriers leads to an overall rise in log harvesting activities in Malaysia and Indonesia despite efficiency improvements in the downstream wood sector in these countries.

We find that Southeast Asian exporters are worse off compared to the status quo once the 1994 Uruguay Round policies are implemented. However, the reverse is true if instead we contrast the outcome of the Uruguay Round with the outcome of a trade war in forest products. This latter approach measures the benefit of maintaining and strengthening WTO trade disciplines (see Perroni and Whalley, 1994). With regards to optimal tax policies, Malaysia and Indonesia can benefit by

imposing large export taxes on logs and downstream products when other regions do not retaliate. However, the threat of retaliation from the North American region is likely to prevent them from doing this. In fact, the North American region (where USA and Canada make up the majority of trade) benefits from trade war since this diverts the world demand for forest products towards North American exports.

The trade model of Part I follows the traditional competitive approach in trade theory: i.e. a Heckscher-Ohlin framework with zero profits, zero excess demands and balanced budget assumption. With few key players in world trade in forest products, some of these assumptions are unwarranted. Specifically one may expect positive profits and strategic interaction among the players. We address this concern in the second part of the thesis. A partial equilibrium model with imperfect competition is used to capture strategic interaction among forest product exporters. Our focus is on the impact of Indonesian government policies on log and plywood industry since the 1960's.

In Chapter 6, a model of vertically linked oligopoly is used to analyse the impact of log export barriers in Indonesia. When exports are vertically-related like those of log and plywood, the export level that maximises the combined profits must take into account the cross-industry effects. Specifically, since plywood exports raise the terms of trade for log exports, it is optimal to strategically raise plywood exports. Conversely, since log exports increase the exports of downstream rivals, and thus lower the terms of trade for plywood, it is optimal to strategically lower log exports.

Our model formalises the link between vertical ownership structure and trade policy impacts. We show that when industries are vertically integrated, strategic behaviour by a vertically integrated home firm implies that both upstream and downstream exports should always be subsidised. When industries are vertically separated, it is still optimal to subsidise downstream exports. However, the optimal trade policy for the upstream exports depends on whether the commitment failure effect due to the Cournot conjecture or the cross-industry effect dominates upstream. Previous analyses have shown that log export barriers during the 1980's and 1990's have led to big losses in Indonesian foreign exchange earnings due to lower profit margin derived from plywood exports (see Manurung and Buongiorno (1997) and Gillis (1988) for estimates of losses in foreign exchange earnings into Indonesia from log export barriers). Our results show that while this may be true when industries are vertically integrated, it may not be true when industries are vertically separated. Given that the Indonesian log and plywood sector have been de-linked to comply with the IMF/World Bank policies in 1998, the impact of log export barriers on foreign exchange earnings should be re-evaluated.

During the forest-based industrialisation drive which began towards the end of the 1970's, Indonesian government imposed export taxes on logs which culminated into an export ban in 1984. In addition, plywood export quotas were imposed to curb competition amongst Indonesian plywood exporters. Both policies came to a halt after the Indonesian financial crisis in 1997. Indonesian forest exports were liberalised to meet IMF-World Bank conditionalities in return for financial support. In Chapter 7, the impact of log export ban and plywood export quotas on Indonesian welfare is analysed and contrasted, first of all, with the case when all quantitative restrictions are removed; and, secondly, with the level of welfare achieved under optimal export taxes and subsidies.

The model in this chapter is similar to the one presented in the previous chapter but is extended to incorporate multiple firms in the home country. Again, the home country should strategically raise plywood exports and reduce log exports to maximise the combined profits of the two industries. Under full liberalisation, three distortionary effects pull log and plywood exports away from the planning optimum: firstly home firms do not (correctly) take into account inter-industry externalities in their export decisions; secondly home firms' choice of exports is restricted by the rivals' conjectures; and lastly, domestic competition tends to raise exports above the optimum. When optimal trade policies are imposed, we find that neither quantitative restrictions nor export taxes and subsidies can bring about the planning optimum. This is because none of them are able to correct all the distortions inherent in firms' export decisions. Given that the distortions under full liberalisation can offset each other, trade policy intervention may result in further deviation away from the planning optimum. Tables 7.2 to 7.4 list the distortionary effects under each policy scenario, together with their implications on log and plywood exports.

In Part II, optimal trade policies are analysed under the assumption that the planner's sole objective is to maximise profits. In this way, we have missed out other important considerations such as consumer surplus, environmental values and non-wood benefits of the forest, political economy, and public finance constraints etc. All these factors should be included for a more complete examination of forest sector trade policies. However, our simple models serve to highlight distortionary effects inherent in the industrial structure of vertically related commodities and the potential corrective effects brought on by trade policies.

Part I

The impact of forest products trade liberalisation on Southeast Asian exporters - An applied general equilibrium analysis

Chapter 1

Introduction and overview

1.1 Introduction

In Southeast Asia and other tropical areas, the most important cause of tropical deforestation is the conversion of forests for agricultural use. Nonetheless, tropical forestry helps to hasten the process of land conversion by providing access into the forests. The practice of logging itself, such as timber extraction techniques and regenerative investments, also contributes to the overall rate of deforestation. Whether a piece of forestland will be used in forestry or converted for agricultural use depends on which land use option yields the greatest net returns (Hyde et al., 1996). Since government policies distort the relative returns between different land use options, they can lead to different forestland alterations.

Misguided government policies have often been blamed for hastening deforestation in the tropics. Although the adverse effect may be obvious for policies such as subsidies for timber mills and for conversion of forestland to agricultural uses, it is less obvious why certain macro policies, such as trade restrictions should have a negative effect on the forest resources more often than they protect them. Since there are many trade policy distortions in the economy that affect the returns and relative returns across land-based sectors, it is useful to examine some of these distortions together and their implications on forestland use. In Part I, we use an applied general equilibrium model to examine the effect of simultaneous reductions in trade taxes in selected forest sectors and the agricultural sector. A general equilibrium model is useful for capturing inter-sectoral interactions such as these. Our focus will be on Southeast Asian exporters, namely Malaysia and Indonesia, and the wood sectors to be analysed are log, sawnwood, and plywood, which are amongst the most important wood sectors in these countries.[1] Given that Malaysia and Indonesia are major tropical forest products exporters, fluctuations in their exports through trade policy changes give rise to large terms of trade effects which are only captured by a general equilibrium model.

Two types of trade barriers are examined: tariffs and export taxes. In general, trade barriers are perceived to be welfare decreasing since they distort allocation

[1]Although secondary forest products, e.g. furniture and joinery are becoming increasingly important as Southeast Asian exports, they are not considered explicitly in the model due to lack of consistent data.

of resources away from the efficient level.[2] Conversely, environmentalists have been vocal about greater deforestation induced by trade liberalisation. They fear that the decline in trade barriers would increase demand for tropical logs and put further pressure on the forest resources.[3] Whether this claim is justifiable is an empirical issue that will be examined in this part.

Another trade policy that has become pervasive in tropical regions over the last thirty years is log export barrier. A variety of export barriers such as taxes, bans, and quotas have been imposed on tropical logs to encourage investments in the downstream wood processing sectors - this policy is also known as 'forest-based industrialisation'. Previous studies on log export barriers in Indonesia have found that they make the country worse off because the implicit subsidy to the milling sector is extremely large, and the policy tends to perpetuate inefficient milling operations. In this way, the value added to wood does not offset the loss in the value of wood as the processing sector expands leading to a huge loss in foreign exchange income (see Bourke, 1988; Gillis, 1988; and Constantino, 1990). However, these

[2]Privately efficient resource allocation may not necessarily coincide with the socially efficient level if the former does not incorporate the effect of environmental externalities into the decision process. In this paper, we do not attempt to quantify the environmental value of the forest but instead concentrate on the timber benefit which is easily identified. However, the discrepancy between privately and socially efficient production must be borne in mind.

[3]Some research that supports this view includes Cruz and Repetto (1992) and Lopez (1993). Cruz and Repetto (1992) claim that trade liberalisation in the Philippines would increase logging and expand production of upland crops. Lopez (1993) obtained a similar result for Ghana. Only Thiele and Wiebelt (1994) are cited in Kaimovitz and Angelsen (1998) for predicting that trade liberalisation would reduce deforestation. Kaimovitz and Angelsen noted, however, that the authors based their predictions on very optimistic view of competitiveness of Cameroon's industries.

studies have examined the effect of unilateral imposition of export barriers, and not the effect of simultaneous imposition by several tropical countries. Thus they have failed to take into account the terms of trade effects induced by simultaneous restrictions of tropical log supply. By comparing the status quo export barriers on tropical logs with the hypothetical case when all log export barriers are removed, we can discern this effect.

Since the independence of Malaysia and Indonesia, forestlands in these countries have become state property. Some of these lands are concessioned out to timber companies for harvesting purposes. Although both countries formulate land use plans by allocating a proportion of forestlands to protection (hydrological), conservation and timber production, there is little or no demarcation of reserved areas in most regions. With the shortage of forestry personnel and weak political stand against powerful interest groups (particularly in Indonesia), much illegal logging still goes on. In this way, forestland use is driven by the market forces. In our model, we discern the effect of trade policy changes on the aggregate log production in each region. This, in turn, signals the changes in the pressure on the forest through trade policy. Although the model does not incorporate land use decisions explicitly in the agricultural and forestry sector, it captures the changes in the returns to each land-based sector as trade policy changes. These returns in turn have implications on forestland use. We apply the forestland use conceptual framework in Hyde et al. (1996) to analyse the land use alterations as the returns across forestry and agricultural sector change (see the discussion in the conclusion to Part I). According to Hyde et al. (1996), an increase in the returns to forestry would lead to more logs being extracted. The rise in log supply may be met through an expansion of the marginal forestland and/or more intensive extraction of secondary forests. If the trade policy results in an increase in the long run returns to forestry relative to that of agriculture, then there would be more investment into forestry and more establishment of plantations.

A multi-country, multi-sectoral general equilibrium model such as ours is useful for examining the changes in welfare, production, prices, and relative returns across forestry and agricultural sector that result from a shift in trade policy. However, it is less useful for analysing unpriced goods, such as the environment. Although estimates of environmental values exist, the figures vary widely. For simplicity, this study disregards the environmental values of the forests and concentrates on economic value of timber only. Thus this model is restricted to answering the following questions:[4]

1. Does the 1994 Uruguay Round tariff reduction on forest products lead to increased pressure on forest resources through a rise in log production?

2. How do the Uruguay Round changes affect the relative returns between agri-

[4]As obvious from the list of questions, we do not attempt to address the magnitude nor the location of deforestation that result from the Uruguay Round. Rather we draw implications on forestland use using a synthesis between our results and Hyde et al. (1996)'s theoretical model of forestland use.

culture and forestry? Which type of land use do the changes favour?

3. Do tropical countries benefit from restricting log export supplies? If yes then how much? Can they improve upon this policy?

4. Could tropical exporters gain from free trade?

5. What would be the consequences on welfare and log production if a trade war were to break out in the forest sector?

The last question refers to the non-cooperative trade equilibrium. As pointed out by Perroni and Whalley (1993) if the real significance of GATT/WTO rounds were the implicit agreement that countries would continue to trade under international trade rules and disciplines, then the result of the Uruguay Round should be evaluated against the non-cooperative equilibrium. The impact of forest products trade war is, however, of interest in itself. The appreciation over environmental and ecological functions of rain- and temperate forests has never been greater than now. Tropical forests in Southeast Asia and other parts of the world, being particularly rich in environmental benefits, have been the focus of concerns over deforestation brought about by log harvesting activity and forest products trade. Trade impediments connected with environmental issues (e.g. a ban on imports of timber from unsustainable harvests; or counter-vailing duties over perceived 'environmental' export subsidies) will increasingly become a feature of forest products trade.[5] In the

[5]See for example, US and Canada softwood lumber case (National Post - Canada, March 2002)

presence of this uncertainty, it is useful to analyse the impact on welfare if countries revert to non-cooperation in forest products trade.

Before turning to the Uruguay Round impact on the forest and agricultural sector, we will consider briefly what other general equilibrium analyses have had to say about the outcome of the Round.

1.2 Previous studies of the Uruguay Round impact on the agricultural and forest sector

Several estimates of global welfare gains from the Uruguay Round were reported, for examples, by Harrison et al. (1995), who used 1992 as a base-year, estimated a gain of US$52.6 billion in the short run and US$188.1 billion in the long run; Hertel et al. (1995), using 2005 as a base-year, estimated a gain for 2005 to be US$257.8 billion or 0.42% of world GDP; Goldin and van der Mensbrugge (1995), using 2002 as a base year, projected the gain to be US$25.4-235.1 billion; and Nguyen et al. (1995), using 1986 as a base-year, estimated the gain to be US$69.9 billion or 0.4% of world GDP. Since different base years are assumed by different studies, these gains are not comparable in level terms. Nonetheless, these studies suggest that the global welfare change as a proportion of the status quo is positive and less than 0.5%.

- US lumber producers have for over a decade made complaints that their Canadian counterparts have been unfairly subsidised by the Canadian government and have dumped their cheaper softwood lumber onto the US market. In turn, US began imposing tariffs on lumber imports from Canada in the second half of 2001. The dispute is on-going.

Large variations in the estimates come from differences in modelling assumptions (e.g. perfect competition vs. imperfect competition; constant vs. increasing returns to scale), data, commodity and country disaggregation, and elasticity estimates used to parameterise behavioural equations. Thus results should only be taken as indicative.

Although little is said about the impact on the forest sector by general equilibrium studies (small trade size relative to global merchandise trade contributes to the relative neglect), the Uruguay Round impact on the agricultural sector has been estimated by several studies. Nguyen et al. (1995), for example, calculated the impact of agricultural sector only liberalisation. They found that while agricultural exporters gain through improved market access, more significant gains are accrued to developed countries' consumers. According to Nguyen et al. (1995) the largest welfare gain relative to the size of GDP goes to middle income agricultural importers, such as South Korea, Taiwan, Hong Kong and Singapore, with a 0.6% gain, followed by agricultural exporters, such as Brazil, Argentina, Indonesia, Thailand, Malaysia and Philippines, with a 0.2% gain. The remaining developing countries experience a smaller gain, approximately 0.1% of GDP. In general, the impact on the agricultural trade volume is larger than the gain in welfare. While Nguyen et al. (1995) predicted a rise in trade volume by less than 10%, a model commissioned by GATT predicted an increase by 12.5%. Developing and countries in transition are expected to experience a larger increase in trade volume of between 12 and 34%

(Francois et al., 1994). A much smaller rise in trade volume is predicted by Page and Davenport (1994) who report a 1.2% rise in export volume for developing countries as a whole. This is due to a significant fall in exports of countries that previously had preferential trade access (GSP) but which were taken away under the Uruguay Round.

Barbier (1999) conducted a partial equilibrium analysis on the impact of the Uruguay Round on forest sector trade: namely logs, sawnwood, veneer, particleboard, fibreboard, plywood, wood pulp, and newsprint. The Uruguay Round stipulates a reduction in tariffs and a rise in the proportion of bound tariffs on forest products; thus its benefits to this sector are expected to come from improved market access. He finds that the trade gains from the Uruguay Round for these products range between US$460 and 593 million per annum or 0.4-0.5% of total forest products imports in 1991. The lower-bound on the gain is derived under the assumption that all developing countries' exports faced GSP rates initially in the developed countries' market (which are taken away post-Uruguay Round). In this scenario, the developed country exporters are the beneficiaries from the trade creation and diversion, whereas the developing countries are net losers. The upper-bound on the gain is derived under the assumption that all developing countries' exports faced MFN rates initially. Without trade diversion effects, both the developed and developing countries stand to gain from trade expansion. However, 70% of the net global gain is reported to go to the developed exporters.

Within the forest sector trade, Barbier estimated that the Uruguay Round would bring about a rise in plywood trade of 3.3-5.1%; while newsprint trade rises by 3.5%. Given that tariffs on primary exports such as logs and sawnwood are already at low levels before the Uruguay Round, the value of trade in these products expands by less, at approximately 0.4% and 0.9% respectively. Thus the results by Barbier suggest that the impact on global forest products trade should be small but positive.

The only general equilibrium study which distinguishes the forest product sector from other economic sectors has been carried out by Francois, McDonald and Nordstrom (1995) who predict a larger increase in forest products trade than Barbier, at 3.7-5.6%. Larger number of forest product lines in Francois, McDonald and Nordstrom's study would have contributed to the larger increase. However, the difference in the results also come from differences in country aggregation and the fact that Barbier's partial equilibrium model does not capture policy repercussions through interlinkages between markets.

As mentioned, these estimates (including those derived by our study) should be viewed with some qualifications. Most studies of this type have left out certain aspects of the Uruguay Round, e.g. trade liberalisation in the service sector; the tightening of intellectual property rights; non-tariff barriers, so not all the policy changes and sectoral impacts are included in the analysis. The studies' coverage of countries and commodities are by no means comprehensive and are varied. Model results are sensitive to trade elasticity assumptions and the data on these are limited. Most models use the standard assumption of constant returns to scale in production; the introduction of increasing-returns-to-scale and imperfect competition would raise gains from trade liberalisation since the latter incorporates benefits from economies of scale and rationalisation.

1.3 Summary of results from this study

According to the model, when the Uruguay Round changes are implemented on log, sawnwood and plywood, we find that both tropical and temperate wood exporters benefit from increased exports. Given that the Uruguay Round weakens tariff escalation, exports of higher processed forest products increase relative to logs. The most substantial gain goes to Indonesia, the world's number one plywood exporter. However, when the Uruguay Round agricultural policy changes are incorporated, we find that the change in welfare of tropical countries is reversed, i.e. they are worse off. Originally some of these countries had extremely high agricultural import taxes but the Uruguay Round dictates a 24% reduction in the agricultural tariffs in these regions, thus a significant fall in tariff revenue ensues. We find that harvest rent for the tropical region on the whole deteriorates because increased agricultural activity puts strain on unskilled labour market and raises wages. In turn, agriculture becomes more attractive as a land use option compared to forestry. This indicates increasing pressure on forest resources from agriculture following the Uruguay

Round policy changes, other things being the same.[6]

When all tropical log export taxes are eliminated, we find that the welfare of tropical regions falls because the large expansion of tropical log supply depresses the world price. This suggests that tropical regions may be benefiting from the widespread use of log export restrictions. Free trade results in an overall rise in the world welfare as expected. However, the gains are very unevenly distributed across regions; while importing regions benefit from such move through reduction in consumer prices, the tropical exporting regions suffer significant losses. Despite trade being created, fierce competition leads to a decline in world prices of many exporting regions. While higher domestic price of logs in the tropical countries improves the efficiency of downstream processing sectors (i.e. log-use per unit of processing output falls), the overall harvesting activity increases due to the surge in demand for tropical log exports. Thus lifting export barriers on tropical logs, as suggested by Vincent (1992), may in fact heighten deforestation.

Since the results suggest that tropical countries are worse off under complete trade liberalisation, there must exist some level of optimal taxes for these countries. We carry out simulations for optimal taxes to discern the potential welfare gain for Malaysia and Indonesia with and without other regions imposing optimal countervailing taxes. The results show that when other regions do not retaliate, Malaysia

[6]According to Hyde et al. (1996), the forest category that would be affected by the changes in the relative return between forestry and agriculture are the forestlands in the neighbourhood of extensive agricultural land and plantations.

can benefit from imposing unilateral export taxes, particularly on logs and plywood. The same is true for Indonesia. The improvements are equivalent to approximately 7.8 and 5.3 percent of agricultural and forest sector income in Malaysia and Indonesia, respectively. Given that the main importers of Southeast Asian forest products are in East Asia, i.e. Japan, China, Hong Kong China, Taiwan Republic of China, and Korea, these countries suffer the most welfare loss from the export restraint. Both Malaysia and Indonesia can benefit from harmonising their export policy on forest products. However, when other regions retaliate, Malaysia and Indonesia are worse off than under free trade. Thus, the possibility of trade war may act as a deterrent to exercising optimal tax policy.

1.4 Forest sector models

Forest sector models loosely fall into two types: demand-side and supply-side models. The first type of models has a multi-country, multi-sectoral structure, and is typically used for trade policy analysis. Our model is of this type. However, the treatment of forestry in these models is often rudimentary (e.g., inelastic supply of timber), so they are not very useful for analysing issues related to forest resource management. The second type of models has sophisticated timber supply structure. These models typically have a dynamic structure with endogenous harvest decisions. Earlier versions assume that forest is an exhaustible resource and optimal harvest path is calculated using the Hotelling framework. More recent models have used optimal control approach, with endogenous stand ages[7], investment decision and forestland use decision (see Adams and Haynes, 1993; Sedjo and Lyon, 1990; Persson and Munasinghe, 1995; Thiele, 1995; and Sohngen et al., 1999). These models are useful for resource management questions, but their treatment of consumer demand for forest products is extremely simplified, usually aggregated into a single global demand. Thus they are not suitable for examining changes in interregional tradeflows and the impact of multilateral trade policy agreements on global timber supply and management.

Ideally to analyse the effect of trade policy on resource management, the first and the second type of models should be combined. However, because of the complexity and the lack of comprehensive data regarding stand ages, harvest and transportation costs in the tropics, this is not possible to do. Instead, we use a simple increasing cost timber supply function to draw implications on the effect of trade policy on forest resources. The model structure used here allows us to discern the impact of trade policy on log production across countries, as well as the impact on the returns to forestry, and the agricultural sector. By recognising the potential effect on production and land use incentives, government can take measures to prevent further deforestation.

It is important, however, to note the drawbacks of this approach. A static model such as this does not take into account changes in technology or consumption

[7]This is the average age of trees per unit of forestland.

that may occur during the implementation of trade policy. Moreover, the harvesting agents are assumed to behave in a myopic fashion. Although there have been no major changes in timber processing technology over the last ten years, some changes in consumption pattern is likely to have occurred with the creation of synthetic substitutes for wood products. As yet there is no empirical evidence to support this. While a static trade model is attractive because it is easy to work with and analytically tractable, a proper consideration of resource management issues requires a dynamic framework.

Our model structure is closest to the Global Trade Model (GTM) of International Institute of Applied System Analysis (IIASA) (see Binkley et al., 1987) which depicts the interaction between several regions engaging in trade in forest resources and wood products.[8] However, we also include the agricultural sector, which has an important role in the rate of deforestation in Southeast Asia. In this way, we are able to draw some implications on forestland use from our model. Similarly to GTM, the cost of timber supply is assumed to be increasing with the amount of timber harvested. The reason being that as timber output increases, harvesters have to go further into the forests, perhaps into less hospitable forest regions so that the accessing cost increases. The model presented here is, however, different from GTM in several ways:

[8]For detailed information of the strengths and weaknesses of the GTM approach in examining forest sector trade issues see Cardellichio et al. (1987).

1. Given its focus on tropical timber and Southeast Asia, the countries have been grouped into regions according to their trading relationship with Southeast Asian exporters. Moreover, only three forest product sectors deemed most important for Southeast Asian trade are included in the model; these are log, sawnwood, and plywood.

2. Substitutions between tropical and temperate forest products are allowed unlike in previous forest trade models. Empirical evidence by Vincent et al. (1991) shows that tropical and temperate forest product markets are not separate, as is assumed by previous models (such as GTM, 1987; and Sohngen et al., 1999). These models are likely to have overstated tropical exporters' market power. We assume some small but positive substitution elasticities between tropical and temperate products.

3. Unlike in GTM, timber supply is endogenised for all regions in our model. So the pressure on the forest in each region post-tariff changes is captured. In this way, trade policy that affects the supply of tropical logs would have an impact over temperate forest resources, and vice versa.

4. Our model is static. As mentioned, by abstracting from dynamics, the model is kept simple. However, there are some drawbacks. Without the dynamic structure, investments in timber regeneration and the associated flows of benefits are not considered explicitly in the model. Since the ability to plan and

capture the flow of timber benefits is crucial element that differentiates the private/state property regime from the open access regime, a static model does not provide a good framework for analysing the issue of property rights. In a static forestry model where log harvesting sector is perfectly competitive, the result is that the open access harvest equilibrium coincides with that of the private property regime (P=MC=MR). This result is an outcome of the model setup. If the model were dynamic or if environmental costs are incorporated, then the open access harvest equilibrium would be different from the private property equilibrium.[9] The issue of property rights is discussed in more detail in Appendix A.1.

We concentrate on modelling the demand-side, which is important for trade policy analysis. Since only four sectors of the economy are examined in this paper, our analysis neglects the impact of the Uruguay Round changes on the rest of the economy, and consequently their repercussions on the forest and agricultural sectors. Although, we have assumed that each sector produces one output, in reality many types and qualities of products exist within each sector. These details are missed out in the aggregation but could be incorporated at the cost of a much bigger and more complicated model.

[9]With our model setup, the only difference between the two regimes comes from the resource rent which may be dissipated through rent seeking in the open access regime. This is because each firm in the open access case perceives its marginal revenue as equal to the price (i.e. average revenue). Thus each one ignores the negative effect that increased number of firms has on the forest, such as congestion cost, land degradation, soil fertility loss, extensive harvesting etc.

Where necessary, we have used the ad valorem equivalent of non-tariff barriers. However, the agricultural sector is particularly problematic since the base levels for tariff cuts have been inflated for many countries so that the agreed reductions are from these high levels, not from the actual tax levels in 1994. In this way, the gains in tariff reductions calculated may have been exaggerated.

The remainder of Part I is organised as follows: Section 1.5 gives a brief overview of the global forest products trade and the role of Southeast Asia. The model is outlined in Chapter 2, together with a discussion on data used. The results of the numerical experiments are laid out in Chapter 3, focusing primarily on trade flows, outputs, relative returns between different land use activities, terms of trade effects and the welfare of various regions. Some sensitivity analyses are carried out on the model parameters at the end of this chapter. Chapter 4 concludes part I of the thesis with a discussion of the implications of the progress towards trade liberalisation on the forest sector.

1.5 The Global forest products trade and the role of Malaysia and Indonesia

Before the production and trade pattern are described, it is useful to note that wood products from tropical forests mainly come under the non-coniferous category (or hardwood); while wood products from temperate forests normally come under the coniferous category (or softwood).

In the last 25 years, demand for wood products has been growing substantially. Between 1970 and 1996, the total consumption of roundwood[10] grew by 40% to 3354 million m^3. The significant rise in the consumption has been brought about by the increase in developing countries' demand for fuel wood (57%) and the increase in industrial roundwood consumption by developed countries (21%). The production of sawnwood, on the other hand, has been relatively stable in the last fifteen years. However, this stability disguises the fall in the share of coniferous sawnwood. Wood-based panels, on the other hand, have experienced a large growth in both developed and developing countries. Non-industrial roundwood, e.g. fuelwood and charcoal, makes up 80% of developing countries' production and are mainly consumed at home, leaving only 6-8% entering international trade.

Exports of most forest products have experienced an increase in the past thirty years. The most significant increase occurs in wood-based panels which saw a four-fold increase; surpassing the rise in the export volume of industrial roundwood (22%) and sawnwood (100%). Within this the pattern of trade amongst countries and the importance of different countries as exporters have also changed.

On the whole, there has been a relative decline in the importance of log trade and to a lesser extent sawnwood trade, towards plywood and other secondary

[10]By definition of FAO, roundwood consists of wood-in-rough, industrial roundwood (e.g. sawlogs and veneer logs, pulpwood, chips and particles), fuelwood and charcoal.

Table 1.1: Top 10 importers and exporters of forest products in 1996

Importers	*1000 US$*	*(%)*	*Exporters*	*1000 US$*	*(%)*
USA	22,147,000	(16.7)	Canada	25,333,000	(19.1)
Japan	15,424,000	(11.6)	USA	16,974,000	(12.8)
Germany	11,370,000	(8.6)	Finland	10,997,000	(8.3)
UK	9,627,000	(7.2)	Sweden	10,301,000	(7.8)
China	6,761,000	(5.1)	Germany	7,555,000	(5.7)
France	6,650,000	(5.0)	Indonesia	5,207,000	(3.9)
Netherlands	5,363,000	(4.0)	France	4,193,000	(3.2)
Italy	5,291,000	(4.0)	Malaysia	4,158,000	(3.1)
Belgium-Lux	3,803,000	(2.9)	Austria	4,150,000	(3.1)
Spain	3,464,000	(2.6)	Brazil	3,235,000	(2.4)
World total	132,884,000	(100.0)	World total	132,884,000	(100.0)

Source: FAO Forest Product Yearbook (1997).

wood products. In 1996, paper and paperboard accounted for 48% of global forest products exports; followed by sawnwood (19%); wood pulp (13%); wood-based panel (12%) and industrial roundwood (8%).

1.5.1 Tropical forest products

The share of forest product exports from tropical resources are fairly small, with the exception of plywood. In 1996, tropical industrial roundwood accounts for 16% of total industrial roundwood export value; 10% of total sawnwood exports; less than 10% of total pulp and paper and paperboard exports; and 39% of total wood-based panel exports. Tropical plywood, however, accounts for 71% of the overall exports. Although the share of tropical wood production has increased overall, the share of tropical exports for industrial roundwood and sawnwood has declined; while the share of tropical exports for wood-based panels has increased.

1.5.2 Patterns of forest products trade

While many countries are involved in the international trade of forest products, the majority of trade is concentrated between a small group of countries. Table 1.1 shows that in 1996 five countries accounted for approximately 50% of global forest product exports and imports.

On the whole global forest products trade is dominated by the developed countries who account for approximately 75% of total forest product exports and imports. US and Canada alone account for approximately 30% of total exports; while US and Japan alone account for approximately 30% of total imports.

Most of the developing countries' exporters are in the tropical region; with countries in Asia being the most significant exporters. Wood-based panels (mostly plywood) account for almost one-third of their forest product exports. Indonesia alone accounts for 46% of plywood exports, making it the world largest exporter of plywood. Malaysia and Brazil account for further 17% and 4% of plywood exports. Malaysia dominates in the exports of tropical log and sawnwood. However, it ranks third in terms of exports of all logs, after USA and Russia; and ranks fifth in terms of exports of all sawnwood. Indonesia has been an important exporter of tropical sawnwood but its exports declined between 1995 and 1996 to $440000m^3$ (due to high export levies). The exports of wood pulp are dominated by the Latin American countries; with Brazil being the world's fourth largest exporter of wood pulp.

There has been a decline in the exports of tropical timber over the last two decades as governments in tropical countries increasingly intervened to encourage exports of higher value added forest products. Although Asia dominates the exports of tropical timber, tropical timber exports from Africa and Latin America are narrowing the export gap.

Given the key exports of Malaysia and Indonesia are logs, sawnwood and plywood, our model will concentrate on these markets only. Although Malaysia and other Southeast Asian countries, such as Thailand and the Philippines, are becoming significant exporters of furniture products, this sector is not examined here due to the lack of reliable statistics.

1.5.3 Malaysia and Indonesia's trading partners

The main export market for Malaysian and Indonesian wood products is in the Asia-Pacific region. Japan is by far the largest importer in this region. Although the majority of exports from Malaysia and Indonesia go to Japan, there is increasing trade with Fneighbouring countries, such as China, Korea, Taiwan and Thailand (see Table 1.2).

In 1996, Japan imported over half of Malaysian log exports. Taiwan, Korea and China account for a further 30% and the Southeast Asian neighbours - the Philippines and Thailand - account for over 7%. In general, Taiwan, Korea and China are becoming more important as importers of global forest product. Taiwan and Korea are also important importers of Malaysia sawnwood, each importing be-

Table 1.2: Size and composition of log, sawnwood and plywood exports from Malaysia and Indonesia in 1996 (export destination as a % share of total export volume).

	Malaysia				Indonesia		
	Tropical logs	Sawnwood	Plywood		Tropical logs	Sawnwood	Plywood
Japan	51.79	10.25	41.10			28.23	43.28
China	4.74						
Korea	7.12	7.65	5.65			4.22	8.06
Thailand	5.20	32.79	1.25			0.53	0.51
Hong Kong		3.93	7.79			2.37	6.06
Philippines	2.17	7.84				0.00	
Taiwan	18.15	6.20	27.04			7.65	12.83
USA		1.01	6.88			2.11	9.63
EU		6.37	1.72			17.68	6.76
Others							
Total %	89.17	76.04	91.43			62.79	87.13
Total value of X (Bill US$)	902.01	1236.12	1748.53		3.8	275.35	3603.61

Source: Bilateral log export flows are taken from ITTO Annual Review (1997); the rest is taken from FAO Forest Product Yearbook (1997).

tween 6 to 8% of the total export. The Philippines import a comparable amount (approximately 8%). These countries are beaten by Thailand who imports approximately one-third; and Japan who imports approximately 10% of Malaysian sawnwood exports. Almost 70% of Malaysia plywood exports are destined for Japan and Taiwan markets. Plywood export is the largest source of foreign exchange revenues out of the three industries for Malaysia, followed by sawnwood and log exports.

In Indonesia, plywood industry is also the most important foreign exchange earner amongst the three industries. The value of Indonesian sawnwood exports is smaller than plywood exports by almost ten-folds. The stark contrast between the value of exports of the three industries is brought about by the government policy since 1979 which promoted higher value added forest industries at the expense of logs and sawnwood. Given that a prohibitive tax on log export is in place in 1996, the value of trade recorded is extremely small and no bilateral trade flows data exists.[11] Japan is the largest importer of Indonesian plywood at over 40% of the total export, followed by Taiwan (12.83%), USA (9.63%), Korea (8.06%) and EU (6.76%). Japan is also the largest importer of Indonesian sawnwood at close to 30% of the total export, followed by EU at almost 20%. Other East Asian countries account for a further 12%.

Thus, the majority of exports from Malaysia and Indonesia goes to Japan,

[11] We use bilateral trade flows data pre-log export ban/prohibitive taxes to conduct counterfactual simulations.

but there is increasing trade with China, Korea, Taiwan and Thailand.

The country aggregation in our simulation model is chosen to capture the trading relationship described and according to the location of the country on the eco-floristic zone. The last criterion is particularly important if the country is a net exporter, since this disaggregation allows us to capture the differing demand elasticities between tropical and temperate products. Thus the net temperate importers, Japan, China, Taiwan Province and Korea, are aggregated into one region. The Philippines and Thailand, on the other hand, are grouped with other tropical regions; and the USA and EU are grouped with other temperate regions.

Chapter 2

The model

2.1 Model Specification

Countries involved in the forest products trade are grouped into different regions according to their trading relationship with Malaysia and Indonesia, and the eco-floristic zone. There are five regions:

1. Malaysia;

2. Indonesia;

3. Asian Importers (consisting of Japan, China, Taiwan Province, Hong Kong China and Korea);

4. Other Tropical Region (consisting of both exporters and importers from tropical region, such as Brazil, Papua New Guinea, Cameroon, Côte d'Ivoire, Thai-

land and the Philippines); and

5. Other Temperate Region (or the rest of the world).

The model incorporates four sectors: three wood product sectors and the agricultural sector. The wood product sectors are log (i.e. the harvesting sector), sawnwood and plywood, which are the main forest products exports of Malaysia and Indonesia. By explicitly incorporating the agricultural sector, we can compare the outcome of trade policy on the returns between the agricultural sector and forestry. However, because the agricultural sector is highly aggregated, the complexity of the changes in tariff and tax structures are not fully captured in our model and some gains are likely to be left out. Nonetheless, given that the baseline agricultural tariffs against which tariff reductions would take place have been exaggerated for many countries, the actual reductions in the agricultural tariffs and thus the gains are likely to be smaller. Moreover, given that rest of the economy is left out of our model, the repercussions to and from sectors such as manufacturing and services are omitted.[1]

All four products are tradable. We use the Armington trade structure so that each good is differentiated across regions. This assumption allows for intra-industry

[1]Thiele (1995), using a CGE model of Indonesia, shows that forward linkages from the wood processing sector affect the extent of forestland use in Indonesia. He finds that a policy to reduce imports of tropical wood products from Indonesia diverts these products towards the domestic market, e.g. the construction industry. This in turn undermines the effectiveness of import bans on desforestation in Indonesian. In Chapter 4, we discuss how the exclusion of the manufacturing sector may have affected our trade liberalisation results.

trade amongst countries which is observed in forest sector trade (Vincent et al., 1991; Waggener et al., 1990). The model specification is a neo-classical type with constant returns to scale and perfect competition. In this way, we concentrate on efficiency gains through the decline in trade barriers and omit gains from economies of scale and rationalisation (which come about with assumptions of increasing returns to scale and imperfect competition).

There is one representative consumer in each region who consumes these four products.[2] For simplicity, we assume that the tax revenue accrued to each region is transferred to the representative consumer in the region, so that we do not have to model the government explicitly.

Factors of production, namely labour and capital, are assumed to be fixed and mobile across sectors within each region but are immobile between region, land used in agricultural and forestry is subsumed in the capital input category (more on this in Section 2.1.1). The various agents and firms in different sectors in the economy are connected in a 'circular flow' framework. The productive sectors purchase factor inputs from the representative household in the region and use them to generate value added. The household in turn receives some income from supplying its factor services. We assume that there are no savings, so that the household in each region spends all its income on goods. Given that this is a static model, there is no capital

[2]It may be more intuitive to think of the representative consumer as a downstream productive sector, consuming intermediate goods such as log, sawnwood, plywood, and agricultural goods. This does not alter the results. More on this issue later.

accumulation. All productive sectors are assumed to be perfectly competitive. In this way, the supplies and demands are equalised through relative price adjustments in various products and factor markets.

The general equilibrium model is made up of three sets of structural equations: production, consumption and market equilibrium. To facilitate the presentation of the model, we use Figure 2.1 and 2.3 to illustrate the production and demand structure. Their details are given in Section 2.1.1 and 2.1.2. The treatment of trade taxes is described in Section 2.1.4. Section 2.1.5 highlights the limitations of the model.

2.1.1 Production structure

All regions have the same production structure for each output. The structure varies from a simple nested function for the agricultural sector to a three-level nested function for the wood processing sectors[3] (see Figure 2.1). Constant elasticity of substitution (CES) production is assumed at each nest, which allows for a certain degree of substitution between various inputs.[4] The production function at each

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[3]Since we are focusing on the effect of trade policy on the forest sector, a more complex production structure is used for this sector.

[4]CES is more flexible than the Cobb-Douglas function since it allows own price elasticities of demand for inputs to be different from one. However, both functions have unitary income elasticity.

nest is thus

$$Q = \gamma[\sum_i (\alpha_i x_i)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}, \text{for all regions,} \tag{2.1}$$

where Q is the output or the composite input; i is the index for inputs into Q; x_i is the demand for input i; α_i is the input share parameter, where $\sum_i \alpha_i = 1$; and σ is the elasticity of substitution between inputs.

The demand for inputs at each nest is derived through the process of production cost minimisation. For CES production function, the demand for input is,

$$x_i = \frac{Q}{\gamma}[\alpha_i + (1-\alpha_i)(\frac{\alpha_i p_i}{(1-\alpha_i)p_j})^{1-\sigma}]^{(\frac{\sigma}{\sigma-1})}, \tag{2.2}$$

where $j \neq i$; p_i and p_j are prices of input i and j respectively.

The production structure of sawnwood and plywood is the most complex one in the model since there are three levels of nests. The multi-level nesting structure enables us to incorporate the differences in the elasticity of substitution between different inputs into the same production. Level one is a CES aggregation of two composite inputs: value added (i.e. labour-capital composite) and log composite; level two is a CES aggregation of hardwood and softwood logs; and level three captures the substitution amongst logs of the same type (i.e. tropical type or temperate type), or 'substitution by origin': softwood is assumed to come from temperate regions, while hardwood comes from tropical regions. These assumptions are reasonable given the actual production and trade flows data. Thus the second level nest essentially accounts for the substitution possibility between tropical and temperate logs. Treating tropical and temperate wood products as substitutes is novel in the forest product trade models, and is a better representation of the actual market, since previous empirical studies have found that the elasticities of substitution across wood types (tropical and temperate woods) are positive (although the values are much smaller than the elasticities of substitution by origin (Vincent et al., 1991)).

Logs are used as intermediate inputs into sawnwood and plywood production. In a static model such as ours, harvesting agents are assumed to be myopic, thus they do not produce at the optimal rate of harvesting over time. An increasing cost function similar to GTM is used to capture the interaction between the supply of timber and the changes in government policy.[5] There are various reasons for this, for example harvesters may have to go further into the forests, maybe into less hospitable part of the region or lower quality forestland to increase production.

[5]Increasing cost of forestry is also used by Coxhead and Shively (1995) and Deacon (1995). However, they explicitly include forestland as a factor of production unlike our model. In their setup, agents clear forestland up to the point where marginal profit of land rent is zero. A more traditional way of setting up this type of problem in applied general equilibrium models is to use an activity matrix. In the activity matrix, forestlands are divided into different land classes (e.g. differentiated by productivity, topology, proximity to roads and rivers, outputs etc.). Each forest land class in turn requires its own fixed combinations of inputs per unit of timber production, thus a Leontief production function is used. However, due to limited data availability on the quality of forestland and cost of harvesting in many regions, we opt for the GTM harvesting specification which does not require any data on land-use. Although less theoretically rigorous, it is easily implemented with minimal data requirement. Nonetheless, the harvesting specification that we use prevents us from explicitly quantifying the impact of trade policies on forestland use.

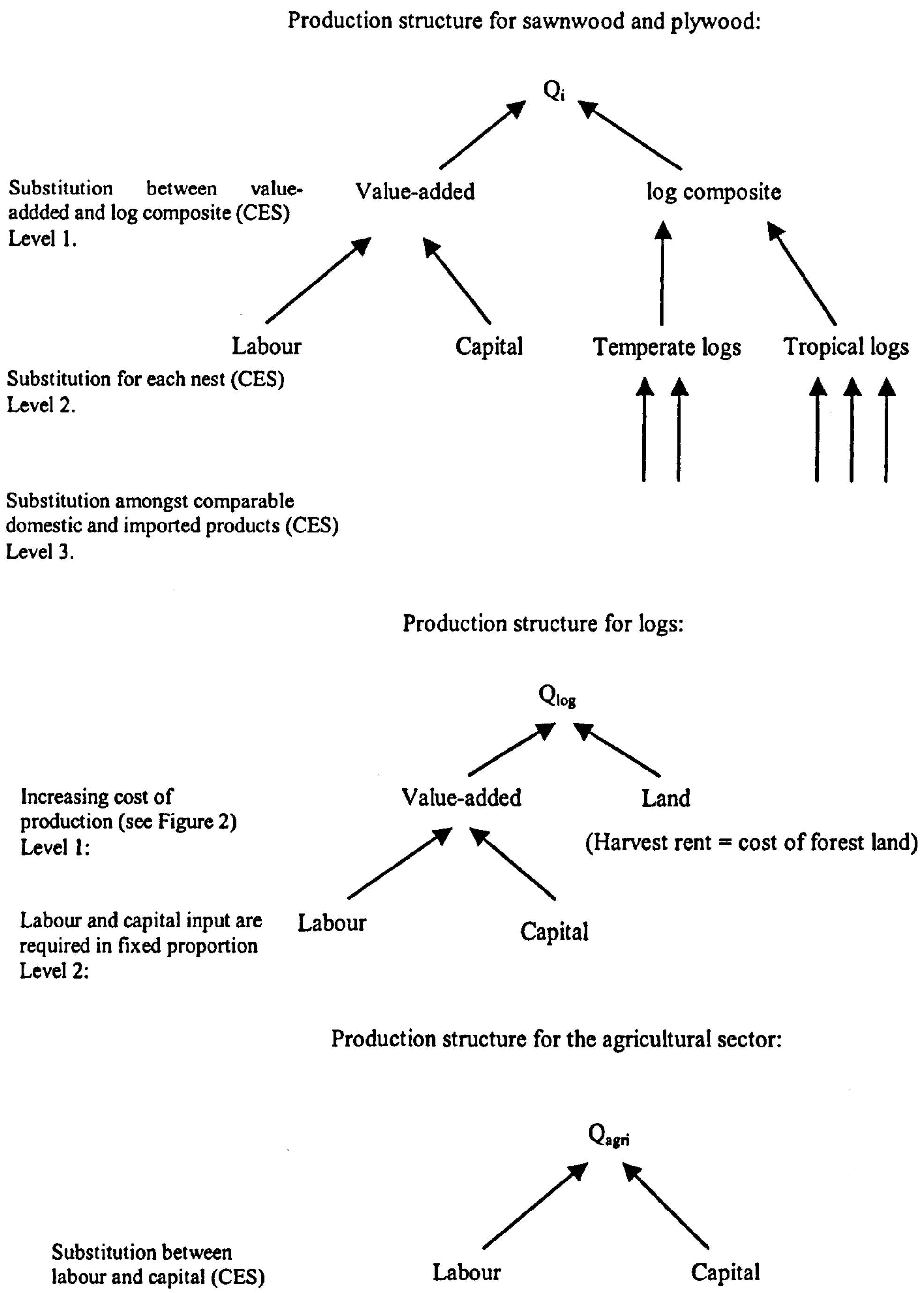

Figure 2.1: Representation of production structures for each region

Increasing marginal cost of harvesting is represented by

$$MC(Q_{log}) = \eta(Q_{log})^{\omega}, \quad \eta, \omega > 1, \tag{2.3}$$

where Q_{log} is the quantity of logs produced; η is the scale parameter, and $1/\omega$ is the short-run elasticity of log supply. Since $MC(Q_{log}) > 0$, the harvesting cost is an increasing function of the volume of logs produced. Differentiating $MC(Q_{log})$ with respect to the volume of log production gives

$$\frac{dMC(Q_{log})}{dQ_{log}} = \eta\omega(Q_{log})^{\omega-1}, \tag{2.4}$$

so the harvesting cost rises more than proportionately as more logs are produced. Note that $MC(Q_{log})$ is also the supply curve for logs. Similarly to GTM, we assume that all of the elasticities of log supply are invariant with respect to the harvest level. Most of the existing data on the elasticity of log supply are quite out of date; nonetheless they are the best estimates currently available. There are independent estimates of these elasticities for US and Sweden only (Adams and Haynes, 1980; and Hultkrantz, 1985). For all the other countries, we use the GTM's estimates which have been derived from the advice of GTM collaborators and their own judgement as to whether the log supply in a particular region tends to be more or less elastic than in North America and Scandinavia. We calculated the weighted average ω for each region using log production weights. The values of ω are presented in Table 2.1.

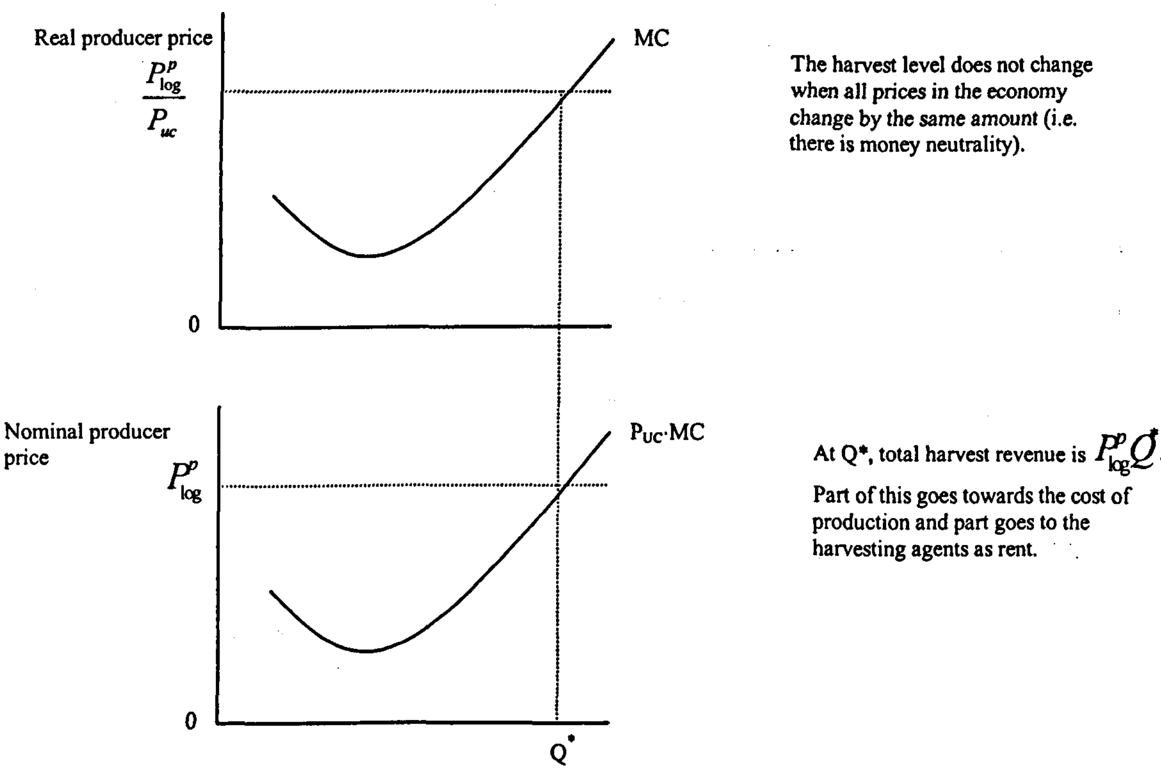

Figure 2.2: The equilibrium harvest level

The difference between the price per unit of log[6] and the harvesting and access cost for that unit is known as the *stumpage value*. Since the cost of logging increases as more logs are produced, the stumpage value declines as the volume of log rises. The revenue maximising harvesters will harvest up to where the returns from harvesting one more unit of timber is equal to the marginal cost of harvesting that unit, i.e.

$$\frac{p^p_{log}}{p_{uc}} = \eta(Q_{log})^\omega + \frac{\pi}{Q_{log}}, \tag{2.5}$$

where p^p_{log} is the producer price of log; p_{uc} is the unit cost of log production, included to ensure there is money neutrality in the harvesting decision; and π is the risk and profit factor which is assumed to be constant.

Condition (2.5) gives the equilibrium harvest output. This equilibrium is illustrated in Figure 2.2. From $MC(Q_{log})$, we derive the total harvest cost, TC:

$$TC = \frac{\eta(Q_{log})^{\omega+1}}{\omega+1} + \pi. \tag{2.6}$$

We assume that labour and capital provide harvesting services in a fixed ratio in this sector and that the total harvest cost net of the risk and profit cost is

$$TC - \pi = wL + rK, \tag{2.7}$$

where w is the cost of labour per unit; r is the cost of capital per unit. The harvest

[6]Although log prices vary between species and log quality, we assume one type of log with an average log price for each region.

rent is

$$RENT = p_{log}Q_{log} - TC. \tag{2.8}$$

Since a static model such as this does not provide insights into the question of property rights, this issue is not dealt with in this paper. [See Appendix A.1 for a discussion of property rights.]

The agricultural sector is assumed to have a simple CES value added production function with labour and capital services as inputs. As mentioned, land input is subsumed in the capital component. In this way, the model does not capture the possibility of forestland conversion to agricultural uses explicitly. The forestry sector is, however, linked to the agricultural sector through other inputs, such as labour and capital.

2.1.2 The derived demand and household consumption structure

As mentioned, we assume one representative household for each region, who maximises a Cobb-Douglas utility function subject to a household budget constraint. All regions have a three-level nested demand structure. In the top nest, the utility of each region is defined over composites of domestic and comparable imports for consumption; these are sawnwood, plywood and agricultural composites. All the other nests are represented by a CES utility function (see Figure 2.3). The second level nests capture the allocation of demand between imports and domestically comparable products in the plywood and agricultural sector. To model the effect of hardwood and softwood substitution in sawnwood, we add an extra nest to the sawnwood demand structure. This nest represents the allocation of demand between two sawnwood composites: hardwood and softwood; followed by a lower nest which captures the demand allocation between imports and domestically comparable sawnwood in each composite.

Intuitively, the representative consumer in each region is equivalent to a downstream productive sector that utilises sawnwood, plywood or agricultural goods, or any combination of the three as intermediate inputs. In this way, we are modelling a subsection of the economy only. This subsection is, however, characterised by its employment of land-based inputs. Data limitations have prevented us from modelling further downstream industries, such as furniture etc. Unfortunately, this means that the interaction between the four sectors represented in the model and the rest of the economy is not captured. Thus, when we talk about welfare changes, it is the welfare changes pertaining to the sectors that use the four intermediate inputs under consideration, other things remaining the same.

The final demand for each of the representative household in each region is generated by maximising a nested Cobb-Douglas utility function, subject to the household budget constraint as follows,

$$U = \Pi_i x_i^{\alpha_i}, \quad \text{for all regions,} \tag{2.9}$$

where $\sum_i \alpha_i = 1$, and expenditure must be less than or equal to the total disposable

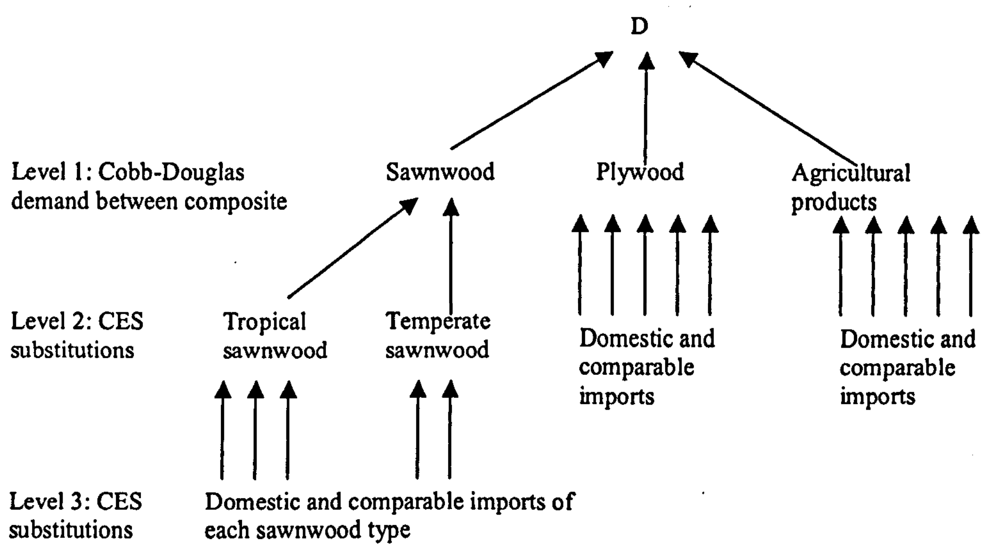

Figure 2.3: Representation of the demand structure for each region

income, so that

$$\sum_i x_i p_i \leq \sum_f w_f L_f + T, \tag{2.10}$$

where i is an index for different consumer goods; x_i is the demand for goods; p_i is the consumer price of goods; f is an index for factors of production; $\sum_f w_f L_f$ is income from endowment of factors of production, or capital and labour; and T is the total revenue from timber royalties, trade tariffs and export taxes.

As mentioned, it is more intuitive to think of the representative consumer as another downstream productive sector that uses agricultural and forest products as intermediate inputs. In this way, the utility is an output ($U = Q$), and the income constraint becomes a zero profit condition, in which the total revenue is captured by $\sum_i x_i p_i$. This term must be equal to the total expenditure which is represented by the total wage bill ($\sum_f w_f L_f$) plus tax to the government.

2.1.3 Market equilibrium conditions and closure rule

The applied general equilibrium model is based on the neo-classical economic theory of producer and consumer behaviour: i.e. markets are assumed to be perfectly competitive, demand and supply functions are homogenous of degree zero in prices and Walras's law of demand is assumed to hold in the equilibrium. Thus the following conditions must be satisfied:

1. Producers' income in each industry must be equal to the cost of production for all regions (zero profit condition).

2. The demand of domestic agents must satisfy their budget constraint.

3. Demand for goods must be equal to the supply of goods in each industry for all regions.

4. Each region is in zero external trade balance.

To obtain zero external trade balance for each region, we adjust the agricultural trade data. For example, when there is a trade surplus in region r, the value of agricultural imports in r is raised until zero trade balance is reached (where the import shares from different sources of imports are kept constant before and after the adjustment). When the trade balance is in deficit however, the value of agricultural imports in r is lowered until trade balance reaches zero (again the import shares from different import sources are kept constant). Given that the adjustment on agricultural imports of one region affects the value of exports of other regions, their export values must also be modified. This process is reiterated for each region until external trade balance is reached in all regions.

The model described is a fully specified general equilibrium model, in which all prices are endogenous. This includes prices for products from the "Rest of the World", i.e. the Other-Temperate region in our model which consists of sizable temperate wood producers (such as Canada and USA).

2.1.4 Treatment of trade taxes

Export taxes reduce the income to producers by an amount that is proportional to the extent of the tax. Total income from export to a producer is thus

$$p^p\tilde{x} = (1 - t^x)p^w\tilde{x} \tag{2.11}$$

s where p^p is the producer price; P^w is the world price; t^x is the export tax and $\tilde{x}$ is the quantity of export. Thus $t^x p^w$ is the per unit tax revenue accrued to the government. In a partial equilibrium framework, an export tax reduces the producer price. Therefore, its elimination is expected to raise the producer price and the supply of the product. In a general equilibrium framework, however, the interaction between markets makes the direction of change of the producer price ambiguous, and thus the effect on the production supply uncertain.

Import tariffs, on the other hand, raises the price faced by consumers above the world price, as follows

$$p^d = (1 + t^m)p^w \tag{2.12}$$

where p^d is the consumer price and t^m is the import tax. In this way, import tariffs tend to reduce the domestic demand for imports. Thus the reduction of tariffs is likely to make imports more competitive relative to domestic products.

2.1.5 Limitations of the model

The model structure presented in Part I is typical of applied general equilibrium models. These models are very stylized, and their structures are kept theoretically consistent to make the analysis tractable. We have assumed perfectly competitive forest and agricultural market, and consequently production and trade data had to be adjusted in several ways to make them consistent with the neoclassical framework, i.e. consumer expenditure must equal consumer income, total demand must equal the total supply of a good, and zero profit conditions must hold. Since only four sectors are included in the model, a partial view of the economy is given. The omitted sectors, such as the manufacturing sector and the service sector, are much larger than the land-based sectors that we focus on. In this way, the Uruguay Round policy changes may induce changes in income and/or input prices that affect the consumption and production of land-based products.

Within these four sectors, several product types have been aggregated to simplify the analysis. Product aggregation makes the analysis insensitive to the diversity of products and policies within log, sawnwood, plywood and agricultural industry. Furthermore, many countries have been aggregated into regions. While this should not affect the Uruguay Round analysis, it is likely to exaggerate the market power of the aggregated region in the optimal tax simulations in Chapter 3. Nonetheless, the current set up is sufficient to give us an overview of the effect of trade policy on these industries.

Finally, given that (1) the model is static; (2) the log supply specification is rather crude; and (3) environmental values of the forests are not taken into account, the model cannot be used to address the issue of forest management directly. However, we can use it to make some inferences from the changes in log and agricultural production resulting from trade policy shifts.

2.2 Base year data

Data used in the model are divided into four groups: (2.2.1) production and trade; (2.2.2) input-output; (2.2.3) elasticities of substitution; and (2.2.4) trade barriers data. The sources of each group are discussed below. Only the data on substitution elasticities and trade barriers are presented, the rest of the data are available from the author.

2.2.1 Production and trade data

The year 1996 has been chosen for the analysis to avoid the effect of the Southeast Asian financial crisis, which began in mid-1997. The main source of data for the production, trade and direction of trade in logs, sawnwood and plywood is FAO Yearbook of Forest Products (1997), supplemented by UNCTAD-TRAINS Database which has a more detailed account of bilateral trade flows. We use the term 'log' to refer to sawlogs and veneer logs that enter as inputs into the production of sawnwood and plywood, respectively. Let CR^r_{sw} and CR^r_{pw} be region r's log conversion ratio for sawnwood and plywood respectively. These are taken from secondary sources, such as Forestry Research Institute of Malaysia (1996) and Cardellichio et al. (1989). A weighted-average conversion ratio is then calculated for each region using production weights. Since $CR^r_{sw} = q^r_{slog}/q^r_{sw}$, where q^r_{slog} is the total sawlog used in the sawnwood production and q^r_{sw} is the total sawnwood produced in region r, the total demand for sawlogs in each region is simply $CR^r_{sw} \cdot q^r_{sw}$. Similarly, since $CR^r_{pw} = q^r_{vlog}/q^r_{pw}$, where q^r_{vlog} is the total veneer log used in the plywood production; and q^r_{pw} is the total plywood produced in region r, the total demand for veneer log is $CR^r_{pw} \cdot q^r_{pw}$. By calculating the demand for sawlogs and veneer logs in this way, we are able to capture some of the illegally harvested logs that end up in the production of sawnwood and plywood. Macro-policies that result in an increase in sawnwood and plywood outputs typically raise the demand for sawlogs and veneer logs. In Indonesia, and other tropical countries, where the legal level of log production is too small to satisfy the production capacity in domestic wood processors, much of the rise in the demand for logs is likely to come from illegal sources.

However, our model does not capture the full extent of the illegal logging activity, since some illegally cut timber ends up as inputs in other processing sectors, e.g. pulp and paper etc. Moreover, the extent of illegal logging depends on the level of enforcement of property rights. With forests in the tropics spread out over large areas, the enforcement of property rights requires large investments on personnel, equipments etc. While a rise in the market value of logs raises incentives to invest in the enforcement of property rights, the pay-off to the illegal logging activity also rises despite greater chance of being caught. Without explicitly modelling the harvesting decisions of concession holders and poachers, the net effect of trade policy changes on the illegal logging activity is ambiguous. Nonetheless, the trade-off between incentives to enforce property rights and to 'cut-and-run' must be borne in mind in view of our simulation results in Chapter 3.

Since there are no trade flows data for sawlogs and veneer logs, we use the shares of trade flows of industrial roundwood to calculate the trade flows for sawlogs and veneer logs.[7]

The FAO agricultural website was the main source of production and trade data for the agricultural sector, while the Handbook of International Trade and Development Statistics (1996/97) was consulted for the direction of agricultural trade.

2.2.2 Input-output data

Statistics on labour, capital and log inputs into industries were calculated using the data from the GTAP database; supplemented by data from Forestry Department Peninsular Malaysia and the Malaysian Timber Council publications; and company data from Indonesia.

[7]The regional bilateral trade flow shares are calculated by dividing each bilateral trade flow, by the total export of that region.

2.2.3 Elasticity specifications

Secondary sources were consulted for the elasticity values. Several price elasticity estimates of supply and demand for Southeast Asian timber are listed in Barbier (1995) and in Hyde et al. (1991). These were converted into substitution elasticities using the following formula presented in Shoven and Whalley (1992):

$$P.E.D. = -\sigma - \frac{\beta_i(1-\sigma)}{p_i^{\sigma-1}} \sum_j \beta_j p_j^{1-\sigma}, \tag{2.13}$$

where σ is the substitution elasticity; β_i is the share or weighting parameter of the CES production function; and p_i is the consumer price of goods in the relevant nest.

Various econometric studies have tried to estimate the elasticities of substitution for different forest products. There is a concensus amongst the studies that the elasticities of substitution across species group (i.e. between tropical and temperate region) are significant but relatively low, whereas elasticities of substitution within species group for tropical sawnwood and plywood are very high (see Constantino, 1988; and Vincent et al., 1991). Elasticity values for forest products trade are thus compiled with these results in mind.

Turning to the elasticities of substitution between productive inputs, these are found in Whalley (1985) and Kallio (1987). All the elasticities have been scaled up or down around unity to aid computation. Table 2.1 displays the elasticity values used in the model.

Table 2.1: Elasticities

	Malaysia	Indonesia	Asian Importers	Other Tropical	Other Temperate
Consumer's demands: elasticity of substitution between					
final good composites	0.86	0.86	0.78	0.88	0.78
temperate and tropical sawnwood	1.15	1.15	1.15	1.15	1.15
sawnwood from temperate region	2.50	1.19	2.20	1.89	2.00
plywood from temperate region	2.50	2.50	2.50	2.93	2.34
plywood from all sources	1.106	1.106	1.106	1.106	1.106
agricultural products from all sources	1.66	1.66	1.66	1.66	1.66
Sawnwood production: elasticity of substitution between					
value-added and logs	0.64	0.61	0.63	0.68	0.64
labour and capital	0.50	0.50	0.40	0.50	0.40
tropical and temperate log composite	0.75	0.73	0.85	0.87	0.93
logs from temperate regions	2.25	2.20	1.52	1.51	1.84
logs from tropical regions	2.25	2.20	1.52	1.51	1.84
Plywood production: elasticity of substitution between					
value-added and logs	0.62	0.64	0.63	0.65	0.66
labour and capital	0.50	0.50	0.40	0.50	0.40
tropical and temperate log composite	0.75	0.73	0.85	0.87	0.93
temperate logs	1.80	1.90	1.30	1.30	1.80
tropical logs	1.80	1.90	1.30	1.30	1.80
Agricultural production: elasticity of substitution between					
labour and capital	0.40	0.40	0.30	0.40	0.30
Log production					
Inverse elasticity of log supply (ω)	2.67	2.67	2.68	2.03	2.69

Sources: Elasticities of substitution of forest products are calculated using price elasticities listed in Barbier (1995) and Hyde et al. (1991); elasticities of substitution between productive outputs are found in Whalley (1985) and Kallio (1987). All elasticities have been scaled up or down around unity to aid computation.

2.2.4 Trade barriers on forest products

Import taxes

Various sources have been consulted for data on tariff barriers, e.g. Bourke and Leitch (1998); UNCTAD (TRAINS Database); Barbier (1999); Malaysian Timber Council and WTO (1994). In turn, import-weighted average tariff rates were calculated for each region. The pre-Uruguay Round weighted average tariff rates for each region and each production category are displayed in Table 2.2 to 2.4 (Note: columns represent exporters and rows represent importers). They are substantially higher in developing countries with tariffs on wood products escalating with the degree of processing.

When carrying out simulations, we assume that there are no changes in the GSP tariffs. Given that most tropical countries face the GSP rates prior to the Uruguay Round, the trade-weighted changes in tariffs facing these countries post-Uruguay Round are smaller than the changes faced by the developed countries.

Export taxes

In the past thirty years, there has been a trend amongst major timber exporters to impose barriers of various kinds on log exports to encourage domestic timber processing activities (e.g.export taxes, quotas and bans). Indonesia is one of the first countries to have banned log exports. In 1985, the government replaced the ban with prohibitive export taxes, ranging between US$500-4800 per m^3. Since

Table 2.2: Tariff rates for logs (percentages)

	Malaysia	Indonesia	Asian Importers	Other Tropical	Other Temperate
Malaysia		0.0	0.0	0.0	0.0
Indonesia	0.0		0.0	0.0	0.0
Asian Importers	0.5	0.6		0.7	0.4
Other Tropical	0.2	0.0	0.0		7.5
Other Temperate	0.3	0.8	0.3	0.1	

Source: Import-weighted average tariff rates were calculated from UNCTAD TRAINS Database.

No change in here since developed countries' import tariffs are already zero, while developing countries have opted for higher bound rates post-Uruguay Round.

Table 2.3: Tariff rates for sawnwood (percentages)

	Malaysia	Indonesia	Asian Importers	Other Tropical	Other Temperate
Malaysia[1]		0.0	0.0	0.0	0.0
Indonesia[2]	10.0		10.0	10.0	10.0
Asian Importers[3]	3.1	2.4		2.5	7.5
Other Tropical[4]	0.3	2.6	0.2		8.4
Other Temperate[5]	0.3	0.7	0.8	0.5	

Source: Import-weighted average tariff rates were calculated from UNCTAD TRAINS Database.

1. No change since Malaysia already has zero tariffs.

2. No change since Indonesia has opted for a uniform high rate for all forest products.

3. Malaysia, Indonesia and Other Tropical region face a 10% reduction in tariffs, while Other Temperate region faces a 30% reduction in the MFN tariffs. This is because most developing countries have been facing GSP rates for exports to Japan.

4. No change for Other Tropical exporters since most opt for higher bound rates.

5. No change because most of the exports to Other temperate region have been facing GSP rates originally.

Table 2.4: Tariff rates for plywood (percentages)

	Malaysia	Indonesia	Asian Importers	Other Tropical	Other Temperate
Malaysia[1]		45.0	45.0	45.0	45.0
Indonesia[2]	20.0		20.0	20.0	20.0
Asian Importers[3]	8.1	8.1		6.0	6.0
Other Tropical[4]	11.8	14.0	13.3		17.4
Other Temperate[5]	7.1	7.6	6.0	7.0	

Source: Import-weighted average tariff rates were calculated from UNCTAD TRAINS Database.

1. Malaysia reduces the tariff rate on plywood to 20% from 45% (i.e. a 55% reduction)

2. No change because tariffs are bounded at higher rates

3. Japan is a major importer in this region. According to the FAO, it reduces tariffs by 20%. We use this to represent tariff reduction for the region. Note that there have been no GSP rates for Japan pre-Uruguay Round.

4. No change given most tropical countries impose a higher bound tariff rate post-Uruguay Round

5. U.S.A. is a major importer in this region, since it has a GSP rate of 0% previously, the change in the trade-weighted tariff for developing countries is less than the developed countries. This reduction is approximated to 20% across all tropical exporting regions, and a reduction of 25% on exports from Asian importing region (most developing countries in this region have had their GSP rates removed pre-Uruguay Round).

1989, specific export taxes have been imposed on sawnwood in 1989 to promote the plywood export, which is exempted from all taxes.

As for Malaysia, both Peninsular Malaysia and Sabah have prohibited the export of logs since 1994; while Sarawak imposes an export tax of 15%. Export tax rates are introduced on sawnwood and plywood in 1996. Another major exporter in Southeast Asia is Papua New Guinea who imposed a log export tax of 13% in 1995.

In Africa, Cameroon and Cote d'Ivôire impose log export restrictions by way of quotas (30% of the annual cut of logs) and an outright ban, respectively. Ghana has banned the export of certain commercial species and introduced export levies on certain species of logs of 20%. The government in Gabon plans to phase in log export reductions. Brazil, on the other hand, imposes a two-year ban on some popular commercial log species. The Colombian government is the only government, reported in ITTO Annual Review 1996, to have encouraged timber production in 1996 through a tax reimbursement scheme. More details of the log export policies of tropical countries can be found in the Annual Review, ITTO (1996,'97,'98) and Barbier (1994,95). The weighted average export tax on each wood product was calculated for each tropical region. Where necessary, we compute the tariff equivalent of the quota and export ban. This is taken to be the proportionate difference between the world price and the domestic price of each country. Table 2.5 presents the export tax estimates used in the simulation.

Table 2.5: Export taxes on forest products used in the model (percentages)

	Malaysia	Indonesia	Other Tropical
Logs	20.0	30.0	20.0
Sawnwood		20.0	
Plywood	0.04		

Sources: ITTO Annual Review (1996,'97,'98) and Barbier (1994,'95).

2.2.5 Trade Barriers on agricultural products

Data on agricultural barriers are taken from WTO Committee on Trade and Development (1994) and OECD (1999). In general, the most significant gain in the agricultural sector comes from the fact that countries have agreed to convert virtually all agricultural non-tariff barriers into tariffs and subject them to the maximum agreed rates or tariff bindings (Martin and Winters, 1995). Tariff rates on the agricultural products are to be reduced by a simple average of 36% over six years in developed countries and 24% in developing countries. On top of this, the Uruguay Round imposes requirements on export subsidy reductions, and minimum access commitments and reductions in domestic support, known as "Total Aggregate Measure of Support" (Total AMS). This covers all domestic support provided on either a product-specific or non-product-specific basis that does not qualify for exemption. Given the lack of quality data on domestic support and that our focus is on forest product trade, the effect of AMS will not be considered in our model.[8] The esti-

[8]This is not to say that the impact of domestic distortions are not important. For theoretical analyses on these issues see Tyers and Falvey (1989) and Alston and Martin (1995). Nonetheless, Anderson (1995) who analyses the impact of the Uruguay Round in the presence of distortionary effects in the agricultural sector in developing economies finds that the direction of welfare change remains the same for Indonesia regardless of whether the domestic distortions are present in the

Table 2.6: Tariff rates and export subsidies for agricultural products (percentages)

	Pre-UR tariffs	Post-UR tariffs	% Change	Pre-UR export subsidies	Post-UR export subsidies	% Change
Malaysia	19.7	15.0	-24.0			
Indonesia	72.8	55.3	-24.0	0.9	0.7	-24.0
Asian Importers	15.8	10.1	-36.0			
Other Tropical	55.5	42.2	-24.0	4.2	3.2	-24.0
Other Temperate	17.8	11.4	-36.0	10.3	6.5	-36.0

Source: WTO Committee on Trade and Development (1994) and OECD (1999).

mated average agricultural tariffs and export subsidy pre and post-Uruguay Round for each region are presented in Table 2.6.

2.3 A note on constructing a micro-consistent data set for this study

First of all, export and bilateral trade data from the FAO Yearbook of Forest Products (1997) and FAO Agricultural data were aggregated into five regions as specified in Section 2.1. The bilateral trade flows were compiled using the export data only (no import data were used). This ensures that for each commodity, the total export is equal to the total imports demanded by different regions.

Given that the model consists of four sectors - log, sawnwood, plywood and agriculture, the total value of trade for each country is made up of these commodities. In each region, the value of agricultural exports and imports are adjusted to

simulation.

ensure that zero external trade balance is satisfied.

The trade data are expanded to incorporate two types of information. The first is region-specific value added in the forest and agricultural production. We use the labour and capital coefficients implied by the GTAP data to calculate the value of factors and intermediate goods employed in the production of the four commodities in each region. The second type of data are trade policy data, e.g. import tariffs, export taxes and subsidies. These are derived mainly from UNCTAD Trains Database and the ITTO Annual Review (1996,'97,'98). For each region, trade weighted-average tariff and export tax rates were calculated. At the sectoral level, the revenue net of intermediate cost, import tariffs and export taxes is equivalent to value added. Value added is in turn divided into labour and capital input using the coefficients derived from the GTAP data mentioned. Assuming that the representative consumers in each region owns labour and capital, they in turn receive income from the four industries from the supply of these factors of production.

As mentioned, the government is not modelled explicitly as an agent in the economy. We assume that tax revenues and subsidies and forest rents are transferred to the representative consumer; therefore, the total consumer income is made up of income from labour supplied, government transfers and forest rent. The total income described acts as a budget constraint for the representative consumer in each region. For Walras's Law to hold, it is necessary that the total expenditure not exceed this constraint. Again some adjustments were made to the agricultural sector trade in each region to ensure that the budget constraint is satisfied.

Thus a consistent account of the transactions across the four markets within and across regions is created and ready for use in counter-factual analyses of trade policy changes.

Chapter 3

Simulation experiments

3.1 Impact of the Uruguay Round 1994 on forest products trade

The GAMS/MINOS non-linear solver based on the *project Lagrangian* algorithm is used to simulate four different policy scenarios as follows.[1]

I Full implementation of the Uruguay Round tariffs on forest products only;

II Full implementation of the trade policy as implied by the Uruguay Round on forest and agricultural products;

III All of the above plus zero log export taxes in tropical regions;

IV Complete liberalisation of agricultural and forest products trade.

[1] See Murtagh et al. (2002) for full details.

As a check of the model's consistency for the 1996 base year, the base case was run to determine if the simulation output matches the actual 1996 data. If it does, this solution becomes the benchmark for comparison with the output obtained after the model is run with tax changes. The changes in the bilateral trade flows resulting from the policy experiments are reported in Figure 3.1.

3.1.1 Experiment I: Reductions in the Uruguay Round tariffs on forest products only

As can be seen in Table 3.2, all tropical exporters and Other Temperate exporters experience an increase in welfare. This is brought about by a rise in the world price of exports from these regions and an overall rise in trade volume. Although the Asian Importing region benefits from the decline in consumer prices, domestic wood production contracts as domestic consumers substitute towards cheaper imports of sawnwood and plywood resulting in a fall in domestic production and an overall loss in welfare. The largest welfare gain goes to Indonesia who enjoys the most favourable terms of trade post-tariff changes since tariffs on plywood experience the largest decline when compared to logs and sawnwood.

Given that the Asian Importing region implements differential tariff reductions which favour temperate wood processors, there is a large increase in imports from this region. This together with an increase in the world price of Indonesian and Malaysian sawnwood meant that other regions substitute away from sawnwood exports of these countries. Although the price of Indonesian plywood rises, a more

		% change in trade flows of logs					% change in trade flows of sawnwood					% change in trade flows of plywood					% change in trade flows of agricultural products				
		From:																			
EXPERIMENTS	To:	Ma	Indo	A-M	Trop	Temp	Ma	Indo	A-M	Trop	Temp	Ma	Indo	A-M	Trop	Temp	Ma	Indo	A-M	Trop	Temp
I	Ma	0.30	-0.72	0.78	0.36	0.32	-0.12	-0.69	0.21	0.30	0.01	-0.81	a.	a.	24.15	22.08	0.01	-0.17	0.18	0.07	0.08
	Indo	1.18	0.18	0.93	1.07	0.45	0.39	-0.19	0.41	0.80	0.31	0.15	-0.18	0.40	0.20	0.31	0.23	0.05	0.40	0.30	0.30
	A-M	-0.41	-1.12	-0.05	-0.50	-0.40	-0.16	-0.89	-0.25	0.11	4.32	1.28	0.95	-0.15	0.91	1.03	-0.24	-0.42	-0.07	-0.17	-0.17
	Trop	-0.22	a.	0.60	0.16	0.29	-0.47	-1.14	0.11	0.01	-0.05	-0.16	-0.49	0.08	-0.12	0.00	-0.06	-0.25	0.11	0.00	0.01
	Temp	-0.10	-0.65	0.68	0.12	0.25	-0.39	-0.92	0.14	0.00	-0.03	1.24	1.01	1.59	1.27	-0.08	-0.08	-0.26	0.09	-0.01	-0.01
II	Ma	-0.22	3.52	-0.64	3.70	0.52	-1.29	1.62	-3.75	-3.77	1.18	-2.25	a.	a.	23.01	21.45	-3.85	4.99	0.90	1.40	0.31
	Indo	-4.00	-0.52	-1.95	-0.33	-0.89	-7.23	-4.50	-7.42	-9.56	-5.19	-6.23	-4.67	-7.20	-5.67	-5.30	5.22	-9.64	3.28	3.79	2.68
	A-M	-1.01	1.60	-0.86	1.62	-0.08	1.63	4.44	-1.65	-1.07	7.66	1.36	3.04	-1.35	1.55	1.94	5.48	7.72	-4.78	4.04	2.92
	Trop	-4.62	a.	-3.39	-1.90	-2.69	-3.29	0.05	-6.92	-6.13	-3.34	-5.28	-3.71	-6.26	-4.72	-4.35	4.06	6.28	2.14	-10.10	1.54
	Temp	-2.65	0.89	-1.06	0.91	-0.09	-0.48	2.25	-4.64	-2.83	-0.75	-0.43	1.32	-1.36	0.14	-0.92	4.24	6.47	2.32	2.82	-1.89
III	Ma	-6.95	112.55	-2.49	1.01	-1.18	-4.69	1.09	-3.08	-2.07	0.11	-5.35	a.	a.	20.34	20.61	-4.73	3.62	-0.36	0.23	-0.85
	Indo	51.26	-2.30	-2.11	47.47	-0.94	-10.71	-5.29	-5.93	-8.25	-4.47	-7.89	-5.57	-5.55	-6.39	-4.61	5.80	-9.50	3.51	4.11	3.00
	A-M	15.09	48.81	-0.95	21.62	-0.09	-3.50	2.18	-0.52	-0.99	7.23	-0.82	1.69	0.02	0.39	2.30	5.80	7.63	-4.81	4.10	2.98
	Trop	42.88	a.	-3.17	-3.61	-2.39	-9.02	-2.53	-5.62	-6.09	-3.28	-7.29	-4.95	-4.93	-5.77	-3.98	4.30	6.11	2.03	-10.11	1.53
	Temp	18.28	53.11	-1.24	19.61	-0.17	-5.26	0.11	-2.97	-2.82	-0.42	-2.59	-0.03	-0.01	-1.01	-0.59	4.50	6.31	2.23	2.82	-1.88
IV	Ma	-6.86	142.42	-2.81	20.70	-0.27	-11.41	82.91	-14.96	-9.99	-4.45	-12.86	a.	a.	44.39	36.28	-16.92	22.60	2.21	6.52	0.22
	Indo	29.84	-3.64	-8.20	48.59	-6.37	-12.06	-27.87	-27.25	-22.86	-23.24	-14.91	-27.42	-19.02	-13.11	-15.73	25.67	-43.66	14.73	19.57	12.49
	A-M	13.05	61.86	-2.76	34.28	-0.76	-0.17	106.86	-4.04	-0.06	24.66	11.37	16.22	-3.04	10.22	7.93	20.52	31.95	-13.78	14.64	7.85
	Trop	21.20	a.	-17.30	-9.83	-7.27	-29.07	103.53	-32.85	-28.33	-14.91	-16.45	-11.11	-19.55	-25.32	-12.65	17.83	29.01	7.54	-42.34	5.44
	Temp	9.85	62.70	-1.39	28.17	-0.27	-6.33	89.87	-9.37	-4.50	-2.10	5.92	11.11	-0.62	7.02	-2.77	16.90	28.01	6.70	11.20	-6.20

Where Ma = Malaysia; Indo = Indonesia; A-M = Asian Importers; Trop = Other Tropical countries; and Temp = Other Temperate countries.

a. No bilateral trade or trade too small to be captured in the model

Figure 3.1: Bilateral trade flows (% Δ)

significant fall in tariffs means that Indonesian plywood export increases on the whole.

As mentioned, tariff escalation is reduced post-Uruguay Round. As a consequence, the proportion of imports of higher processed products increases relative to log imports. Given that logs enter as intermediate inputs into the milling sector, the changes in trade flows of logs are dictated by the demand from these industries. In all tropical regions, increased plywood production (induced by increased exports) raises the domestic demand for logs. Increased sawnwood production, on the other hand, causes a rise in the domestic log consumption in Other Temperate region. The world price of log appreciates due to the increase in domestic demand for logs in wood processing regions and a general decline in the log exports. As a consequence, logs become more expensive relative to other inputs into the milling sector, leading to a substitution away from log inputs. Thus the intensity of log use per unit of sawnwood and plywood in the milling sector decreases. Despite the fall in exports, log production rises in all producing regions, so there is likely to be more pressure on forest resources. Nonetheless, the rise in harvest rent in Indonesia and Malaysia is likely to raise incentives to invest in forest management and the enforcement of property rights.

Table 3.1 shows our results in contrast with the partial equilibrium results of the Uruguay Round agreement on forest products trade obtained in Barbier (1999). His 'Experiment A', which assumes that the pre-Uruguay Round tariffs on imports

Table 3.1: Gains in the value of imports for selected forest products (percentages)

	This study[a]	*Barbier*[b] *(1999)*
Logs	-0.3	0.4
Sawnwood	0.5	0.9
Plywood	1.3	3.3

[a] Figures shown are the change in the value of imports at world prices.
[b] Figures shown are the change in the value of imports in Scenario A, Table 4.

in developing country markets are at MFN rates; and pre-Uruguay Round tariffs on imports in developed countries are at GSP rates for developing countries and MFN rates for developed countries, is similar to our Experiment I. Although both studies show that the greatest change in the value of trade comes from the plywood sector, followed by the sawnwood sector, our results of the gain from trade is much smaller than Barbier's. Moreover, we find that the Urugauy Round agreement on forest products trade causes the value of log imports to decline. This may be due to two reasons. Firstly a partial equilibrium model like Barbier's does not pick up the rise in terms of trade of forest products which is likely to dampen trade expansion. Since the demand for forest product imports is elastic, the rise in price brings about a greater than proportionate fall in the volume of imports. Secondly, while Barbier captures the effect of trade diversion within sector (i.e. trade diversion from developing countries' imports to developed countries' imports), his model does not capture the trade diversion across sectors due to the reduction in tariff escalation (i.e. trade diversion from imports of logs to imports of sawnwood and plywood).

Table 3.2: Results from Experiment I - Reductions in the Uruguay Round tariffs on forest products only

	Malaysia	*Indonesia*	*Asian M*	*O-Trop*	*O-Temp*
Welfare change %Δ	0.06	0.20	-0.05	0.01	+0.00
EV, Billion US$	0.02	0.06	-0.09	0.03	0.03
terms of trade[a] %	0.10	0.33	-0.06	0.02	0.01
Factor prices %Δ					
Forestland rent	0.47	1.21	0.03	-0.00	-0.00
Labour wage	-0.02	-0.03	0.01	0.00	[b]
Capital rent	0.08	0.27	-0.09	0.01	0.01
SW conversion ratio, %	-0.01	-0.13	-0.01	-0.16	-0.03
PW conversion ratio, %	-0.02	-0.10	-0.00	-0.08	-0.03
Ratio of forest rtns to agricultural returns	0.43	1.05	0.09	-0.02	-0.01
Producer prices %Δ					
Logs	0.19	0.68	-0.17	0.26	0.07
Sawnwood	0.18	0.41	-0.06	0.02	0.03
Plywood	0.17	0.47	-0.05	0.13	0.02
Agriculture	0.05	0.16	-0.05	0.01	0.00
World price %Δ					
Logs	0.19	0.68	-0.17	0.26	0.07
Sawnwood	0.18	0.41	-0.06	0.02	0.03
Plywood	0.17	0.47	-0.05	0.13	0.02
Agriculture	0.05	0.16	-0.05	0.01	0.00
Production %Δ					
Logs	0.04	0.15	-0.03	0.12	0.02
Sawnwood	-0.22	-0.23	-0.24	0.04	0.29
Plywood	1.18	0.84	-0.07	0.33	0.17
Agriculture	-0.05	-0.16	0.06	-0.01	-0.01
Exports %Δ					
Logs	-0.41	-0.73	0.87	-0.15	-0.38
Sawnwood	-0.34	-0.90	0.17	0.05	4.04
Plywood	1.20	0.96	0.95	1.23	0.99
Agriculture	-0.10	-0.27	0.10	-0.01	-0.02

[a] terms of trade here refers to the change in the production weighted-average producer price of all tradables. This definition is used in Whalley (1985).

[b] The price of labour in the Other Temperate region is fixed as a numeraire price; therefore, does not change.

3.1.2 Experiment II: Full implementation of the Uruguay Round trade policy on forest and agricultural products, i.e. Experiment I with agricultural policy changes

Table 3.3 presents the results from Experiment II. Two additional policy changes are captured here:

1. fall in tariff rates on agricultural products; and

2. fall in agricultural export subsidies.

These policy changes have opposing effects. The fall in tariff rates leads to a reduction in import prices and thus an expansion in the agricultural product trade. However, a cut in the export subsidies tends to reduce the agricultural production and thus raise consumer prices. The results show a rise in agricultural exports in all regions, even for those regions with cuts in agricultural export subsidies, i.e. Indonesia, Other Tropical, and Other Temperate region. As the agricultural sector expands, more factor inputs are demanded. Since the agricultural sector is much larger than the forest product sector, the increase in the demand for factors has a repercussion on the forest sector through factor price rises. The price of labour is particularly affected since it is employed more intensively in the agricultural sector. In turn, timber rent and production fall in all regions as the real producer price of timber declines.

Forest rent falls in all tropical regions, while the returns to agricultural producers rise (producer prices were used to represent this). Thus the returns to forestry fall relative to those of the agricultural sector. The decline in log production means that forestry is likely to exert less pressure on forest resources post-Uruguay Round. While increased real returns to the agricultural sector and increased agricultural returns relative to timber harvesting meant that the pressure for conversion of forestlands for agricultural uses is likely to increase. The appreciation of factor prices results in logs becoming less expensive relative to other inputs into the processing sector, consequently there is greater intensity of log use in the milling sector.

On the whole, the welfare of all tropical countries declines. For Indonesia and Other Tropical regions, this is due to the fall in the timber rent and agricultural tariff revenues. Originally Indonesia and Other Tropical region had extremely high agricultural import taxes, 72% and 55% respectively. The Uruguay Round imposes a 24% cut in the agricultural tariffs, thus results in a significant reduction of tariff revenues. Since government budget surplus or deficit is transferred directly to households in our model, the reduction in government revenues translate to a one-to-one fall in household income in the respective region. Although Indonesia and Other Tropical regions have agreed to reduce export subsidies on agricultural products, these have been small originally, so the reduction in subsidy is not sufficient to compensate for the big loss in tariff revenues.

Relative to other regions, Malaysia has the highest ratio of agricultural imports to total agricultural and forest sector imports. The rise in the world price of agricultural product thus hits Malaysian consumer the most. Unlike Other Temperate and Asian Importing regions, Malaysian consumer benefits much less from the decline in the prices of some forest products.

Francois et al. (1996) use a CGE model with nineteen sectors and thirteen regions to quantify the impact of the 1994 Uruguay Round agreement. Their policy scenario includes tariff reductions for industrial products; liberalisation of industrial nontariff barriers; reductions in agricultural export subsidies; and minimum market access on agricultural imports (from 3% to 5%). Under the constant returns to scale, perfect competition and Armington assumptions, he finds that the gain from trade is driven by the relaxation of the Multi-Fibre Agreement (MFA). In East Asia, South Asia, China and Latin America, production of textile and clothing rises, while production of other manufacturing contracts. There is a small rise in real wages in these regions which is driven by the increase in the production of textile and clothing. They also observe a rise in the forestry activity in countries in the temperate region; these are: 0.74% in Australia and New Zealand; 0.52% in Canada; 0.41% in US and 0.15% in EU. However, a fall in the forestry activity is observed in tropical producing regions; these are: −0.27% in Latin America; −1.33% in South Asia; and −1.02% in China. Our results in Table 3.3 show a decline in the forestry activity across all regions, although the decline in the forestry activity in the Other Temperate region (−0.09%) is smaller than the decline in the forestry activity in Malaysia (-0.51%), Indonesia (-0.43%), the Other Tropical region (−1.48%). Our results for the wood processing sectors cannot be compared with Francois et al.'s since they aggregate lumber and pulp and paper together.

Our welfare results are not directly comparable with Francois et al. for three main reasons. Firstly their model does not focus on the welfare impact on Southeast Asian countries but on the impact on developed countries such as US, Canada and Japan. In this way, the developing countries are aggregated together, into Latin America, South Asia etc. Secondly their model covers a wider range of products, including the manufacturing and the service sector and their agricultural sector is much more disaggregated. Their results show that the changes in MFA have a general equilibrium repercussion on the rest of the economy through real wages. Given that our model omits the manufacturing sector, its effect is absent. Thirdly, they use a watered down version of the agricultural agreement, so that they omit the decline in the agricultural tariffs by 36% for developed countries and by 24% for developing countries (which are included in our experiment).

Francois et. al. (1996) also carried out experiments under different cost and market assumptions, such as increasing returns to scale, imperfect competition and fixed and endogenous capital accumulation. In general, the welfare impacts that result from trade liberalisation in these scenarios are found to be greater than the experiment conducted under perfect competition and constant returns to scale assumptions.

Table 3.3: Results from Experiment II - Reductions in the Uruguay Round tariffs on forest and agricultural products

	Malaysia	*Indonesia*	*Asian M*	*O-Trop*	*O-Temp*
Welfare change %Δ	-0.79	-0.62	0.42	-0.05	0.37
EV, Billion US$	-0.20	-0.18	0.69	-0.21	2.71
terms of trade[a], %	1.47	-0.17	2.63	1.73	-0.02
Factor prices %Δ					
Forestland rent	-0.20	-2.17	-0.98	-0.85	+0.00
Labour wage	2.24	1.52	3.84	2.05	[b]
Capital rent	1.83	-0.14	2.68	1.74	-0.01
SW conversion ratio, %	0.12	0.43	1.17	2.04	0.12
PW conversion ratio, %	0.22	0.34	1.06	1.02	0.13
Ratio of forest rtns to agricultural returns	-2.11	-2.60	-3.96	-2.62	0.01
Producer prices %Δ					
Logs	0.46	-1.29	0.28	-1.30	-0.25
Sawnwood	0.66	-0.51	1.92	1.69	-0.09
Plywood	0.81	-0.68	1.76	0.27	-0.08
Agriculture	1.96	0.45	3.11	1.81	-0.01
World price %Δ					
Logs	0.46	-1.29	0.28	-1.30	-0.25
Sawnwood	0.66	-0.51	1.92	1.69	-0.09
Plywood	0.81	-0.68	1.76	0.27	-0.08
Agriculture	1.96	0.67	3.11	2.80	3.47
Production %Δ					
Logs	-0.51	-0.43	-0.88	-1.48	-0.09
Sawnwood	-0.90	-4.02	-1.72	-3.38	-0.15
Plywood	0.82	1.80	-1.51	-3.05	-0.42
Agriculture	0.18	0.88	0.68	0.40	0.01
Exports %Δ					
Logs	-1.02	2.63	-1.89	1.22	-0.10
Sawnwood	-0.41	3.75	-5.78	-2.59	6.96
Plywood	0.84	2.57	-3.47	0.30	1.22
Agriculture	4.51	6.53	2.27	2.80	1.85

[a] terms of trade here refers to the change in the production weighted-average producer price of all tradables. This definition is used in Whalley (1985).

[b] The price of labour in the Other Temperate region is fixed as a numeraire price; therefore, does not change.

3.1.3 Experiment III - Elimination of log export taxes in tropical countries

Table 3.4 presents the results of Experiment III. Since the Uruguay Round policy changes have already been agreed upon, in this section, we ask whether the tropical exporters could improve their situation by eliminating the export barriers on logs. The results of Experiment III are compared to those of Experiment II.

The elimination of log export barriers is found to have mixed effects on the welfare of tropical regions. The policy worsens welfare for Malaysia and Other Tropical region, but improves welfare for Indonesia slightly. As expected, the producer price of log rises and log exports increase in all tropical regions. However, the big surge in tropical log exports sends the world price of tropical logs spiralling downwards (between 18.72% and 29.58%). This also dampens the world price of temperate logs, although to a much smaller extent.

There is a small improvement in the conversion ratio for sawnwood and plywood in both Malaysia and Indonesia as the domestic price of log rises relative to other inputs (i.e. less intensity of log use in the milling sector).

Despite some improvements in the efficiency of log use in the downstream processing sectors, logging activities increase in Malaysia and Indonesia, as the foreign demand for their logs rise significantly. Thus lifting log export barriers, without a policy to contain the demand, is likely to add to the pressure on forest resources in these countries. The harvesting rent in both Malaysia and Indonesia also increases, rendering forestry more attractive as a land use option compared to agriculture. We find that log production in Other Tropical regions falls following the elimination of log export tax. Although the nominal producer price of log rises, the input cost rises faster in this region leading to a fall in the real producer price of timber and so to a corresponding fall in timber production.

Our result that log export barriers lead to a fall in logging activities supports Deacon (1995), who uses a theoretical general equilibrium model to analyse the impact of log export ban. His model consists of two sectors: timber and manufacturing, whereby only the former uses forestlands as inputs. If forestlands are left standing, they provide forest service flows which are proportional to the stock. Thus there is a trade-off between forest service flows and the amount of timber harvested. In Deacon's model and our model, timber production is driven by the market price. Therefore, an export ban which reduces the total demand for logs as well as its price, also brings about a fall in the logging activity. Unlike Deacon, however, our specification of the wood processing technology is more flexible. Wood processors may substitute logs for other inputs. Thus when logs become expensive relative to other inputs, firms have incentives to use log inputs more efficiently. While our results show that the elimination of log export barriers brings about an improvement in log conversion ratios in the wood processing sectors, log production rises overall.

Kaimowitz and Angelsen (1998) criticise this type of setup for ignoring the political economy aspect of deforestation. Given that log export ban induces excessive investment and over-capacity in wood processing sectors, developing country governments may find it politically damaging to reduce future harvests. In this way, log production continues to rise during the log export ban, despite the fall in the domestic price of logs.

Van Soest (1995) uses a more sophisticated supply-side specification to analyse trade policy impact on property rights. He assumes that harvesters may choose between assigning labour to logging or preventing encroachment; as well as choosing between work and leisure. He finds that lower log prices from the export ban reduce incentives for harvesters to invest in the enforcement of property rights against small farmers encroaching upon their concessions.

Thus while our results help to highlight the general equilibrium effect on world prices and trade volumes from simultaneous liberalisation of tropical log exports, the implication on forest resources is highly uncertain. In Section 4.2, we use the conceptual model of forestland use of Hyde et al. (1996) to analyse the link between agricultural and log prices on forestland use.

3.1.4 Experiment IV: Complete trade liberalisation in both agricultural and forest sectors

Table 3.5 shows the results of Experiment IV. As expected, free trade in the agricultural and forest sector lead to an overall rise in the world welfare. However, the gain is very unevenly distributed across regions. Asian Importers and Other Temperate region benefit from such move, while all the tropical regions are found to

Table 3.4: Results from Experiment III - Elimination of log export taxes in Tropical regions

	Malaysia	*Indonesia*	*Asian M*	*O-Trop*	*O-Temp*
Welfare change %Δ	-2.00	-0.49	0.72	-0.08	0.37
EV, Billion US$	-0.52	-0.14	1.18	-0.32	2.67
terms of trade[a], %	2.51	0.58	2.37	1.78	-0.04
Factor prices %Δ					
Forestland rent	7.43	1.80	-1.03	-0.85	+0.00
Labour wage	1.60	1.53	3.75	2.04	[b]
Capital rent	1.90	-0.01	2.82	1.74	-0.01
SW conversion ratio, %	-0.58	-0.18	1.89	0.58	0.46
PW conversion ratio, %	-0.56	-0.14	1.66	0.29	0.52
Ratio of forest rtns to agricultural returns	5.52	1.26	-4.06	-2.61	0.01
Producer prices %Δ					
Logs	4.75	0.85	0.18	0.91	-0.40
Sawnwood	2.87	0.48	0.89	1.76	-0.41
Plywood	2.85	0.55	0.54	1.35	-0.36
Agriculture	1.81	0.54	3.16	1.81	-0.01
World price %Δ					
Logs	-21.05	-29.58	0.18	-18.72	-0.40
Sawnwood	2.87	0.48	0.89	1.76	-0.41
Plywood	2.85	0.55	0.54	1.35	-0.36
Agriculture	1.81	0.76	3.16	2.80	3.47
Production %Δ					
Logs	1.04	0.32	-0.97	-0.40	-0.15
Sawnwood	-5.02	-4.89	-0.58	-3.32	0.12
Plywood	-1.36	0.50	-0.14	-4.13	-0.08
Agriculture	-0.14	0.81	0.57	0.37	0.01
Exports %Δ					
Logs	15.15	90.86	-2.04	20.53	-0.11
Sawnwood	-5.44	1.54	-4.29	-2.53	6.55
Plywood	-1.32	1.22	-2.12	-0.86	1.58
Agriculture	4.78	6.35	2.12	2.78	1.85

[a] terms of trade here refers to the change in the production weighted-average producer price of all tradables. This definition is used in Whalley (1985).

[b] The price of labour in the Other Temperate region is fixed as a numeraire price; therefore, does not change.

Table 3.5: Results from Experiment IV - Trade liberalisation in the agricultural and forest sectors

	Malaysia	*Indonesia*	*Asian M*	*O-Trop*	*O-Temp*
Welfare change %Δ	-4.48	-5.12	1.59	-2.00	1.82
EV, Billion US$	-1.15	-1.49	2.62	-8.31	13.20
terms of trade[a], %	3.17	-4.34	7.07	1.76	-0.10
Factor prices %Δ					
Forestland rent	5.66	-7.76	-2.71	-1.07	0.01
Labour wage	3.07	0.48	11.24	2.73	[b]
Capital rent	3.17	-5.27	7.65	1.80	-0.04
SW conversion ratio, %	-0.28	0.47	4.56	6.31	1.03
PW conversion ratio, %	-0.16	0.36	4.08	3.15	1.12
Ratio of forest rtns to agricultural returns	2.45	-4.66	-10.71	-3.02	0.04
Producer prices %Δ					
Logs	4.12	-6.12	-0.38	-7.12	-1.35
Sawnwood	2.28	-5.10	3.94	1.64	-0.79
Plywood	2.53	-5.29	3.21	-2.57	-0.70
Agriculture	3.14	-3.22	8.97	2.01	-0.03
World price %Δ					
Logs	-21.52	-34.45	-0.38	-25.19	-1.35
Sawnwood	2.28	-23.47	3.94	1.64	-0.79
Plywood	2.53	-5.29	3.21	-2.57	-0.70
Agriculture	3.14	-2.33	8.97	6.29	10.27
Production %Δ					
Logs	0.34	-0.34	-2.85	-4.42	-0.49
Sawnwood	-10.17	-20.31	-4.28	-9.36	-0.22
Plywood	9.18	10.32	-3.46	-14.42	-0.84
Agriculture	-0.04	3.14	2.01	1.17	0.04
Exports %Δ					
Logs	13.06	113.68	-7.61	30.89	-0.87
Sawnwood	-8.62	101.51	-19.97	-3.94	22.09
Plywood	9.37	14.80	-8.70	7.36	5.41
Agriculture	18.02	28.25	6.58	11.14	6.10

[a] terms of trade here refers to the change in the production weighted-average producer price of all tradables. This definition is used in Whalley (1985).

[b] The price of labour in the Other Temperate region is fixed as a numeraire price; therefore, does not change.

suffer significant losses (worse than all previous scenarios). This is not so surprising given that the Asian Importing and Other Temperate regions consist of some very important forest and agricultural product importers, who tend to benefit most from increased consumer surplus following the reduction in consumer prices. Since the base tariffs are highest in the plywood and agricultural sector, trade expansion is greatest in these sectors post-liberalisation. Exports of plywood and agricultural goods from all tropical producers and Other Temperate producers increase. Although the proportionate change in agricultural exports of Other Temperate region is smaller than the change in agricultural exports of Malaysia and Indonesia, the actual value of exports is much higher in the Other Tropical region, thus the actual benefit is greater.

Similarly to Simulation III, the world price of tropical logs experiences a significant fall (between 21.52% and 34.48%) due to a large influx of exports in the absence of log export barriers. This in turn has a negative repercussion on the prices of temperate logs. We find that the producer price of timber (both in nominal and real term) falls in all regions apart from Malaysia. In all other regions, this decline leads to a fall in the log production. We find that timber becomes less expensive when compared to other inputs, and so the milling industries in these regions substitute towards timber, leading to higher log conversion ratio (i.e. more intensive use of logs). However, the reverse applies to the Malaysian milling industry, where the real producer price rises. Given that logs become more expensive compared to other factor inputs, the intensity of log use falls in Malaysia.

Log production contracts while agricultural production expands in Indonesian and Other Tropical region. Assuming that all agricultural lands are fully employed in these regions prior to the implementation of the Uruguay Round agreement, without technological improvements in the agricultural sector, there must be some clear-cutting of forestlands for agricultural use. In Malaysia, however, log production expands while the agricultural production contracts. The rise in log production may be met in the long run either through increased forest plantations or harvests from mature forests. The expansion of logging activities into mature forests would, however, make these forestlands more prone to agricultural encroachment. (See further discussions on the impact of agricultural and logging activities on forestland use in Section 4.2).

Unlike our model, other CGE models that focus on forestland use or deforestation tend to be national models. In general, these models find a positive link between trade liberalisation and deforestation. Cruz and Repetto (1992) find that trade liberalisation in the Philippines raises logging activities, as well as the production of upland crops. Lopez (1993) finds a similar result for Ghana. Thiele (1995) finds that the imposition of an import ban on Indonesian wood products leads to substantial output losses in wood processing and in forestry. However, some of the foregone export demands are substituted by an increase in domestic use, especially the construction sector. In addition, agricultural land conversion rises following a decline in forestry profits. Persson and Munasinghe (1995), who examine barriers to log exports in Costa Rica, find that the barriers have little effect on forest clearing due to a similar reason.

Since results in Table 3.5 suggest that tropical countries are worse off under complete trade liberalisation of the forest product and agricultural sector, this implies that there exist some positive optimal taxes for these countries. In the next section, we examine the optimal forest product taxes for Malaysia and Indonesia and the associated welfare gains. The effects of optimal countervailing tariffs by importing regions will also be studied. Although optimal taxes and tariffs on tropical forest products have been analysed by Vincent (1989), his model does not allow for tropical and temperate products substitution. Thus the market power of tropical countries would have been exaggerated in his analysis.

3.2 Optimal export taxes and tariffs

In this section, we examine whether Malaysia and Indonesia can improve their welfare through restrictive wood export regimes. Five optimal tax simulations are carried out:

V Indonesia optimises export taxes on forest products, other regions set taxes equal to zero;

VI Like V. but for Malaysia;

VII Indonesia and Malaysia maximise own welfare by selecting optimal export taxes on forest products, other regions set taxes equal to zero;

VIII Indonesia and Malaysia maximise joint welfare by selecting optimal export taxes on forest products, other regions set taxes equal to zero;

IX Nash equilibrium (all regions set unilaterally optimal taxes on forest products).

Simulation V and VI are single country optimisations. The export taxes on logs, sawnwood and plywood are allowed to vary so as to maximise each country's welfare. These simulations provide a measure for the potential welfare gains from optimal policies in Malaysia and Indonesia in the absence of retaliation. In Simulation VII, both Malaysia and Indonesia optimise export taxes independently without policy response from other countries. In Simulation VIII, Malaysia and Indonesia choose export taxes to maximise joint welfare. By coordinating their export tax policy in this way, it is anticipated that Malaysia and Indonesia could increase their market power and so improve the overall welfare of the two countries. We compare the welfare results from Simulation VIII with those from Simulation VII to discern the gain from export policy coordination. In Simulation IX, each region selects optimal taxes on forest products. Export taxes are allowed to vary so as to maximise the welfare of each tropical region; while import tariffs are allowed to vary to maximise the welfare of temperate regions. Since the Other Tropical region consists of some important importers of forest products from Malaysia and

Indonesia, we simulate the countervailing tariffs for this region also. Simulation IX indicates the effect of retaliation on the welfare of Malaysia and Indonesia. Since Other Tropical region, Other Temperate region and Asian Importers are made up of many significant tropical wood producers, temperate wood producers and wood products consumers, respectively, the market power of these regions is exaggerated in the model. It follows that the welfare loss that they able to inflict upon Malaysia and Indonesia in Simulation IX should be taken as an upper-bound loss.

The GAMS/Conopt solver is used to solve for the optimal forest taxes. The algorithm used is based on GRG algorithm[2] first suggested by Abadie and Carpentier (1969). Details of the algorithm can be found in Drud (1985 and 1992). The model is solved by maximising the welfare of one region at a time. The process is repeated iteratively until the tax results converge. We find that it normally takes less than fifteen sets of iterations for the optimal taxes to converge. All the results reported in Table 3.6 are compared to the free trade level.

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[2]The GRG-based algorithm is specifically designed for large nonlinear programming problems expressed as follows:

$$\begin{aligned} \text{max or min} \quad & f(x); \\ \text{subject to} \quad & g(x) = b; \\ \text{lo} \leq x \leq \text{up}, \end{aligned}$$

where x is the vector of optimisation variables; 'lo' and 'up' are vectors of lower and upper bounds; b is a vector; and f and g are differentiable nonlinear functions that define the model. More details of the GAMS/CONOPT solver are available at the GAMS Corporation website (www.gams.com). The key steps in a GRG algorithm (adapted from the GAMS Corporation website) is listed in Appendix A.2.

The results indicate that Malaysia and Indonesia can indeed improve their welfare by imposing optimal taxes when there is no retaliation. The improvement is equivalent to 5.3% of agricultural and forest sector income for Indonesia and 7.8% for Malaysia. If Malaysia sets optimal taxes, Indonesia could improve its situation by imposing its own optimal taxes also, however, both would be worse off than if they were imposing optimal taxes alone (compare Simulation VII with Simulation V and VI).

If both Malaysia and Indonesia were to carry out optimal export policies on forest products, it would be in the interest of these countries to coordinate their export policy so as to maximise the joint welfare. Comparing the results from Simulation VIII with those from Simulation VII, we find that welfare of Indonesia improves more than five-folds; while Malaysia stands to gain even more. Given that the main importer of Southeast Asian forest products is the Asian Importing region, this region suffers the most welfare loss from export restraints. When other regions retaliate, Malaysia and Indonesia are worse off than the free trade case. Although most regions lose out under trade war, some actually benefit, e.g. the temperate region in this case. This may act to deter Malaysia and Indonesia from implementing optimal taxes. In 1996 (before the onset of the financial crisis), some co-operation is known to exist between Malaysia and Indonesia on forest product exports. However, in comparing the optimal taxes under harmonisation with the actual export tax levels in 1996, we find that the taxes on log and plywood fall well below the optimal level.

Our findings of optimal export taxes are comparable to those reported in Vincent (1989), for example our estimate of the optimal log tax for Malaysia is 72.4%, while that of Vincent is 76.6%. However, our estimate of the welfare loss to Malaysia from trade war is much higher at 30.7% of forest product and agricultural sector income, compared to Vincent's figure at 11.8% of forest products trade.[3] The difference comes about because tropical-temperate product substitution is missing from Vincent's model, which exaggerates the market power of tropical producers. When substitution is allowed, the trade and welfare of tropical countries are more adversely affected through trade war.

3.2.1 Value of strengthening the world trade system on forest products

As pointed out by Perroni and Whalley (1993), if the real significance of the Uruguay Round lies in the implicit agreement between countries to continue with international trade rules and disciplines, then the result of the Uruguay Round should be evaluated against the non-cooperative tariff equilibrium. The trade war outcome is shown in Table 3.6 (Simulation IX).

According to our model, all tropical countries would lose from trade war when

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[3] Forest product trade in both studies refers to log, sawnwood and plywood only.

Table 3.6: Optimal tax calculation results

	EV in Billion US$	EV as % of Income	% Change in Log Output	Optimal Log Tax	Optimal SW[1] Tax	Optimal PW[2] Tax
Simulation V: Indonesia optimising log, sawnwood and plywood export taxes simultaneously, no retaliation by other regions.						
Malaysia	0.02	0.10	-0.02			
Indonesia	1.07	5.31	-7.46	14.24	9.02	50.85
Asian M	-1.44	-0.87	-0.05			
O-Trop	-0.10	-0.03	0.01			
O-Temp	-0.10	-0.01	-0.01			
Simulation VI: Malaysia optimising log, sawnwood and plywood export taxes simultaneously, no retaliation by other regions.						
Malaysia	1.81	7.76	-14.26	72.38	19.52	75.51
Indonesia	-0.02	-0.12	-0.48			
Asian M	-3.78	-2.28	0.29			
O-Trop	-0.03	-0.01	1.67			
O-Temp	0.31	0.04	0.18			
Simulation VII: Indonesia and Malaysia maximise own welfare by selecting optimal export taxes on forest products, no retaliation by other regions.						
Malaysia	-0.49	-2.07	-55.28	59.80	26.30	87.57
Indonesia	0.28	1.37	-56.13	6.76	20.04	87.22
Asian M	-11.59	-7.00	3.60			
O-Trop	0.13	0.04	1.86			
O-Temp	-1.96	-0.28	2.15			
Simulation VIII: Indonesia and Malaysia maximise joint welfare by selecting optimal export taxes on forest products, no retaliation by other regions.						
Malaysia	1.88	8.08	-13.90	72.00	17.39	75.35
Indonesia	1.54	7.65	-13.52	27.92	16.25	76.71
Asian M	-6.82	-4.12	0.26			
O-Trop	-0.16	-0.05	1.75			
O-Temp	-0.19	-0.02	0.20			
Simulation IX: Nash equilibrium (each region sets taxes independently so as to maximise own welfare).						
X taxes:						
Malaysia	-7.22	-30.57	-56.14	64.14	39.04	81.82
Indonesia	-8.99	-44.71	-56.69	37.00	23.41	86.65
O-Trop	-155.44	-51.26	-36.48	35.08	35.43	77.65
M taxes:						
Asian M	-65.94	-39.88	22.51	132.80	179.91	151.44
O-Trop				92.87	286.55	196.44
O-Temp	15.04	2.14	31.57	266.52	260.59	222.54

[1]= sawnwood; [2] = plywood.

compared to the outcome of the Uruguay Round. The loss as a percentage to the forest products and agricultural income is 31% for Malaysia; 45% for Indonesia; and 51% for Other Tropical region. Note that the latter group consists of major tropical exporters and importers of forest and agricultural products. While the importers in this group suffer from a large fall in the consumer surplus; the tropical exporters suffer from a significant drop in foreign exchange earnings.

For Malaysia and Indonesia, the overall loss through trade war is between 6- to 8-folds of the loss experienced as a result of the Uruguay Round. Both Malaysia and Indonesia are net exporters of both commodities and, therefore, suffer a sizeable fall in export earnings (between US$7 and 9 billion). Given that foreign export demand elasticity specification for plywood is relatively small (close to unity), the optimal export taxes on plywood are relatively high.

The Asian Importing region also loses in the trade war; its welfare change moves from positive under the Uruguay Round outcome to negative under the trade war. This region contains some major importers of agricultural and forest products, such as Japan, Taiwan, Korea and Hong Kong. The welfare of consumers in these countries is expected to deteriorate with the rise in world prices sparked by the trade war. The simulation results indicate high optimal tariffs. This is again due to low foreign export demand elasticity specification in the importing regions.

The only region that stands to gain from a trade war is the Other Temperate region; its welfare is actually greater under trade war than under the Uruguay

Round. This region is dominated by US and Canada who are the largest temperate forest product exporters and, therefore, stands to benefit from increased market shares in forest products. However, given that the forest sector in these countries are relatively small, the gain as a proportion of the forest and agricultural sector incomes is rather modest (2.1%).

As mentioned, given our regional aggregations, the loss inflicted upon Malaysia and Indonesia through trade war should be taken as an upper bound. Given the key role played by trade elasticities in determining optimal tariffs and thus the size of welfare gains and losses encountered by each region, in the next section we investigate alternative trade elasticity specifications to assess the sensitivity of our results.

3.3 Sensitivity analysis

A number of sensitivity analysis experiments are carried out to check how sensitive the findings on welfare and terms of trade are to these parameters. In the first sensitivity check, elasticities of substitution between tropical and temperate products, and between imports and domestic products for the logs, sawnwood, plywood and agricultural products, are increased by 50%. In the second sensitivity check, the same set of elasticities is decreased by 50%.

In comparing Table 3.7 with the welfare results in Table 3.2, 3.3 and 3.4, we find that the direction of welfare change is only robust for the first and fourth

Table 3.7: Welfare and terms of trade effect when the elasticities of substitution increase or decrease by 50%

	50% Increase in the Elasticities of Substitution				50% Decrease in the Elasticities of Substitution			
	EV as a % of Income				*EV as a % of Income*			
	I	II	III	IV	I	II	III	IV
Malaysia	0.05	-0.64	-1.72	-3.99	0.10	-1.09	-2.77	-5.74
Indonesia	0.18	0.13	0.38	-2.22	0.26	-1.96	-2.00	-10.24
Asian M	-0.05	0.47	0.77	1.62	-0.06	0.43	0.77	2.06
O-Trop	0.01	0.24	0.22	-0.96	0.01	-0.37	-0.42	-3.08
O-Temp	0.01	0.38	0.36	1.62	0.00	0.39	0.40	1.98
	terms of trade effect				*terms of trade effect*			
	I	II	III	IV	I	II	III	IV
Malaysia	0.08	1.64	2.82	4.01	0.15	0.99	1.34	1.08
Indonesia	0.32	0.39	1.42	-1.00	0.43	-1.68	-1.13	-11.07
Asian M	-0.06	2.65	2.30	6.92	-0.06	2.67	2.57	8.08
O-Trop	0.02	1.80	1.87	2.45	0.02	1.62	1.65	1.04
O-Temp	0.01	0.00	-0.04	-0.10	0.01	-0.04	-0.02	-0.06

Table 3.8: Optimal export policy when elasticities of substitution increase or decrease by 50%

	50% Increase in Foreign Export Demand Elasticities			50% Decrease in Foreign Export Demand Elasticities		
	Optimal export tax (%) on			*Optimal export tax (%) on*		
	Log	*Sawnwood*	*Plywood*	*Log*	*Sawnwood*	*Plywood*
Indonesia	23.78	-2.26	51.56	87.83	72.66	76.24
Malaysia	67.83	5.43	51.24	76.59	74.36	78.12

experiment only (i.e. tariff changes in forest products trade and the free trade simulation).

Table 3.8 reports the optimal export policy when the elasticities of substitution between logs of tropical origins, sawnwood of tropical origins, and plywood are increased by 50% and decreased by 50%. Optimal export policy combination without countervailing tariffs is solved for Indonesia. The process is then repeated for Malaysia.

The optimal policies above are compared to those given in Table 3.6 (Experiments V and VI). While the sign of the optimal trade policy remains the same when foreign export demand becomes less elastic by 50%, it changes with higher elasticities. Specifically, the optimal trade policy on Indonesian sawnwood becomes a subsidy.

Given that our results are not robust to changes in elasticity values (by 50%), they should be taken as indicative only.

Chapter 4

Conclusions

In progressing towards trade liberalisation of the forest product and agricultural sector, we detect mixed effects on the forest rent and timber production in different regions. In this way, reduction in trade barriers does not always lead to more log production as feared by some non-governmental organisations. Amongst other things, the direction of change in log production depends on the general equilibrium effects on the world price of logs and factor prices.

When the Uruguay Round policy changes are implemented on the forest sector alone, we find that the welfare and terms of trade of all tropical regions increase. Moreover, log production increases in these regions. This is due to increased demand for logs into the downstream processing sectors as processed exports, particularly plywood, expand. However, the picture changes dramatically when the Uruguay Round changes on the agricultural sector are incorporated. The welfare of tropical countries deteriorates and the terms of trade falls in some countries. This is due to the decline in timber rents and agricultural tariff revenues. Some tropical countries (e.g. Indonesia) had extremely high agricultural tariffs prior to the Uruguay Round agreement. Although tariff cuts are higher in developed countries in percentage terms, the actual depths of the tariff cuts are higher in some developing countries so that a large fall in tax revenue ensues. The agricultural expansion raises the demand for factors and in turn leads to an appreciation of factor prices, particularly wages. The rise in factor prices has a negative effect on the harvest rent. On the whole, log production declines so the pressure on forest resources from forestry is reduced. Given that the returns to forestry declines relative to those of the agricultural sector, the latter is likely to become a more attractive form of land use post-Uruguay Round.

The adverse welfare results in Experiment II may have been exaggerated for two reasons. Firstly, many agricultural barriers are non-tariff barriers, but the simulations were conducted using their tariff equivalents. This means that the actual fall in tariff revenues should be smaller. Secondly, the base-line agricultural tariffs (against which tariff reductions would take place) have been exaggerated for many countries. Therefore, the actual reductions in the agricultural tariffs are smaller, leading to lower gains to the agricultural sector (Martins and Winters, 1995).

Francois et al. (1996) find that the Uruguay Round agreement in MFA brings about large growth in clothing productions in East Asia, South Asia and China.

This in turn causes real wages of unskilled labour to rise by a small amount in Asia. Thus it is possible that the inclusion of the manufacturing sector into our model would raise labour wages and adversely affect the agricultural and forestry activities in Malaysia and Indonesia, although these countries would benefit from growth in clothing production.

We find that the elimination of log export barriers post-Uruguay Round generally worsens tropical countries' welfare. The widespread use of log export barriers reduces the world supply of tropical logs and in turn raises the terms of trade of tropical log exporters. Simultaneous lifting of the log export barriers increases supply and sends the world price of logs down. Importing countries, such as Japan, Korea and China benefit through increased consumer surplus. We find that the elimination of log export barriers has mixed effects on log production: rising in Malaysia and Indonesia but falling in Other Tropical region. While the real producer price of log rises in Malaysia and Indonesia, it falls in Other Tropical region. In turn, log output in Other Tropical region falls. Since the returns to forestry in Malaysia and Indonesia increase relative to the returns to agriculture, the elimination of log export barriers is expected to promote forestry in these countries. Nonetheless, logs are likely to be used less intensively (i.e. more efficiently) in the milling sector as the domestic price of log increases relative to other factor inputs.

Since log export liberalisation has adverse effects on the welfare of tropical regions, we examined the optimal tax levels for these regions. We find that the pre-Uruguay Round export tax levels in 1996 are lower than the optimal levels for Malaysia and Indonesia; particularly the export tax on plywood. It may be that the threat of retaliation has prevented these countries from implementing their optimal tax policies.

Complete trade liberalisation in the agricultural and forest sector makes tropical countries even worse off than all previous scenarios, for similar reasons as discussed with reference to Experiments II and III. However, the tariff and export tax cuts are much larger here so the impact is greater.

As expected, the gains from the Uruguay Round is much greater when compared to the non-cooperative trade outcome. Tropical exporters and importers in East Asia, such as Japan, Korea, Taiwan and Hong Kong are estimated to lose over US$200 billion in total. Thus although the Uruguay Round may bring about a reduction in welfare against the status quo for tropical countries, these countries benefit substantially from the continuation of trade rules and disciplines under the GATT/WTO.

4.1 The model's predictions vs. what has actually happened

Figure 4.1 show the actual production and exports for log, sawnwood and plywood in Indonesia and Malaysia between 1989 and 1999. The production of log and

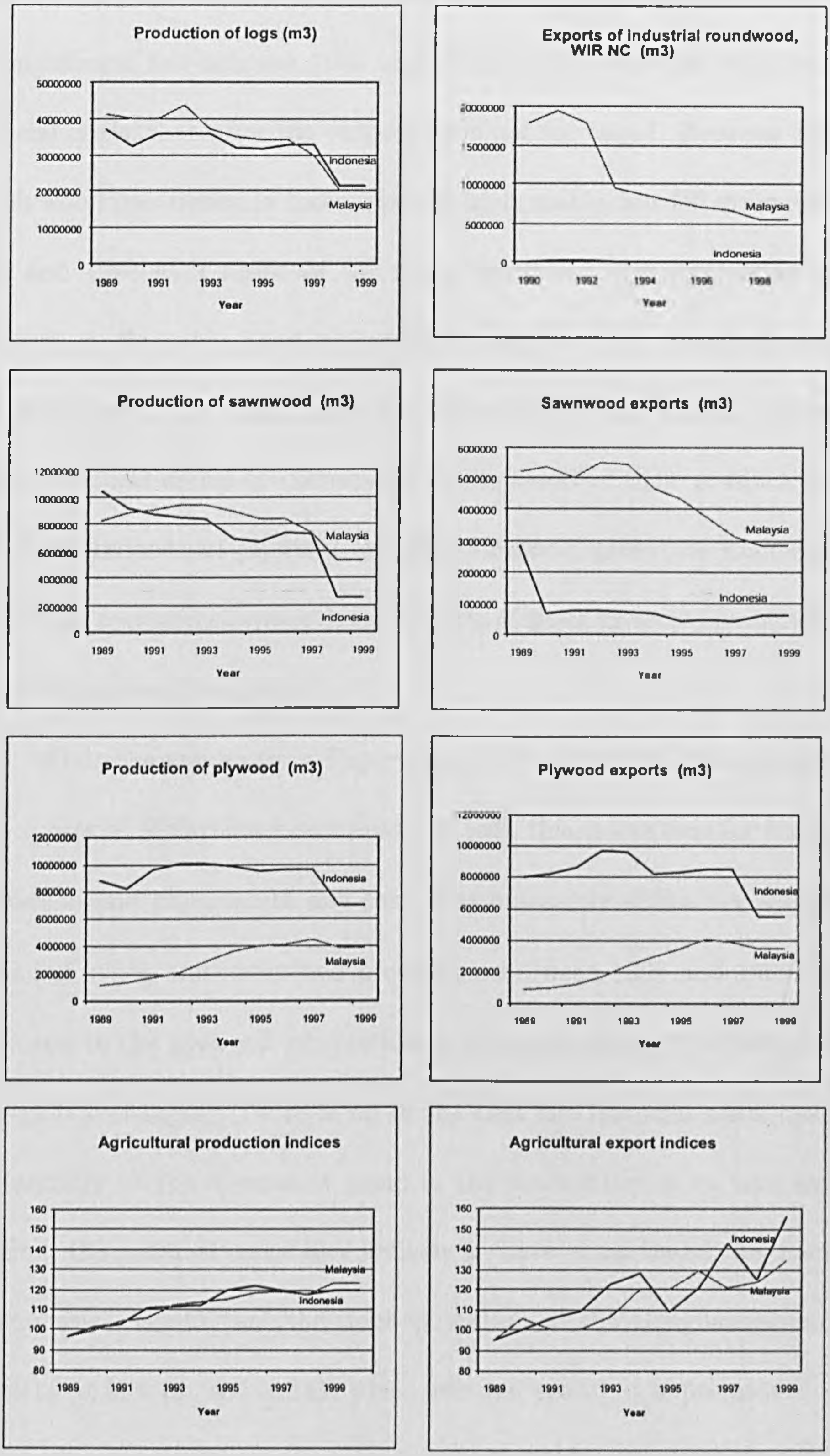

Figure 4.1: Actual production and exports of log, sawnwood and plywood in Indonesia and Malaysia between 1989 and 1999

sawnwood experience an overall decline in both countries during this period. There is a significant fall between 1997 and 1998, which coincides with the start of the financial crisis, thereafter the outputs have not recovered. Between 1992 and 1997, the plywood production in Indonesia was fairly stable, but fell dramatically between 1997 and 1998 as a result of the financial crisis. The production of Malaysian plywood, on the other hand, rises substantially over the decade but experiences a mild fall between 1997 and 1998 due to the crisis. The trend in Malaysian forest product exports seems to correspond to the trend in their production. The same is true for Indonesian plywood exports. However, given the high export barriers imposed on logs and sawnwood, the exports of these products remain fairly low and stable throughout this period.

While the results from Experiment II fit the trend in the actual production and exports of Malaysian forest products well, this is less true for Indonesian forest production and exports. In any case, it is extremely difficult to gauge how much of the fall in log and sawnwood production between 1995 and 1999. or how much of the rise in the plywood production in Malaysia during this period, is driven by trade policy changes. There is no doubt that the financial crisis has contributed substantially to the downward trend in the production of log and sawnwood. In addition, the political instability is likely to have exacerbated the downward trend in Indonesia. Given that the implementation of the Uruguay Round is not yet complete (it is supposed to take place over ten years), it is premature at this point to compare the results of the model with the actual production and trade data.

The agricultural production and export indices in Figure 4.1 show an upward trend over the last ten years. The rate of increase in agricultural exports is, however, larger than the rate of increase in agricultural production which fits with the results derived from Experiment II. Indonesian agricultural exports indices show greater fluctuations than the Malaysian case. At the onset of the Asian Financial Crisis in 1997, Indonesian agricultural exports fell sharply; however, this was followed by a significant rise one year later as agricultural exports were encouraged by the government to raise foreign exchange earnings. In this way, the Uruguay Round policy changes can only partially explain the rising trend in agricultural exports of Indonesia between 1997 and 1999.

4.2 Implications for forestland use

Although the model presented does not incorporate land use explicitly in the agricultural and the forestry sector, it can be used to quantify the changes in the returns to each land-based sector (forestry and agriculture) as trade policy changes. We apply the changes in the returns to each land-based activity to the conceptual model of forestland use of Hyde et al. (1996). Hyde et al. classify forestlands into five categories of differing distances from the market. These are listed below starting with forestlands furthest from the market:

1. Economically inaccessible mature natural forestland (i.e. forestland where the

cost of harvest and transport to the market exceeds the value of timber);

2. Marginal forestland or mature natural forests from which timber is currently harvested. This land area is highly responsive to changes in prices, harvest and access costs and forest sector policies;

3. Secondary forests or forests that support repeated harvests. Access to the resources in this region remains open since the cost of engaging in property rights exceeds the potential returns to forest management;

4. Forestland in the neighbourhood of extensive agriculture. Here the expected in situ returns on forest investments exceed the costs of protecting rights to forest property;

5. Plantations - the in situ forest product price justifies the cost of trees managed as an agricultural crop.

As trade policy changes, the boundaries between these different forestland categories are altered. The model predicts that the Uruguay Round changes would result in forestry becoming a less attractive land use option when compared to agriculture. In this way, we would expect timber plantations and forestlands in the neighbourhood of extensive agriculture to decline (category 4 and 5). Even secondary forests (category 3) may be converted for agricultural uses if the cost of clearing forestland and establishing property rights in those lands exceed the potential returns to forest management post-Uruguay Round. The actual data show a slight increase in agricultural land areas in Malaysia and Indonesia by 0.11 and 0.02 percent per annum, respectively, between 1995 and 1998 (see Table 4.2). Given the long run decline in the relative returns to forestry, we would expect the total land areas devoted to forestry to fall. The actual combined areas of opened for logging and plantations in Peninsular Malaysia rose between 1994 and 1996 but fell between 1997 and 1998 (see Table 4.2). However, it is very difficult to discern how much the changes in land use in Peninsular Malaysia and Indonesia are induced by trade policy changes. Again, the financial crisis is likely to have a significant impact during this period, since these countries tried to promote primary output and exports in response to the currency depreciation. As mentioned, the full implementation of the Uruguay Round has not been completed, so the full effects have yet to come.

Although previous literature finds the forest products trade to be a minor cause of deforestation, trade policy itself such as log export policy has a wider implication than the changes in the value of trade alone. Trade policy alters the returns to the whole of the timber industry, and thereby alters the incentives to produce and the land allocation between forestry and agriculture. Thus it is the trade policy rather than the amount of forest product trade that is likely to have a significant impact on the land use pattern and deforestation. Once data become available, more quantitative research to establish the significance of trade policy on forest-land use pattern could be extremely useful. In the mean time, governments should be extremely cautious of trade policy changes that affect incentives for activities

Table 4.1: The average annual change in agricultural land area in Peninsular Malaysia and Indonesia, 1995 to 1999 (% change)

	% Change in land area, per annum
Peninsular Malaysia	0.11
Indonesia	0.02

Source: FAO Agricultural Statistics.

Table 4.2: Total forestland in Peninsular Malaysia, 1994 to 1998 (hectares)

	Plantation	*Area opened for logging*	*Total area under forestry*	*% Change year-on-year*
1994	61525	160222	221747	
1995	62536	168265	230800	4.08
1996	66754	164245	230999	0.09
1997	73060	139686	212746	-7.90
1998	73735	114998	188733	-11.29
Average % change p.a.	4.69	-7.5	-3.76	

Source: Forest statistics Peninsular Malaysia 1994, 1995, 1996, 1997, 1998.

competing for forestland use.

Appendix A

Appendix

A.1 Property rights issues

When property rights are well established, each competitive harvester will harvest up to where the marginal revenue from extracting one more unit of timber is equal to the marginal cost as shown in Figure 2.2 in Chapter 2. The difference between the total revenue and total cost of production is the resource rent that accrues to the concessionaire. However, as Hyde et al. (1996) point out, sometimes the cost of establishing property rights is too high (e.g. in the remote parts of the forests), so that property rights are absent and the forests are treated as open access resources. In an open access regime, each firm in a competitive industry would harvest up to where the average revenue (AR) or the producer price of log, is equal to the marginal cost (MC). When property rights are enforced, the profit maximising producer would harvest up to where MR = MC. Since AR = MR in a perfectly competitive industry, the log production equilibrium in an open access regime is the same as the equilibrium in the state/private property regime in our model. The only difference between the two regimes lies in the associated resource rent. If open access brings about rent seeking costs (through congestion and land degradation etc.), the total resource rent would be lower under an open access regime (i.e. MC curve shifts up in Figure 2.2). In the extreme, rent would be driven to zero.

The harvesting equilibrium under open access and private property regimes coincide because of our assumption on the structure of the timber market (perfectly competitive market) and because the model is static. The latter implies that uncertainty over future timber revenues associated with open access forestry is not captured in our model. In a dynamic model, open access regime implies insecure land tenure. This, in turn, destroys incentives to manage forest resources over time because leaving potential rents behind would only risk others benefiting from it. Thus too much forests are logged too quickly, leading to land degradation, loss of soil fertility and rapid conversion of marginal land etc. These 'cut and run' forest practices due to insecure land tenure are the main case of inefficiency. Since our static model cannot yield much insight into the issue of property rights, we have left this issue out of our analysis.

A.2 GRG Algorithm (adapted from the GAMS/ CONOPT manual produced by ARKI Consulting and Development)

Given the following nonlinear programming problem:

$$\text{max or} \quad f(x);$$

$$\text{subject to} \quad g(x) = b;$$

$$\text{lo} \leq x \leq \text{up},$$

the key steps in any GRG algorithm are as follws,

1. Initialise and find a feasible solution;
2. Compute the Jocabian of the constraints, J;
3. Select a set of n basic variables, x_b, such that B, the submatrix of basic column from J is nonsingular. Factorise B. The remaining variables, x_n, are called nonbasic.
4. Solve $B^T = df/dx_b$ for the multipliers u.
5. Compute the reduced gradient, $r = df/dx - J^T u$. r will by definition be zero for the basic variables.
6. If r projected on the bounds is small, then stop. The current point is close to optimal.

7. Select the set of superbasic variables, x_s, as a subset of the nonbasic variables that profitably can be changed, and find a search direction, d_s for the superbasic variables based on r_s and possibly on some second order information.

8. Perform a line search along the direction d. For each step, x_s is changed in the direction d_s and x_b is subsequently adjusted to satisfy $f(x_b, x_s) = b$ in a pseudo-Newton process using factored B from step 3.

9. Go to 2.

A.3 Ways in which the model could be improved

1. As mentioned, the model presented here represents a sub-section of the economy. This makes the factor market equilibrium condition unrealistic, and may have interfered with the results to some extent, leading to a bias in the implication on forestland use. For a more complete analysis, the rest of the economy should be included. Nonetheless, tariff reductions such as those of the Uruguay Round are likely to lead to trade expansion, so the direction of change in factor prices is expected to be the same.

2. We have used a specification for the harvest sector that is similar to the one used in the Global Trade Model (1987). The specification is attractive because it is easily implemented and requires minimum amount of data, unlike the activity matrix approach that is normally employed by AGE modellers.

However, this specification is rather crude; thus the results are highly dependent on the elasticity of log supply, and cannot be interpreted too precisely. Nonetheless, once better micro forest data (i.e. data on revenue and cost of forestry for different classifications of forestland) become available, more detailed activity analysis would be extremely useful since it would enable us to predict the effect of trade policy on different types of forestlands. In this way, governments can be made aware in advance which forest area would be prone to development etc.

3. Still on the supply-side issue, given that the current specification has no dynamics - nor does it take into account the stand ages of timber, investment and technological changes - the impact of trade policies on forest management has not been captured in our analysis. All we have been able to do is to discuss the effect of trade policy on incentives over forestland use, and draw some implications on forestland use alterations. Once better data in Indonesia and Malaysia become available, a more complete supply-side structure can be incorporated to link trade policy with forest management decision explicitly. For now, there is a case for pursuing the GTM's approach.

4. The only benefit accrued from the forests is timber in our model. Thus the equilibrium level of log production under conditions of perfect competition is not the socially optimal outcome, given that there exist non-timber benefits which are not taken into account in the harvesting decision, e.g. ecological

functions of the forests and other externalities that might be associated with inefficient land use due to attenuation of property rights. It would be useful to incorporate non-timber benefits into the model, but finding reliable estimates of non-timber values such as environmental benefits of forests remains a major obstacle.

5. We have aggregated countries into regions and several product types to simplify the analysis. While regional aggregation is likely to exaggerate the market power of the aggregated region, product aggregation (each industry is assumed to produce one output) makes the analysis insensitive to the diversity of products and policies within log, sawnwood and plywood industries. For a more detailed analysis, the output from each industry needs to be disaggregated. Although our analysis has excluded secondary processed forest products altogether, some are gaining prominence in Southeast Asian exports. These sectors should also be included in the model for a more complete analysis of Southeast Asian forest product trade. Unfortunately, there are no reliable production and trade data on these products as yet.

Part II

Strategic trade policy and institutional structure in Indonesian wood industries

Chapter 5

Some backgrounds on the development of Indonesian log and plywood industries

This chapter gives a brief overview of issues related to the next two chapters of the thesis. We begin by highlighting major policy changes that have occured in the Indonesian log and plywood industry since 1970. This is followed by a selective literature review of empirical and theoretical analyses of trade barriers. Finally we discuss why a strategic trade policy framework is useful for analysing the Indonesian case.

5.1 Forest sector trade policy since 1960

The rise of the Suharto government in the 1960's came with a huge increase in log harvesting activity and exports. With supply of high quality timber in abundance, Indonesia quickly became the world largest exporter of tropical logs. At the height of the timber boom in 1979, Indonesia accounted for 41% of the world market (Gillis, 1987). However, towards the end of the 1970's, the Indonesian government embarked on a forest-based industrialisation programme. The aim of the programme was to raise Indonesian exports of higher value added wood products. Taxes were imposed on log exports to encourage investment, particularly by timber concessionaires, in wood processing industries. Later, sawnwood exports were also taxed to induce timber concessionaires to integrate forward into the plywood sector. Log export taxes escalated until eventually an export ban was imposed in 1985. As a result, a high degree of vertical integration now exists between timber concessionaires and the plywood sector.

Between 1980 and 1986, the number of plywood mills rose more than three-folds, with plywood production rising from 1 million m^3 to 4.9 million m^3. Approximately 80% of output was destined for exports. By 1995, the number of plywood mills levelled out at 120 plywood mills with a capacity of over 11 million m^3. However, there was a dramatic drop in timber export earnings, particularly in the early stages of the programme. Between 1979 and 1983, timber export earnings plunged from US$2.17 billion to US$0.9 billion. As new processing mills came into operation, the foreign exchange earnings began to increase, reaching US$1.2 billion in 1985. Throughout the 1980's and for most of the 1990's, sustained prohibitive barriers on log exports meant that plywood mills enjoyed low input cost. Many applied studies have attributed the inefficiency of Indonesian mills to the long standing protection implied by log export barriers.[1]

During this period, harvesting firms and plywood mills were only allowed to operate under the concession and plywood license respectively. Demand for these licenses generally outstripped supply. Despite the large number of firms in both industries, high industry concentrations are found. For example, in 1995 there were 585 timber concessions covering 62 million hectares. The top five largest concessionaires held 30% of the total area under concession. These five companies were integrated timber concession-plywood companies who controlled a similar share of the total country's plywood supply.

To reduce competition among Indonesian plywood exporters, the government set up 'Joint marketing boards' (JMBs). These boards were given the task of overseeing exports to different regions. An exporter must obtain an export license from a JMB of his export destination before he can engage in sales contracts with a buyer from overseas. Overseeing JMB was the plywood association, APKINDO, whose job was to set plywood export quotas for the whole of Indonesia. In turn, APKINDO

[1]Indonesian mills are found to require 15% more logs per unit of plywood than elsewhere in Asia (see Repetto and Gillis, 1988; Manurung and Buongiorno, 1997).

was maintained through export levies on plywood producers who must make use of its services, such as shipping, insurance and distributors in the importing countries.

Since the Asian financial crisis of 1997, Indonesian government has turned to the IMF for financial support. In turn, they agreed to undertake a number of policy reforms designed to improve efficiency of the forest sector. The conditionalities invoke liberalisation measures; such as the dismantling of plywood quota system, the removal of export barriers on logs, sawnwood and wood panels, de-linking between timber concessionaires and the processing sector, and reforms of forest concession policy to increase transparency etc.

However, the IMF and the World Bank have been heavily criticised for their lack of insight into the situation of the Indonesian forest sector, and for promoting policies harmful to Indonesian forests. Between 1998 and 2001, the number of cases of illegal logging rose dramatically (both for the purpose of land conversion and commercial use). Barr (2000) attributed the problem to the huge over-capacity in Indonesian processing sector, in particular the plywood sector. The derived demand for logs from these sectors currently more than doubles the annual allowable cut, resulting in a strong demand for illegal timber. By October 2001, Indonesia reinstated a ban on log exports for an indefinite period in line with the recommendation of the International Timber Trade Organisation (ITTO). [2]

[2]The ITTO made a wide range of other policy recommendations for short-, medium- and long-term. For more details see the ITTO report (2001).

The discussion above illustrates that trade policies, among other things, have considerable influence on agents' choices in wood industries. Given the linkage with the environment, many empirical studies of log export barriers focus on both the impact on log consumption and profits. We review some of them below.

5.2 Previous literature on the impact of log export barriers

Literature on the impact of log export ban in Indonesia (e.g. Manurung and Buongiorno, 1997; Vincent, 1992; and Gillis, 1988) found that although log export restrictions led to an expansion in the processing capacity and created jobs, these objectives were achieved at a considerable cost. Gillis estimated that the export tax created effective rates of protection of 222 percent for plywood exports. Given that the loss in export earnings from log exports was not compensated for by the gains in value added in the processing sector, he concluded that Indonesia's forest sector export earnings actually fell in the 1980s (with an estimated loss of US$15 per m^3 at world prices). In addition, the sustained protection to the processing industries created inefficient timber processing operations. During this period, Indonesia had the lowest conversion rate in Asia whereby for every m^3 of Indonesian plywood produced, 15% more trees had to be cut relative to plywood elsewhere. Between 1979-82, Gillis found that the total log consumption in Indonesia in fact rose after the log export ban. This is, however, contradicted by Constantino (1990) who found that the ban reduced log consumption compared to the pre-ban level.

Economic theory would suggest that log export ban would reduce the total demand for logs since one source of demand is eliminated. Deacon (1995), in observing Gillis' results, attributes his findings to political factors. Once the mills are established, the government is under pressure to maintain the operations at whatever the cost.

Log barriers have also been blaimed for upsetting the price signals that are needed to balance timber demand and supply (Vincent, 1992). As timber becomes more scarce, log prices must rise and in turn domestic processing industries must respond. Without this signal, the processing industry cannot develop along a sustainable path.

A static partial equilibrium simulation model is used by Barbier et al. (1994) to examine timber trade and tropical deforestation in Indonesia. They simulate a counter-factual case when different levels of tax were imposed on sawnwood exports as a strategy to shift processing activities to plywood and analysed the impact on timber-related tropical deforestation in Indonesia (using 1988 data as the base scenario). They find that the sawnwood export tax does not bring about a major shift of processing capacity to plywood. Barbier et al. attribute this to structural factors that limit the diversion in the short run. However, the short run cost on sawnwood exports and production is found to be severe. The loss in foreign exchange earnings increases the higher the export tax; however, some reductions in deforestation occur in the short run.

Constantino (1988) conducted some simulations to determine demand and supply projections for Indonesian forestry. He found that export restrictions on sawnwood and plywood lead to a loss in the world market share for Indonesia, lower foreign exchange earnings, employment and royalty revenues from timber concessions as well as forestland rent. However, the restrictions would lead to lower domestic prices that benefit Indonesian consumers and lower log consumption.

To summarise, the previous empirical literature on log export barriers in Indonesia suggest that, although the log export ban has been moderately successful in promoting the downstream processing sector, this was achieved at great economic costs in terms of loss in foreign exchange earnings. However, there is a conflict of opinion on the impact on log consumption.

Constantino's results are suggestive that there may exist some optimal trade policy for Indonesian processing industries. Provided that Indonesia has some market power in these industries, the government can strategically intervene with optimal taxes and/or subsidies to improve the country's welfare. In the next section, we examine the conditions for strategic trade policy to be effective.

5.3 Effectiveness of strategic trade policy in wood products market

Strategic trade policy can be effective if Indonesia has market power in the international market for log and plywood. The greater the availability of substitutes for Indonesian forest products, the less effective will be the strategic trade policy. Empirical findings show that the elasticities of substitution between temperate (generally coniferous wood) and tropical (generally non-coniferous) wood products are very low (Barbier et al., 1994; Constantino, 1988; and NEI, 1989). However, the substitution effect between products from different tropical regions is much higher. Moreover, there exists some anecdotal evidence that certain tropical timber products are substituted by non-wood products in end uses and final markets. For example, plywood is believed to be faced with competition from other non-wood materials used by the construction industry. However, the scale and the extent of this is uncertain.

The above suggests that unilateral export restrictions by Indonesia alone, in isolation of other tropical producers, may be ineffective. However, in the log market, dwindling supplies of tropical timber resources and widespread use of log export barriers among tropical producers impose some constraints on the availability of substitutes among tropical timber exports. For most commodities trade, it is extremely difficult for an exporter from a country without established presence to break into a new (import) market. Established market presence and reputation are key to trade, this is why bilateral trade patterns between countries tend to change slowly over time. In this way, it is useful to view each importing country as a separate market.[3] The major importer of logs and plywood from Southeast Asian producers is Japan.[4] Table 5.1 and 5.2 show the top five sources for the imports of non-coniferous roundwood and plywood imports into Japan. While Malaysia and Papua New Ginea account for 77% of all non-coniferous round wood imports in 1996; Indonesia and Malaysia account for 88% of all plywood imports into Japan in the same year. The Indonesian plywood marketing board is also rumoured to have coordinated its plywood export policy with the Malaysian Timber Industry Board (MTIB) prior to the Asian financial crisis in 1997. Nonetheless, without the policy coordination with the Malaysian government, it is possible that the market power of Indonesia is weakened by competition from Malaysian firms.[5]

Sedjo and Wiseman (1983) who analysed the impact of federal export restrictions in the United States found that log export restrictions were effective in raising

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[3]When two producers export to several markets and meet in more than one market, there is *multi-market contact.* This is found to facilitate collusion amongst producers. However, we do not examine this issue in our models (see Bernheim and Whinston (1990) for an analysis of this type of interaction).

[4]In 1996, Japan accounted for over 50% of Malaysian roundwood exports and almost 40% of Indonesian plywood exports.

[5]In 1996, the number of plywood/veneer mills in the whole of Malaysia is 166. However, the market concentration ratio and the proportion of firms that produce for exports statistics are not available.

Table 5.1: Top five sources for non-coniferous roundwood imports and their import shares (percentages) into Japan in 1996

Exporters[a]	%
Malaysia	51.60
Papua New Ginea	25.26
Gabon	4.97
Solomon Island	5.06
Russian Federation	6.72

[a] Indonesia is not listed amongst the top five sources of Japanese imports since prohibitive log export taxes were in place in 1996.

Table 5.2: Top five sources for plywood imports and their import shares (percentages) into Japan in 1996

Exporters	%
Indonesia	60.66
Malaysia	27.71
Canada	7.86
New Zealand	1.08
USA	0.72

export prices of highly-valued timber species but not low-valued species. Unfortunately, estimates of substitution elasticities for sawnwood and plywood found by Constantino (1988) do not differentiate between high and low quality wood products. Nonetheless, Sedjo and Wiseman's results suggest that the market power of Indonesia is likely to lie in the exports of timber species and processed products at the upper-end of the market. Therefore, this segment of the market is likely to benefit from strategic trade policy the most.

Although optimal trade policy analysis has been conducted for Malaysian log and processed products (see Vincent, 1989), as far as I know no analysis of this type has been conducted for Indonesia. In the next two chapters, we examine whether the trade policies on log and plywood sector subscribed by the Indonesian government coincide with the optimal trade policies implied by strategic trade theory. This framework sheds light on whether the Indonesian government is driven by the strategic trade motive. Our results provide fuller intuition about the impact of export restrictions, and complements some of the simulation results of previous models.

Before proceeding, I will briefly mention some shortcomings of our approach. Firstly, we will not explicitly consider trade policy retaliation by foreign exporters and importers in our analysis. Trade war if sparked off by strategic trade policy will have a detrimental impact on Indonesia. In general, the impact of strategic trade policy by Indonesia will be affected by other countries' policies. Although import tariffs on tropical forest products are low and declining, non-tariff barriers (mostly environmentally-related regulations) are likely to have more significant impact. Secondly, our analysis will focus on the effect of trade restrictions on producer surplus, thus abstracting from environmental benefits, consumer surplus, property rights, etc. Such factors must be taken into account for a more complete analysis.

Chapter 6

Can Indonesia gain from log export barriers?

6.1 Introduction

As mentioned in Chapter 5, towards the end of the 1970's, the Indonesian government began to impose log export barriers to encourage the growth of downstream wood industries, primarily the plywood industry. Since then many tropical timber countries have followed suit. Several economic studies on the impact of log export barriers in Indonesia between 1978 and 1989 suggest a substantial loss in government revenues through large implicit subsidies to the downstream processing industry and foregone revenues from log exports (see, for example, Gillis, 1988; Manurung and Buongiorno, 1997; and for a survey see Barbier et al., 1994). These findings, however, do not shed light on the question of optimal trade policy for the Indonesian forest sector on the whole. This Chapter uses strategic trade policy theory to examine this. Since vertical ownership structure (i.e. vertical separation and integration) affects the optimal trade policy outcome, its effect is also analysed. Chapter 6 is the first to model the connection between vertical ownership structure and optimal trade policy explicitly for the forest sector.

Given that the majority of forest products, e.g. log and plywood, is traded between a small group of countries, imperfect competition is the most appropriate analytical framework. Indonesia itself has been a key player in both markets at different times. For example, in 1978, its share of log exports amounted to 40% of the world market. Following a forest-based industrialisation drive, the Indonesian share of log exports dwindled. The drive propelled Indonesia to become the largest exporter of plywood with a market share of over 50% by 1992.

When a market is imperfectly competitive, such as in this case, Brander and Spencer (1985) show that a government of an exporting country can raise profits accrued to the domestic firms by imposing an export subsidy.[1] A complication arises, however, when exports are vertically related (e.g. exports from the forest sector may consist of logs, primary, and secondary processing). Here policy intervention in one market affects firm(s)' strategies in the related markets (e.g. through changing marginal costs and/or revenues); and optimal trade policy must take these cross-

[1]In effect, subsidy raises the home firm's exports to the level of Stackelberg leader's. Note that the welfare of home consumers should be taken into account also if they exist. However, in this chapter we assume that all final outputs are for exports. See Eaton and Grossman (1986) for the analysis of optimal trade policies under a range of market structures and conducts.

industry effects into account.

Although the optimal trade policy for a vertically integrated home firm has been analysed by Spencer and Jones (1991,92), their study assumed that the firm is a monopoly in one of the markets and their results were derived accordingly. This industrial structure is not appropriate for the forest sector, which is characterised by vertically related oligopolistic industries. Unlike Spencer and Jones' model, in our model the government has a role to play in both markets. Another difference between our analysis and Spencer and Jones' is that we do not take the vertical ownership structure for granted. Governments can and do try to influence the ownership structure across vertically related industries. The Indonesian government has in fact encouraged vertical integration between log and plywood industry.[2] Our analysis does examine the impact of vertical integration. Since a vertically integrated firm maximises the combined profits between the industries, this structure is expected to bring about an outcome that is closer to the planning optimum.

We adopt a simple sequential duopoly framework and assume that logs and plywood from different sources (home and foreign) are homogenous. Firms in the log and plywood markets compete in a Cournot fashion to determine the supply in each market. Similar to Greenhut and Ohta (1979), Salinger (1988) and Abiru et al. (1998), the log producers are assumed to move first followed by the final

[2]By restricting exports of logs and sawnwood, the Indonesian government has forced forest concessionaires to integrate forward into the plywood sector, since this was the only way to capture rent.

good producers. Thus we can solve the model in two stages. In second stage, plywood firms compete to determine the plywood supply, taking the price of logs as given; while in first stage, log suppliers compete taking into account the equilibrium relationship between output and price in the second stage. To determine the effect of integration, we solve for both an equilibrium with vertical separation and an equilibrium with vertical integration, and then compare the two.[3]

Given that the two exports are vertically related, there are cross-industry effects (that is, a rise in the export of one product alters the marginal profit accrued to the other product). When maximising the combined profits of the two exports, these cross-industry effects must be taken into account. We find three distortionary effects are at work pushing exports away from the planning optimum (or the maximum combined profits equilibrium). These are double marginalisation; commitment failure and cross-industry effects. The first distortion arises from the mark-up on the intermediate supply when firms are vertically separated. This in turn depresses the downstream exports. The second distortion arises from the Cournot conjecture of domestic firms, which does not properly reflect the competitors' behaviour. Subsequently they do not take advantage of the fact that competitors would accommodate if they behave aggressively in the market. The third distortion refers to the repercussion of export decisions across vertically related industries. We find that a rise in

[3]We are not concerned with anti-trust policy here but with how institutional structure affects optimal trade policy, welfare and production levels in Indonesia. Literature on vertically related industries generally focus on factors that affect industry competition, e.g. incentives for vertical foreclosure, impact of vertical integration on market prices etc.

plywood exports from the home country ultimately raises the terms of trade for log exports. The rise in home export causes the foreign plywood export to decline and thus the demand for log exports is reduced. As the log export supply contracts, the terms of trade for log rises. This positive externality on upstream profits implies that downstream exports should be raised. On the other hand, a rise in log exports from the home country ultimately reduce the terms on trade for plywood. With greater availability of log inputs, the foreign plywood supplier increases his exports and, thereby, reduces the international price of plywood. The negative externality from the upstream to the downstream sector would suggest that upstream exports should be reduced.

We find that the cross-industry effect is either not taken into account at all (by vertically separated firms); or is incorrectly taken into account (by the vertically integrated firm). The vertically separated firms maximise own profits in each sector rather than the joint profits and; therefore, do not take into account the cross-industry effects. Although integrated firm deliberately accommodates in the upstream market to counteract the negative cross-industry effect on its downstream profits, it over-compensates for the cross-industry effect. This is because it incorrectly anticipates the behaviour of the downstream rival.

While optimal trade policy is effective in realigning firms' incentives against the commitment failure and cross-industry effects, it is not effective against the double marginalisation problem. It follows that vertical integration is preferred when optimal trade policy is implementable since the double marginalisation problem is avoided.

We find that an export subsidy is always optimal in the downstream sector regardless of the ownership structure. However, the optimal trade policy for the upstream sector is ambiguous. An export subsidy is optimal under vertical integration, since the strategic effect ensures that the commitment failure effect always dominates. When industries are vertically separated on the other hand, an export subsidy on upstream exports is optimal when the commitment failure effect dominates. When the cross-industry effect dominates, however, an export tax is optimal.

When optimal trade policies are not implementable, we find that integration is the preferred structure when the cross-industry effect dominates or when the commitment failure effect is small in the upstream market.

Much quantitative work has been carried out to estimate the cost of tropical log export barriers, but few insights are gained from these studies about the role of strategic trade policy. The only existing analysis of log trade barriers under conditions of imperfect competition is Vincent (1989), who uses a numerical model to derive optimal trade policies for vertically related wood sectors in Malaysia. Nonetheless, the theoretical intuition that can be derived from his simulations is limited. Our model offers a full theoretical foundation for his findings.

The model presented in the next section is closest to the strategic trade policy model of Spencer and Jones (1991). We show that when both markets under consideration are duopolies (rather than a monopoly in one and a duopoly in another) a richer and different set of results from Spencer and Jones' emerge. That is, rather than always taxing and subsidising both exports, a policy to tax and subsidise the upstream and downstream sector simultaneously can makesense.

The rest of the chapter is organised as follows: Section 6.2 presents the model setup. The optimal outputs and trade policy under nonintegration are presented in Section 6.3; while those for the integrated case are presented in Section 6.4. Section 6.5 contrasts the implications of different ownership structures. Section 6.6 concludes and discusses policy implications.

6.2 Model

We consider two vertically related industries: log and plywood. Three countries are involved in the production and trade of these products, Indonesia, which is referred to as the home country (denoted by D), country A and country B. The home country has the facilities to produce both products; whereas country A produces plywood only and country B produces log only. Thus country A is representative of those countries that import tropical logs, and country B of those with tropical forest resources. It follows that a duopoly exists in both the upstream and the downstream market.

When deciding to sell an intermediate good and a final good, a firm needs to make conjectures about the effect of its action on both the intermediate and the final good producers. We assume that logs and plywood from different sources are homogenous, and that firms in each market engage in Cournot competition. The following assumptions are also made on firms' behaviour:

Assumption 1 When a firm sells an extra unit of intermediate good, it conjectures that the other intermediate good producer maintains its output constant (e.g. according to firm D, $\frac{dx^B}{dx^D} = 0$), and that the derived demand for the intermediate good (i.e. the final good production) responds to price changes (i.e. firm D assumes $\mu^A \frac{dy^A}{dx^D}\Big|_{x^B} = 1$).

Assumption 2 When a firm sells an extra unit of final good, it conjectures that the other final good producer does not change its output (e.g. according to firm D, $\frac{dy^A}{dy^D} = 0$) but that the supply of intermediate good is infinitely elastic (i.e. $\tilde{r}_Y = 0$, where $\tilde{r}$ is the equilibrium market price of log).

(Similar assumptions have been made by Greenhut and Ohta (1979), Salinger (1988), Abiru et al. (1998) and Gaudet et al. (1999) to solve for equilibrium with successive oligopolists. However, with the exception of Gaudet et al., all previous studies assume that integrated firms make more profits from downstream sales than from upstream sales and, therefore, participate in the downstream market only.)

We consider two institutional setups in the home country: (1) unintegrated intermediate and final good sectors; and (2) integrated intermediate and final good sectors (where the latter has been encouraged by the Indonesian government). With integration, the integrated firm maximises the joint profits of the upstream and the downstream sector, thus taking into account some of the cross-industry externalities created by the output decision in one market on the other.

Throughout our analysis, the price of intermediate good, r, is assumed to be greater than the cost of producing it, m^D. Constant-returns-to-scale production is also assumed in both sectors. It follows that the integrated firm sources all intermediate goods for the downstream operation internally,[4] and the unintegrated plywood producer in country A is the sole buyer of log exports from country B and D. When both downstream firms are unintegrated, they must source intermediate inputs from outside at the market price.

The relationship between the price of the intermediate good exports and the equilibrium output of the unintegrated plywood firms represents the market demand curve faced by intermediate good exporters. As discussed in Lewis, Lindsey and Ware (1986), this setup amounts to assuming a two-stage game, where the upstream producers move first, followed by the final good producers. In stage 2, plywood firms compete in a Cournot fashion to determine the plywood supplies, taking r as given. In stage 1, the export supply of the intermediate good is an outcome of the Cournot competition between the home firm and firm B in the logging industry, taking into account the equilibrium relationship between output and price in the second stage.

[4]Note that with more complex production structure, such as decreasing returns to scale in the intermediate good production, it may be optimal for the integrated firm to seek intermediate supplies from external sources.

The Cournot outcome in the intermediate good market in turn determines the price of logs observed in the second stage.

We characterise optimal trade policies under nonintegration and integration. The two types of trade policies considered in this chapter are: (i) a specific subsidy s on plywood exports and (ii) a specific tax t on log exports. The governments in country A and B are assumed not to use countervailing taxes. To understand the role of optimal trade policy, we contrast the action of the home firm(s) in each case with the planning optimum, i.e. the output mix that would be hypothetically chosen by a social planner, anticipating foreign producers' reactions, in order to maximise domestic welfare.

Assuming that the home country exports all its downstream outputs, the objective of the social planner is to choose the values of upstream output (denote by x^D) and downstream output (denote by y^D) to maximise the combined profits of the two exports. Given that the price of logs is greater than their marginal cost, the social planner will produce plywood using only the local log supplies. His objective function is thus

$$\max_{x^D, y^D} \; W = (p(Y) - c^D)y^D - m^D z^D + (r(X) - m^D)x^D, \tag{6.1}$$

where $p(Y)$ is the market price of plywood; $Y = y^D + y^A$, i.e. the total plywood supply from the home country and from country A (denote by y^A); m^D and c^D are the marginal cost of the home country's log and plywood production, respectively; and z^D denotes the total quantity of logs used in the home country's plywood production. As mentioned, $r(X)$ is the inverse demand for logs where X is the total log exports which is made up of the supply from the home country, x^D, and from country B, x^B.

Let μ^D and μ^A be the log conversion ratios per unit of plywood in the home country and country A, respectively. Since Country A has no intermediate good industry, it must import all of its intermediate inputs. In the equilibrium, the quantity of log supplies must be equal to the derived demand for logs in country D and A, i.e. $z^D = \mu^D y^D$ and $x^D + x^B(x^D) = \mu^A y^A(r, y^D)$, where $y^A(r, y^D)$ and $x^B(x^D)$ are the Cournot outputs of country A and B, respectively. Substituting these constraints into (6.1) gives

$$\max_{x^D, y^D} W = (p(Y) - c^D - \mu^D m^D)y^D + (\tilde{r}(X) - m^D)(\mu^A y^A(\tilde{r}, y^D) - x^B(x^D)), \tag{6.2}$$

where $\tilde{r}$ is the price of log export when the log market is in equilibrium.

When exports are positive in both markets, the interconnection between the upstream and the downstream market matters. A welfare maximising social planner will choose y^D to satisfy

$$\left.\frac{dW}{dy^D}\right|_{x^D} = \frac{dp}{dy^D}y^D + p - c^D - \mu^D m^D + \frac{d\tilde{r}}{dy^D}x^D = 0, \tag{6.3}$$

where

$$\begin{aligned} \frac{dp}{dy^D} &= p_Y\left(1 + \frac{dy^A}{dy^D}\right), \text{ in turn, } \frac{dy^A}{dy^D} = \frac{\partial y^A}{\partial y^D} + y^A_r \tilde{r}_{y^D}; \\ \frac{d\tilde{r}}{dy^D} &= \tilde{r}_{y^D}. \end{aligned}$$

The choice of x^D, in turn, is

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \frac{d\tilde{r}}{dx^D}x^D + \tilde{r} - m^D + \frac{dp}{dx^D}y^D = 0, \tag{6.4}$$

where

$$\begin{aligned}\frac{dp}{dx^D} &= p_Y y_r^A \frac{d\tilde{r}}{dx^D};\\ \frac{d\tilde{r}}{dx^D} &= \tilde{r}_X \left(1 + \frac{dx^B}{dx^D}\right).\end{aligned}$$

$\frac{d\tilde{r}}{dy^D}$ and $\frac{dp}{dx^D}$ in (6.3) and (6.4) represent the cross-industry effects from log and plywood exports respectively. As plywood exports from the home country increase, plywood exports from the foreign rival y^A decline resulting in a fall in the derived demand for log exports. As log export supply contracts, the terms of trade for log exports rises $\frac{d\tilde{r}}{dy^D} > 0$.

Conversely, increased log exports imply greater availability of log inputs to the foreign plywood producer at lower prices, in turn the foreign plywood export rises. The rise in the total plywood supply causes the price of plywood to fall, thus the cross-industry effect from the log market is represented by $\frac{dp}{dx^D} < 0$.

These cross-industry effects are characteristics of vertically related industries. Given that the downstream export creates positive externality and the upstream sector creates a negative externality, the planning optimum for vertically related exports will be larger than non-related exports in the downstream sector and smaller than non-related exports in the upstream sector.

The next two sections characterise firms' behaviour in a decentralised market outcome. Under each ownership structure, the equilibrium solution without trade policy is presented first, followed by analysis of optimal trade policies.

6.3 No vertical integration at home

When the upstream and downstream production unit at home are unintegrated, the downstream producer must purchase intermediate inputs at the market price. Potentially, there are two sources of intermediate inputs for the unintegrated downstream producer at home: local supplies and imports from country B. However, we will assume that the home processor uses local supplies of intermediate inputs only. This would be the case if log transport costs are sufficiently high. We will also assume that the log harvester at home differentiates between production for the local market and for exports, which has been the case in Indonesia. Thus different prices are charged for each destination. Possible justifications for such market segmentation are differences in quality requirements, differentiated health and safety regulations, etc. Let g and r be the intermediate input prices at home and in country A, respectively; and let π^{D2} be the profit of the unintegrated plywood firm at home.

Below, we characterise a subgame-perfect equilibrium of the above game, solving for an equilibrium in the second-stage game first.

6.3.1 Equilibrium in the plywood market

In stage two, the unintegrated home firm aims to maximise the plywood profit and thus solves the following problem:

$$\max_{y^D} \pi^{D2}(y^D)\Big|_{y^A,g} = (p(Y) + s - c^D - \mu^D g)y^D. \tag{6.5}$$

The plywood producer in country A, on the other hand, faces the following problem:

$$\max_{y^A} \pi^A(y^A)\Big|_{y^D,r} = (p(Y) - c^A - \mu^A r)y^A. \tag{6.6}$$

Each firm determines the quantity of plywood to produce by taking the other firm's output and input prices g and r as given. The first-order conditions (FOCs) for a Cournot-Nash equilibrium in the plywood market are

$$\frac{d\pi^{D2}}{dy^D}\Big|_{y^A} = \pi^{D2}_{y^D} = \frac{dp}{dy^D}\Big|_{y^A} y^D + p + s - c^D - \mu^D g = 0, \tag{6.7}$$

$$\frac{d\pi^A}{dy^A}\Big|_{y^D} = \pi^A_{y^A} = \frac{dp}{dy^A}\Big|_{y^D} y^A + p - c^A - \mu^D r = 0. \tag{6.8}$$

where $\frac{dp}{dy^D}\Big|_{y^A} = \frac{dp}{dy^A}\Big|_{y^D} = p_Y$.

From (6.7) and (6.8), the equilibrium plywood output levels can be expressed as implicit functions of the input prices and trade policy: r, g, and s, as follows

$$y^D_N = y^D(r, g, s); \quad y^A_N = y^A(r, g, s). \tag{6.9}$$

We shall assume that both profit functions display the necessary properties for an equilibrium (i.e. that each production function is continuous, strictly increasing and strictly quasiconcave on inputs), and let $|H| \equiv \pi^{D2}_{y^D y^D}\pi^A_{y^A y^A} - \pi^{D2}_{y^D y^A}\pi^A_{y^A y^D} > 0$.

By totally differentiating (6.7) and (6.8), we discern how the plywood outputs vary with export subsidy (see Appendix B.1 for derivations):

$$\frac{dy_N^D}{ds} = -\frac{\pi^A_{y^A y^A}}{H} > 0; \ \frac{dy_N^A}{ds} = \frac{\pi^A_{y^A y^D}}{H} < 0. \tag{6.10}$$

From (6.10), the industry output is increasing in the subsidy: $\frac{dY}{ds} = \frac{dy^D}{ds} + \frac{dy^A}{ds} = \frac{\pi^A_{y^A y^D} - \pi^A_{y^A y^A}}{H} > 0$.

Since a log export tax affects the output choices in the intermediate good sector, it is analysed in the next section.

6.3.2 Equilibrium in log markets

Turning now to intermediate good markets, the unintegrated harvester in the home country is assumed to supply intermediate inputs to both the home country and country A. Since logs supplied to these two markets are differentiated, the harvester faces two separate prices. Let π^{D1} be the profit of the unintegrated log harvester at home, and π^B be the profit of log harvester in country B. The harvesters solve the following problems:

$$\max_{x^D, z^D} \pi^{D1}\Big|_{x^B} = (g(Z) - m^D)z^D + (r(X) - t - m^D)x^D; \tag{6.11}$$

$$\max_{x^B} \pi^B\Big|_{x^D} = (r(X) - m^B)x^B; \tag{6.12}$$

where $Z = z^D$ and $X = x^D + x^B$ are the total market demand for logs at home and in country A, respectively. $r(X)$ is the derived demand for intermediate exports of country A obtained from (6.9), at the log market equilibrium $\mu^A y_N^A(r, g, s) =$

$x^D + x^B$. Similarly, $g(Z)$ is the derived demand for inputs of country D obtained from (6.9), using $\mu^D y_N^D(r, g, s) = z^D$.

By totally differentiating (6.7), (6.8) and the log market equilibrium in country A, we discern how the equilibrium price of log $\tilde{r}$ varies with the supply of logs. Let Ω^A represent country A's log market at the equilibrium, such that $\Omega^A \equiv \mu^A y_N^A(y_N^D, \tilde{r}) - X = 0$, where $X = x^1 + x^2 + x^B$. Assuming that the log market equilibrium is locally strictly stable, and let $|H_1| = -\pi^D_{y^D y^D}\pi^A_{y^A y^A} + \pi^D_{y^D y^A}\pi^A_{y^A y^D} < 0$, we find that an increase in the supply of log exports has a negative effect on the equilibrium log price as follows, $\frac{d\tilde{r}}{dX} < 0$ (see Appendix B.2 for the derivations).[5]

Similarly, the effect of changes in the supply of logs on the equilibrium price of log in country D, $\tilde{g}$, is found by totally differentiating (6.7), (6.8) and the log market equilibrium in country D. Let $\Omega^D \equiv \mu^D y_N^D(y_N^A, \tilde{g}) - Z = 0$, assuming that the domestic log market equilibrium is locally strictly stable, changes in the domestic log supply are found to have a negative effect on the domestic price of log, i.e. $\frac{d\tilde{g}}{dZ} < 0$ (see Appendix B.3 for the derivations).

When forming a supply decision, the unintegrated harvester in D takes into account $r(X)$ and $g(Z)$, i.e. the derived demand for logs in each market; and anticipates the downstream repercussion that results from changes in intermediate supplies to each market. The first-order condition for a profit maximising choice of

[5]Since log and plywood are strategic substitutes, the cross-industry effect implies that $\frac{d\tilde{r}}{dX} < \frac{\partial \tilde{r}}{\partial X}$.

z^D and x^D by the domestic harvester is thus

$$\begin{aligned}
\left.\frac{d\pi^{D1}}{dz^D}\right|_{x^B,x^D} &= \pi^{D1}_{z^D} + \pi^{D1}_{y^D}\frac{dy^D}{dz^D} + \pi^{D1}_{y^A}\frac{dy^A}{dz^D} \\
&= \left.\frac{d\tilde{g}}{dz^D}\right|_{x^D,x^B} z^D + g - m^D = 0; \qquad (6.13)\\
\left.\frac{d\pi^{D1}}{dx^D}\right|_{x^B,z^D} &= \pi^{D1}_{x^D} + \pi^{D1}_{y^D}\frac{dy^D}{dx^D} + \pi^{D1}_{y^A}\frac{dy^A}{dx^D} \\
&= \left.\frac{d\tilde{r}}{dx^D}\right|_{x^B z^D} x^D + r - t - m^D = 0, \qquad (6.14)
\end{aligned}$$

where $\frac{d\tilde{g}}{dz^D}\big|_{x^D,x^B} = \tilde{g}_Z$ and $\frac{d\tilde{r}}{dx^D}\big|_{x^B z^D} = \tilde{r}_X$.

Since $\pi^{D1}_{y^D} = 0$ from (6.7), the only strategic effect in (6.13) is $\pi^{D1}_{y^A}\frac{dy^A}{dz^D}$. However, without integration $\pi^{D1}_{y^A} = 0$, therefore, all the strategic terms drop out of (6.13) and (6.14).

On the other hand, firm B produces x^B so as to maximise its profit, given by

$$\pi^B = (r(X) - m^B)x^B, \qquad (6.15)$$

subject to the log market equilibrium condition.

At the log market equilibrium, the profit maximising choice of x^B satisfies:

$$\left.\frac{d\pi^B}{dx^B}\right|_{x^D,z^D} = \left.\frac{d\tilde{r}}{dx^B}\right|_{x^D z^D} x^B + r - m^B = 0, \qquad (6.16)$$

where $\frac{d\tilde{r}}{dx^B}\big|_{x^D,z^D} = \tilde{r}_X$.

(6.14) and (6.16) show that, despite the first mover advantage enjoyed by being upstream, the unintegrated firms are not able to use it to their benefit (since all strategic terms drop out).

From (6.13), (6.14) and (6.16), the Cournot equilibrium levels of log output can be defined as a function of the trade policy in the log market: $z_N^D(t), x_N^D(t)$, and $x_N^B(t)$.

The impact of an increase in log export tax on the equilibrium log export is found by totally differentiating (6.14) and (6.16). Let $|D^N| = \pi^{D1}_{x^D x^D}\pi^B_{x^B x^B} - \pi^{D1}_{x^D x^B}\pi^B_{x^B x^D} > 0$, the effect of export tax is reported below (see Appendix B.4 for the derivations).

$$\frac{dx_N^D}{dt} = \frac{\pi^{D1}_{x^B x^B}}{|D^N|} < 0; \text{ and } \frac{dx_N^B}{dt} = -\frac{\pi^B_{x^B x^D}}{|D^N|} > 0. \qquad (6.17)$$

Since $\frac{dX}{dt} = \frac{dx_N^D}{dt} + \frac{dx_N^B}{dt} < 0$, the total log supply to country A is decreasing in t.

6.3.3 Optimal export policy when industries are unintegrated

We next turn to examine the policy incentives in the home country. Welfare in the home country with unintegrated industries is

$$\begin{aligned} W^N(s,t,y_N^D(s),x_N^D(t)) &= \pi^{D1}(t,x_N^D(t)) + \pi^{D2}(s,y_N^D(s)) - sy_N^D(s) \\ &\quad + tx_N^D(t). \end{aligned} \qquad (6.18)$$

Assuming that the government does not suffer from the time inconsistency problem, the optimal trade policy is a combination of s and t that brings the country's exports closest to the planning optimum given by (6.3) and (6.4).

As pointed out by Brander and Spencer (1985), when a country engages in exports in one market, trade policy can bring about the planning optimum.

Moreover, the planning optimum coincides with the Stackelberg outcome. In effect, the optimal policy realigns the home firm's interest with the country's interest and changes the rival firms' conjectures about the home firm accordingly. However, the problem presented here differs from Brander and Spencer's since we are examining upstream-downstream duopolies. Therefore, strategic effects across markets must also be considered.[6] With two related but nonintegrated markets, trade policy has the additional task of correcting for externalities across industries.[7]

Proposition 1 *When upstream and downstream industries are not integrated, optimal trade policies fail to support the planning optimum.*

Proof: See Appendix B.6.

Before attempting to understand why trade policy fails to move exports to the planner's choice, let's first consider what trade policy has to overcome in order to reach the planning optimum. Equation (6.19) and (6.20) contrast the action of the nonintegrated suppliers under Cournot duopoly with the planning optimum. From (6.7), (6.13) and (6.14), at the Cournot equilibrium with $s = t = 0$, (6.3) and

[6] Although Spencer and Jones (1991,92) examine the optimal tax strategies in vertically related industries, they assume that the upstream firm is a monopoly and so arrive at a different policy conclusion.

[7] Bulow, Geanakoplos and Klemperer (1985) discuss different ways in which markets may be related, e.g. through cost or demand structures. The problem considered here is one in which products are related through demands. Whereby an increase in the supply to one market affects the marginal profit in the other market. Since $\pi^{D2}_{y^D x^D} < 0$ and $\pi^{D1}_{x^D y^D} < 0$, y^D and x^D are strategic substitutes in BGK's terminology.

(6.4) become

$$\left.\frac{dW}{dy^D}\right|_{x^D} = \mu^D(g - m^D) + p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D; \tag{6.19}$$

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D \tag{6.20}$$

where $\frac{dp}{dx^D} = p_Y y_r^A \frac{d\tilde{r}}{dx^D}$ and $\frac{d\tilde{r}}{dx^D} = \tilde{r}_X \left(1 + \frac{dx^B}{dx^D}\right)$.

The divergence from the planning choice of y^D stems from three distortions: (i) double marginalisation; (ii) commitment failure; (iii) cross-industry externality. The double marginalisation effect comes from the mark-up on intermediate supplies, which tends to depress the downstream exports (i.e. double marginalisation). The second component of (6.19) represents the commitment failure in the plywood market. That is, although the home plywood firm could increase its profits by being more aggressive in the plywood market (given that $\frac{dy^A}{dy^D} < 0$), Cournot conjectures prevent it from doing so. The last component of (6.19) is the cross-industry effect. As mentioned, the terms of trade of log exports rises as plywood exports increase. Failure to take this into account would depress plywood exports below the planning optimum. Thus all three effects call for a policy to raise plywood exports.

Turning to the choice of x^D, the Cournot log export choice suffers from similar effects, although the double marginalisation problem does not feature in this market. The first component of (6.20) represents the commitment failure in the log market which calls for a policy to increase log exports. The second component represents the cross-industry effect. As log exports rise, the market price of log declines, enabling foreign plywood producer to raise his exports. This in turn brings about a decline in the international price of plywood and, therefore, log exports should be curbed. Since the components in Condition (6.20) have opposing signs, whether log export should be curbed or promoted depends on the sign of the net effect.

6.3.4 Export taxes and subsidies under non-integration

The exporting country will set s and t to maximise welfare in (6.18). The optimisation problem is laid out in Appendix B.5. Note that when the value of export is zero in one industry, the optimal trade policy coincides with Brander and Spencer (1985)'s result.[8] When both exports are positive, the optimal export policy in the log and plywood market are as follows,

$$t^N = -\tilde{r}_X \left(\frac{dx^B}{dx^D}\right) x^D - \frac{dp}{dx^D} y^D; \tag{6.21}$$

$$s^N = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D. \tag{6.22}$$

As mentioned, in both industries, the divergence from the planning optimum comes from the commitment failure and the cross-industry effect. In turn, the optimal trade policies are determined by the nature of these effects. In comparing the optimal trade policies in (6.21) and (6.22) with the divergences stated in (6.20) and (6.19) respectively, we find that the optimal trade policies completely offset these two effects. However, the double marginalisation effect remains in the plywood market, so that plywood exports are below the planning optimum post-trade policy.

[8] See Condition (B.21) and (B.23) in Appendix B.5.

Proposition 2 sets out the optimal policy towards the plywood and log exports when firms are unintegrated.

Proposition 2 *When a country exports two vertically related products and the exporting industries are unintegrated, a subsidy is always optimal for downstream exports. However, the optimal trade policy for the upstream sector is ambiguous. If the commitment failure effect dominates, then a log export subsidy is optimal; but if the cross-industry effect dominates, then a log export tax is optimal.*

By substituting s^N and t^N into (6.7) and (6.14), respectively, we find that although the optimal trade policy brings about the planning optimum in the logging sector, it fails to eliminate the double marginalisation effect present in the plywood sector.

In the next section, we examine the implications of changes in the ownership structure of the domestic wood industry. Specifically, we analyse the optimal trade policy when home firms are vertically integrated. The two institutional structures - vertical separation and integration - are then compared in Section 6.5.

6.4 Vertical integration at home

In this section the upstream and downstream production unit at home are assumed to be integrated. As mentioned, this structure was promoted by the Indonesian government during the forest-based industrialisation drive. Again we solve for an equilibrium of the second-stage game first.

6.4.1 Equilibrium in the plywood market

The integrated home firm aims to maximise joint log and plywood profits. The assumption $r > m^D$ implies that the home plywood producer always uses his own log supplies in plywood production. Thus he solves the following problem:

$$\max_{y^D, x^D} \pi^D = (p(Y) + s - c^D - \mu^D m^D) y^D + (r(X) - t - m^D) x^D. \tag{6.23}$$

The maximisation problem of the unintegrated foreign plywood firm remains the same as (6.6). The first-order conditions stemming from Cournot-Nash competition in the plywood market are:

$$\left.\frac{d\pi^D}{dy^D}\right|_{y^A, x^D, x^B} = \pi^D_{y^D} = p_Y y^D + p + s - c^D - \mu^D m^D = 0; \tag{6.24}$$

$$\left.\frac{d\pi^D}{dy^A}\right|_{y^D, x^D, x^B} = \pi^A_{y^A} = p_Y y^A + p - c^A - \mu^A r = 0. \tag{6.25}$$

Since the cost of log input for the integrated home firm is less than the unintegrated home firm, i.e. $m^D < g$, the level of plywood production implied by (6.24) is greater than that in (6.7).

From (6.24) and (6.25), the equilibrium plywood outputs can be expressed as a function of r and s:

$$y^D_N = y^D(r, s); \quad y^A_N = y^A(r, s). \tag{6.26}$$

A subsidy shock affects the plywood equilibrium under vertical integration in the same way as under vertical separation, therefore,

$$\frac{dy^D_N}{ds} = \frac{-\pi^A_{y^A y^A}}{H} > 0; \; \frac{dy^A_N}{ds} = \frac{\pi^A_{y^A y^D}}{H} < 0; \tag{6.27}$$

where $H \equiv \pi^D_{y^D y^D}\pi^A_{y^A y^A} - \pi^D_{y^D y^A}\pi^A_{y^A y^D} > 0$.

6.4.2 Equilibrium in the log market

Again the log harvesters choose outputs to maximise profits, subject to the log market equilibrium in country A. Unlike in the previous section, the integrated home firm chooses x^D to maximise the joint profit from its upstream and downstream operations, thus chooses

$$\begin{aligned} \left.\frac{d\pi^D}{dx^D}\right|_{x^B} &= \pi^D_{x^D} + \pi^D_{y^D}\left.\frac{dy^D}{dx^D}\right|_{x^B} + \pi^D_{y^A}\left.\frac{dy^A}{dx^D}\right|_{x^B} \\ &= \tilde{r}_X x^D + r - t - m^D + p_Y\left.\frac{dy^A}{dx^D}\right|_{x^B} y^D = 0, \end{aligned} \tag{6.28}$$

where $\pi^D_{y^D} = 0$ from (6.24) and $\pi^D_{y^A}\left.\frac{dy^A}{dx^D}\right|_{x^B} = p_Y\left.\frac{dy^A}{dx^D}\right|_{x^B} y^D < 0$. The latter is a negative strategic term which is only present in the log export decision of an integrated firm. This leads to Lemma 1.

Lemma 1 *A vertically integrated firm will accommodate rivals in the intermediate good market more than an unintegrated firm.*

Proof: Since the strategic component in (6.28) is always negative, the rest of (6.28) must always be positive, i.e. $\pi^D_{x^D} \equiv MR - MC > 0$. *Q.E.D.*

Unlike the nonintegrated harvester, the integrated firm anticipates the loss in terms of trade incurred on the downstream exports as intermediate exports rise. Thus the integrated firm will be more accommodating in the upstream market.

Since firm B exports x^B to country A only, the profit maximising x^B is the same as (6.16) in the previous section. From (6.28) and (6.16), the Cournot log export choice become $x^D(t)$ and $x^B(t)$.

Again assuming that the second-order conditions for maximisation are satisfied, and let $|D^I| = (r_{XX}x^D + 2r_X + p_{XX})(r_{XX}x^B + 2r_X) - (r_{XX}x^D + r_X + p_{XX})(r_{XX}x^B + r_X) > 0$, the impact of an increase in log export tax on x^D and x^B are summarised below (see Appendix B.7 for the derivations):

$$\frac{dx^D}{dt} = \frac{r_{XX}x^B + 2r_X}{|D^I|} < 0; \quad \frac{dx^B}{dt} = \frac{-(r_{XX}x^B + r_X)}{|D^I|} > 0; \tag{6.29}$$

and the industry output decreases with log export tax, $\frac{dX}{dt} < 0$.[9]

6.4.3 Optimal export policy under vertical integration

The welfare in the home country with integrated industry is

$$W(s, t, y^D(s), x^D(s)) = \pi^D(s, t, y_N^D(s), x_N^D(t)) - sy_N^D(s) + tx_N^D(t). \tag{6.30}$$

As explained in Section 6.3.4, the optimal policy does not correct the double marginalisation problem. However, when $r > m^D$, the integrated firm sources all intermediate supplies internally and, therefore, by-passes the double marginalisation problem altogether.

Proposition 3 *Optimal trade policies under vertical integration achieve the planning optimum combination of log and plywood exports.*

[9] Since $0 < |D^N| < |D^I|$, log export decision of a vertically integrated firm is less responsive to the log export tax than the log export decision of a vertically separated firm, owing to the strategic effect.

Proof: See Appendix B.9.

Again, to understand the role of trade policy, we contrast the action of the integrated firm with the social planner's action stated in (6.3) and (6.4). In a Cournot equilibrium with $s = t = 0$, (6.3) and (6.4) become:

$$\left.\frac{dW}{dy^D}\right|_{x^D} = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D > 0; \tag{6.31}$$

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \tilde{r}_X \frac{dx^B}{dx^D} x^D + p_Y y^A_{\tilde{r}} \tilde{r}_{x^B} \frac{dx^B}{dx^D} y^D > 0. \tag{6.32}$$

With the exception of the double marginalisation effect which is absent under vertical integration, similar distortionary effects are at work in the plywood sector for the vertically integrated case and the vertically separated case. In (6.31), the commitment failure $p_Y \frac{dy^A}{dy^D} y^D > 0$ and the cross-industry effect $\tilde{r}_{y^D} x^D > 0$ depress plywood exports below the planning optimum.

In the upstream industry, two effects are at work: first the (direct) commitment failure effect due to the Cournot conjecture; the second effect is also caused by the Cournot conjecture but is fed through the strategic effect. As mentioned, the integrated firm strategically accommodates the rival firm in the log market. This action is desirable to the extent that the cross-industry effect is compensated for; however, the integrated firm compensates too much because it fails to accurately anticipate the action of the competitor in the log market. These *direct* and *indirect* commitment failures work to suppress log exports below the planning optimum for the integrated firm.

6.4.4 Export taxes and subsidies

Again the exporting country sets s and t to maximise welfare given in (6.30).

When both exports are positive, the optimal export subsidy and tax satisfy (B.32) and (B.33) in Appendix B.8. Rearranging gives

$$s^I = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D > 0; \tag{6.33}$$

$$t^I = -\tilde{r}_X \frac{dx^B}{dx^D} x^D - p_Y y^A_{\tilde{r}} \tilde{r}_{x^B} \frac{dx^B}{dx^D} y^D < 0. \tag{6.34}$$

Proposition 4 spells out the set of optimal trade policies.

Proposition 4 *When a country exports two vertically related products and the exporting industries are integrated, it is always optimal to subsidise both exports.*

Substituting s^I and t^I into (6.28) and (6.24), we find that the planning optimum is reached in both sectors. Thus the export subsidy in the log market completely eliminates the distortion stemming from *direct* and *indirect* commitment failures.

6.5 Comparing integrated and nonintegrated ownership structure on welfare

In this section, we examine the impact of changes in the domestic ownership structure on output and welfare. Table 6.1 sets out the extent to which Cournot first-order conditions under each ownership structure deviate from the planning optimum,

Table 6.1: The divergence between the planner's choice and the Cournot log and plywood first-order conditions under different ownership structures, with and without optimal trade policy

	Without optimal trade policy, $t = s = 0$	
	No integration	Integration
log	$\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D$	$\tilde{r}_X \frac{dx^B}{dx^D} x^D + p_Y y^A_{\tilde{r}} \tilde{r}_{x^B} \frac{dx^B}{dx^D} y^D > 0$
plywood	$\mu^D(g - m^D) + p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D$ > 0	$p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D > 0$ which implies: $x^I < \min\{x^N, x^*\}$[a] $y^N < y^I < y^*$
	With optimal trade policy	
	No integration	Integration
log	0	0
plywood	$\mu^D(g - m^D) > 0$	0 which implies: $x^* = x^I = x^N$ $y^N < y^I = y^*$

[a] $x^N < x^*$ when the commitment failure dominates, i.e. $\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D > 0$.
$x^* < x^N$ when the cross-industry effect dominates, i.e. $\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D < 0$.

with and without trade policy; while Table 6.2 sets out the preferred ownership structure when optimal trade policy is not available.

From Table 6.1, when optimal trade policy can be implemented, vertical integration is the preferred ownership structure since the double marginalisation effect (which is not corrected through optimal trade taxes) is avoided.

When trade policy is not implementable, however, vertical integration always

Table 6.2: Without optimal trade policy, which vertical structure yields exports closest to the planning optimum?

	Cross-industry effect dominates	Commitment failure dominates
log	$\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D < 0$ Integration - if the commitment failure is also small.	$\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D > 0$ Nonintegration - since the cross-industry effect counteracts some of the commitment failure effect.
plywood	$0 < p_Y \frac{dy^A}{dy^D} y^D$ and $0 < \tilde{r}_{y^D} x^D$ Integration - since the cross-industry effect and the commitment effect have the same sign in the plywood industry, so $y^N < y^I < y^*$.	

yields superior outcome in the plywood market. This is because all three distortionary effects in this market, namely the commitment failure; the cross-industry effect; and double marginalisation effect depress plywood exports. Given that vertical integration eliminates the effect of double marginalisation, it yields a superior outcome.

Turning to the log market, vertical integration is the preferred structure if the commitment failure effect is small or if the cross-industry effect is large. This is because vertically integrated firm already takes into account most of the negative cross-industry effect in its log export decision.

6.6 Conclusions

We have shown that when a country exports vertically related products, optimal export policy of each product depends on the vertical ownership structure and the net distortionary effect (that pushes exports away from the planning optimum). Three types of distortionary effects are identified: double marginalisation; commitment failure and cross-industry effects. The first is associated with the choice of ownership structure. Double marginalisation arises from the mark-up on intermediate supplies which is only present when the downstream firm sources intermediate inputs from outside (i.e. when it is vertically separated). The second or the commitment failure arises from the Cournot conjecture of domestic firms in each market, which does not correctly anticipate the competitor's behaviour. That is, although the home firm(s) in both markets can raise profits by being more aggressive since $\frac{dy^A}{dy^D} < 0$ and $\frac{dx^B}{dx^D} < 0$, they fail to recognise this and thus do not take advantage of it. The third effect or the cross-industry externality is characteristic of vertically-related industries. We have found that a rise in downstream exports raises the terms of trade of the upstream product; while a rise in upstream exports reduces the terms of trade of the downstream product. Specifically, as the downstream or plywood exports from the home country increase, the plywood exports from the foreign rival decline, resulting in a fall in the derived demand for log exports. At the log market equilibrium, the international price of log rises. Conversely, increased log exports imply greater availability of log inputs to the foreign plywood firm, in turn foreign plywood supply rises which causes the international price of plywood to fall.

The optimal trade policy is found to be effective in realigning firms' incentives against the commitment failure and cross-industry effects, but not against the double marginalisation problem. Therefore, when optimal trade policy is implementable, vertical integration is always preferred to vertical separation.

When home firms are vertically separated, a subsidy is always optimal in the downstream sector. However, the optimal trade policy in the upstream sector is ambiguous. An export subsidy is optimal when the commitment failure effect dominates; while an export tax is optimal when the cross-industry effect dominates.

When home firms are vertically integrated, a subsidy is optimal in the downstream sector. However, given that the integrated firm strategically accommodates in the log market to counteract the negative cross-industry effect, a subsidy on the upstream export is also optimal.

It follows that, when exports are vertically-related, the government should either subsidise both exports; or tax the upstream export and subsidise the downstream export.

Although the Indonesian log and plywood industry were vertically integrated between 1980 and 1998, trade policy during this period discriminated against log exports. Our results suggest that the optimal trade policy is a subsidy so the policy used diverged from the planning optimum.

In the analysis, we assumed that the government wants to maximise the total export surplus into the country. However, a host of other factors could distort government's objective away from the maximisation of aggregate producer surplus. In Indonesia, the close connection between plywood conglomerates and the government is likely to have had some bearing on the favourable trade policies towards the downstream group during this period. Vincent (1989), who performed optimal trade policy simulations for the Malaysian wood sectors, found that the optimal trade policy on log and the downstream exports involves large export taxes on both sectors (assuming other countries do not retaliate). In Malaysia, where wood sectors are vertically separated, our results suggest that the downstream exports should be subsidised and the upstream exports should be taxed if and only if the cross-industry effect dominates in this sector. The downstream trade policy result of Vincent is driven by his definition of government objective which is broader than ours. In Vincent's model, the government maximises the consumer surplus, on top of the producer surplus and tax revenues from trade. By taxing the downstream exports, the price for domestic consumers is lowered and larger consumer surplus is achieved. Thus the presence of consumer surplus provides a reason for the tax outcome in the downstream sector.

When government cannot implement optimal trade policies, vertical integration always brings about a downstream export outcome that is closer to the planning outcome. However, vertical integration will also bring about an upstream export outcome that is closer to the planning outcome if the commitment effect is small.

When the latter is not true, it is ambiguous which ownership structure yields the largest combined profits.

Since the Asian financial crisis in 1997, the IMF has stepped in with its economic reforms programme for Indonesia. Part of the programme requires the Indonesian government to phase out log export taxes within three years and to de-link restrictive arrangements between the logging and wood processing sector. Judging by our results of the static case, the elimination of export taxes on its own would move log industry closer to the planning optimum. However, when the upstream and the downstream sectors are de-linked, exports of the log industry would only move closer to the planning optimum if the commitment problem dominates. However, with log supply still in abundance relative to other countries, and with a vast amount of illegal logging in Indonesia, this is unlikely to be the case.

Throughout the analysis, we have focused on wood products trade and, therefore, the timber benefit of the forest. Thus, a plethora of environmental functions and other non-wood benefits of the forest has been omitted. A more complete analysis of trade policy for wood products should account for these other functions and benefits of the forest in the government's objective.

Appendix B

Appendix

B.1 The effect of a subsidy on plywood exports under vertical separation

The impact of a subsidy shock on the plywood equilibrium output under vertical separation is found by totally differentiating the FOCs in the plywood market in country D and A:

$$\pi^{D2}_{y^Dy^D} dy^D_N + \pi^{D2}_{y^Dy^A} dy^A_N + \pi^{D2}_{y^Ds} ds \quad = 0; \tag{B.1}$$

$$\pi^{A}_{y^Ay^D} dy^D_N + \pi^{A}_{y^Ay^D} dy^A_N + \pi^{A}_{y^As} ds \quad = 0; \tag{B.2}$$

Since $\pi^{D2}_{y^Ds} = 1$ and $\pi^{A}_{y^As} = 0$, these equations can be simplified to

$$\begin{pmatrix} \pi^D_{y^Dy^D} & \pi^D_{y^Dy^A} \\ \pi^A_{y^Ay^D} & \pi^D_{y^Ay^A} \end{pmatrix} \begin{pmatrix} dy^D_N \\ dy^A_N \end{pmatrix} = \begin{pmatrix} -1ds \\ 0 \end{pmatrix}. \tag{B.3}$$

The determinant of the matrix above is $|H| = (p_{YY}y^D + 2p_Y)(p_{YY}y^A + 2p_Y) - (p_{YY}y^D + p_Y)(p_{YY}y^A + p_Y) > 0$. Solving for $\frac{dy^D_N}{ds}$ and $\frac{dy^A_N}{ds}$ gives the effect of *subsidy* on the Nash equilibrium in the downstream market as follows

1. $\frac{dy^D_N}{ds} = \frac{-(p_{YY}y^A+2p_Y)}{|H|} > 0$;

2. $\frac{dy^A_N}{ds} = \frac{(p_{YY}+p_Y)}{|H|} < 0$.

B.2 How log export price changes as log and plywood exports increase

$\frac{d\tilde{r}}{dX}$ must satisfy the log market equilibrium in country A and the FOCs for y_N^D and y_N^A. Let $\Omega^A \equiv \mu^A y_N^A(y_N^D, \tilde{r}) - X = 0$, where $X = x^D + x^B$. Totally differentiating this and the FOC for plywood exports give,

$$\pi^D_{y^D y^D} dy_N^D + \pi^D_{y^D y^A} dy_N^A + \pi^D_{y^D X} dX + \pi^D_{y^D r} dr = 0; \tag{B.4}$$

$$\pi^A_{y^A y^D} dy_N^D + \pi^A_{y^A y^A} dy_N^A + \pi^A_{y^A X} dX + \pi^A_{y^A r} dr = 0; \tag{B.5}$$

$$\Omega^A_{y^D} dy_N^D + \Omega^A_{y^A} dy_N^A + \Omega^A_X dX + \Omega^A_r dr = 0. \tag{B.6}$$

Since $\pi^D_{y^D X} = \pi^A_{y^A X} = \pi^D_{y^D r} = 0, \pi^A_{y^A r} = \mu^A; \Omega^A_X = -1; \Omega^A_{y^A} = \mu^A; \Omega^A_{y^D} = \mu^A \partial y^A / \partial y^D$ and $\Omega^A_r = \mu^A y^A_r$, these equations can be simplified to

$$\begin{pmatrix} \pi^D_{y^D y^D} & \pi^D_{y^D y^A} & 0 \\ \pi^A_{y^A y^D} & \pi^A_{y^A y^A} & 0 \\ \mu^A \partial y^A / \partial y^D & \mu^A & -1 \end{pmatrix} \begin{pmatrix} dy_N^D \\ dy_N^A \\ dX \end{pmatrix} = \begin{pmatrix} 0 \\ \mu^A \\ -\mu^A y_r^A \end{pmatrix}. \tag{B.7}$$

Since we assume that the equilibrium is locally strictly stable, the determinant of the matrix above is negative, i.e. $|H_1| = -\pi^D_{y^D y^D}\pi^A_{y^A y^A} + \pi^A_{y^A y^D}\pi^D_{y^D y^A} < 0$. Solving for $\frac{dy_N^D}{dr}$, $\frac{dy_N^A}{dr}$ and $\frac{dX}{dr}$ give:

1. $\frac{dy_N^D}{d\tilde{r}} = \frac{\mu^A \pi^D_{y^D y^A}}{|H_1|} > 0$;

2. $\frac{dy_N^A}{d\tilde{r}} = \frac{-\mu^A \pi^D_{y^D y^D}}{|H_1|} < 0$;

3. $\frac{dX}{d\tilde{r}} = \frac{-\mu^A y_r^A [\pi^D_{y^D y^D}\pi^A_{y^A y^A} - \pi^A_{y^A y^D}\pi^D_{y^D y^A}] - \mu^A [\mu^A \pi^D_{y^D y^D} - \mu^A (\partial y^A / \partial y^D) \pi^D_{y^D y^A}]}{|H_1|} < 0.$

I.e. $\frac{d\tilde{r}}{dX} = \frac{|H_1|}{-\mu^A y_r^A [\pi^D_{y^D y^D}\pi^A_{y^A y^A} - \pi^A_{y^A y^D}\pi^D_{y^D y^A}] - \mu^A [\mu^A \pi^D_{y^D y^D} - \mu^A (\partial y^A / \partial y^D) \pi^D_{y^D y^A}]} < 0.$

B.3 How the price of logs in country D changes as domestic log supply increases

$\frac{d\tilde{g}}{dZ}$ must satisfy the log market equilibrium in country A and the FOCs for y_N^D and y_N^A. Let $\Omega^D \equiv \mu^D y_N^D(y_A^D, \tilde{g}) - Z = 0$, totally differentiating this and the FOC for plywood exports give,

$$\pi^D_{y^D y^D} dy^D_N + \pi^D_{y^D y^A} dy^A_N + \pi^D_{y^D Z} dZ + \pi^D_{y^D g} dg = 0; \tag{B.8}$$

$$\pi^A_{y^A y^D} dy^D_N + \pi^A_{y^A y^A} dy^A_N + \pi^A_{y^A Z} dZ + \pi^A_{y^A g} dg = 0; \tag{B.9}$$

$$\Omega^D_{y^D} dy^D_N + \Omega^D_{y^A} dy^A_N + \Omega^D_Z dZ + \Omega^D_g dg = 0. \tag{B.10}$$

Since $\pi^D_{y^D Z} = \pi^A_{y^A Z} = \pi^A_{y^A g} = 0, \pi^D_{y^D g} = \mu^D; \Omega^D_Z = -1; \Omega^D_{y^A} = \mu^D \partial y^A / \partial y^D; \Omega^D_{y^D} = \mu^D$ and $\Omega^D_g = \mu^D y^D_g$, these equations can be simplified to

$$\begin{pmatrix} \pi^D_{y^D y^D} & \pi^D_{y^D y^A} & 0 \\ \pi^A_{y^A y^D} & \pi^A_{y^A y^A} & 0 \\ \mu^D & \mu^D \partial y^D / \partial y^A & -1 \end{pmatrix} \begin{pmatrix} dy^D_N \\ dy^A_N \\ dZ \end{pmatrix} = \begin{pmatrix} \mu^D \\ 0 \\ -\mu^D y^D_g \end{pmatrix}. \tag{B.11}$$

Since we assume that the equilibrium is locally strictly stable, the determinant of the matrix above is negative, i.e. $|H_2| = -\pi^D_{y^D y^D}\pi^A_{y^A y^A} + \pi^A_{y^A y^D}\pi^D_{y^D y^A} < 0$, so $|H_2| = |H_1|$. Solving for $\frac{dy^D_N}{dg}$, $\frac{dy^A_N}{dg}$ and $\frac{dZ}{dg}$ give:

1. $\frac{dy^D_N}{d\bar{g}} = \frac{-\mu^D \pi^A_{y^A y^A}}{|H_2|} < 0;$

2. $\frac{dy^A_N}{d\bar{g}} = \frac{\mu^D \pi^A_{y^A y^D}}{|H_2|} > 0;$

3. $\frac{dZ}{d\bar{g}} = \frac{-\mu^D y^D_g [\pi^D_{y^D y^D}\pi^A_{y^A y^A} - \pi^A_{y^A y^D}\pi^D_{y^D y^A}] - \mu^D [\mu^D \pi^A_{y^A y^A} - \mu^D (\partial y^D / \partial y^A) \pi^A_{y^A y^D}]}{|H_2|} < 0.$

I.e. $\frac{d\bar{g}}{dZ} = \frac{|H_2|}{-\mu^D y^D_g [\pi^D_{y^D y^D}\pi^A_{y^A y^A} - \pi^A_{y^A y^D}\pi^D_{y^D y^A}] - \mu^D [\mu^D \pi^A_{y^A y^A} - \mu^D (\partial y^D / \partial y^A) \pi^A_{y^A y^D}]} < 0.$

B.4 Effect of trade policy on log exports under vertical separation

The impact of a tax shock on log exports under vertical separation is found by totally differentiating the FOCs in the log market in country A:

$$\pi^{D1}_{x^D x^D} dx^D_N + \pi^{D1}_{x^D x^B} dx^B_N + \pi^{D1}_{x^D t} dt = 0; \tag{B.12}$$

$$\pi^B_{x^B x^D} dx^D_N + \pi^B_{x^B x^B} dx^B_N + \pi^B_{x^B t} dt = 0. \tag{B.13}$$

Since $\pi^{D1}_{x^D t} = -1$ and $\pi^B_{x^B t} = 0$, these equations can be simplified to

$$\begin{pmatrix} \pi^{D1}_{x^D x^D} & \pi^{D1}_{x^D x^B} \\ \pi^B_{x^B x^D} & \pi^B_{x^B x^B} \end{pmatrix} \begin{pmatrix} dx^D_N \\ dx^B_N \end{pmatrix} = \begin{pmatrix} dt \\ 0 \end{pmatrix}. \tag{B.14}$$

The determinant of the matrix above is $|D^N| = (r_{XX}x^D + 2r_X)(r_{XX}x^B + 2r_X) - (r_{XX}x^D + r_X)(r_{XX}x^B + r_X) > 0$, implying that the equilibrium is locally strictly stable. Solving for $\frac{dx_N^D}{dt}$ and $\frac{dx_N^B}{dt}$ gives the effect of tax as follows:

1. $\frac{dx_N^D}{dt} = \frac{r_{XX}x^B+2r_X}{|D^N|} < 0$;

2. $\frac{dx_N^B}{dt} = \frac{-(r_{XX}x^B+r_X)}{|D^N|} > 0$.

B.5 Optimal export policy when the home industries are unintegrated

The home government sets s and t to maximise W subject to the constraint $y_N^D \geq 0$ and $x_N^D \geq 0$. Let $L^N = W^N(s,t) + \lambda_1^N y_N^D + \lambda_2^N x_N^D$, where $\lambda_1^N, \lambda_2^N \geq 0$ are Lagrange multipliers. At the maximum, s and t satisfy the following FOCs

$$\begin{aligned} L_s^N &= \frac{dW^N}{ds} + \lambda_1^N \frac{dy_N^D}{ds} = 0; \\ L_t^N &= \frac{dW^N}{dt} + \lambda_2^N \frac{dx_N^D}{dt} = 0; \\ L_{\lambda_1^N}^N &= y_N^D \geq 0 \text{ where } \lambda_1^N y_N^D = 0; \\ L_{\lambda_2^N}^N &= x_N^D \geq 0 \text{ where } \lambda_2^N x_N^D = 0. \end{aligned} \tag{B.15}$$

When $y_N^D > 0$, $\lambda_1^N = 0$, and $L_s^N = \frac{dW^N}{ds}$. Similarly when $x_N^D > 0$, $\lambda_2^N = 0$, and $L_t^N = \frac{dW^N}{dt}$. Assuming that the SOCs $\frac{d^2W^N}{ds\partial s} < 0$, $\frac{d^2W^N}{dt\partial t} < 0$ and $\frac{d^2W^N}{ds\partial s}\frac{d^2W^N}{dt\partial t} - (\frac{d^2W^N}{ds\partial t}\frac{d^2W^N}{dt\partial s}) > 0$ are satisfied, the optimal values of s and t are represented by

$$\begin{aligned} \left.\frac{dW^N(s,t)}{ds}\right|_t &= \pi_s^{DC} + \pi_{y^D}^{DC}\frac{dy_N^D}{ds} - y^D - s\frac{dy_N^D}{ds} \\ &= y^D + p_Y\left(1 + \frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D \frac{dy_N^D}{ds} + (p + s - c^D - \mu^D g)\frac{dy_N^D}{ds} \\ &\quad + \tilde{r}_{y^D} x^D \frac{dy_N^D}{ds} - s\frac{dy_N^D}{ds} - y^D = 0; \end{aligned} \tag{B.16}$$

$$\begin{aligned} \left.\frac{dW^N(s,t)}{dt}\right|_s &= \pi_t^{DC} + \pi_{x^D}^{DC}\frac{dx_N^D}{dt} + x^D + t\frac{dx_N^D}{dt} \\ &= -x^D + \tilde{r}_X\left(1 + \frac{dx^B}{dx^D}\right) x^D \frac{dx_N^D}{dt} + (\tilde{r} - t - m^D)\frac{dx_N^D}{dt} \\ &\quad + p_Y y_r^A \tilde{r}_X\left(1 + \frac{dx^D}{dx^B}\frac{dx^B}{dx^D}\right) y^D \frac{dx_N^D}{dt} + t\frac{dx_N^D}{dt} + x^D = 0, \end{aligned} \tag{B.17}$$

where $\pi^{DC} = \pi^{D1} + \pi^{D2}$.

When $x_N^D > 0$ and $y_N^D > 0$, the FOCs for profit maximisation (6.7) and (6.14) hold so that (B.16) and (B.17) simplify to

$$\begin{aligned} \frac{dW^N}{ds} &= p_Y\left(\frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D \frac{dy_N^D}{ds} + \tilde{r}_{y^D} x^D \frac{dy_N^D}{ds} - s\frac{dy_N^D}{ds} = 0; && \text{(B.18)} \\ \frac{dW^N}{dt} &= t\frac{dx^D}{dt} + \tilde{r}_X \frac{dx^B}{dx^D} x^D \frac{dx_N^D}{dt} + p_Y y_r^A \tilde{r}_X \left(1 + \frac{dx^B}{dx^D}\right) y^D \frac{dx_N^D}{dt} = 0, && \text{(B.19)} \end{aligned}$$

which are (6.22) and (6.21) of the text, respectively.

When $x^D = 0$, $L_s^N = \frac{dW^N}{ds}$. Using (6.7), $\frac{dW^N}{ds}$ simplifies to

$$\frac{dW^N}{ds} = p_Y\left(\frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D \frac{dy_N^D}{ds} - s\frac{dy_N^D}{ds} = 0. \tag{B.20}$$

Rearranging in terms of s gives

$$s^N = p_Y\left(\frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D > 0. \tag{B.21}$$

When $y^D = 0$, $L_t^N = \frac{dW^N}{dt}$. Using (6.14), $\frac{dW^N}{dt}$ simplifies to

$$\frac{dW^N}{dt} = t\frac{dx_N^D}{dt} + \tilde{r}_X \frac{dx^B}{dx^D} x^D \frac{dx_N^D}{dt} = 0. \tag{B.22}$$

Rearranging in terms of t gives

$$t^N = -\tilde{r}_X \frac{dx^B}{dx^D} x^D < 0. \tag{B.23}$$

B.6 Proof of Proposition 1

Substituting (6.21) and (6.22) into (6.7) and (6.14), Equation (6.28) and (6.24) become

$$\begin{aligned} \frac{d\pi^{D1}}{dx^D} &= \left.\frac{dW}{dx^D}\right|_{y^D} = 0; && \text{(B.24)} \\ \frac{d\pi^{D2}}{dy^D} &= \left.\frac{dW}{dy^D}\right|_{x^D} - (g - m^D)\mu^D = 0. && \text{(B.25)} \end{aligned}$$

From (B.25) and (B.24), the optimal trade policy adjusts log exports but fails to adjust plywood exports to coincide with the planning optimum. Specifically the policy fails to correct the distortion arising from double marginalisation, which dampens the exports of the downstream products. *Q.E.D.*

B.7 Effect of trade policies on log exports under integration at home

The impact of a tax on log exports under vertical integration is found by totally differentiating the FOCs in the log market in country A:

$$\frac{d^2\pi^D}{dx^D\partial x^D}dx_N^D + \frac{d^2\pi^D}{dx^D\partial x^B}dx_N^B + \frac{d^2\pi^D}{dx^D\partial t}dt = 0; \quad \text{(B.26)}$$

$$\frac{d^2\pi^B}{dx^B\partial x^D}dx_N^D + \frac{d^2\pi^B}{dx^B\partial x^B}dx^B + \frac{d^2\pi^B}{dx^B\partial t}dt = 0. \quad \text{(B.27)}$$

Since $\frac{d^2\pi^{D1}}{dx^D\partial t} = -1$ and $\frac{d^2\pi^B}{dx^B\partial t} = 0$, these equations can be simplified to

$$\begin{pmatrix} \frac{d^2\pi^D}{dx^D\partial x^D} & \frac{d^2\pi^D}{dx^D\partial x^B} \\ \frac{d^2\pi^B}{dx^B\partial x^D} & \frac{d^2\pi^B}{dx^B\partial x^B} \end{pmatrix} \begin{pmatrix} dx_N^D \\ dx_N^B \end{pmatrix} = \begin{pmatrix} dt \\ 0 \end{pmatrix}. \quad \text{(B.28)}$$

The determinant of the matrix above is $|D^I| = (r_{XX}x^D + 2r_X + p_{XX})(r_{XX}x^B + 2r_X) - (r_{XX}x^D + r_X + p_{XX})(r_{XX}x^B + r_X) > 0$, implying that the equilibrium is locally strictly stable. Given that the integrated firm takes into account cross-industry effects (evident in the FOC), this also feeds into the SOC. In turn, the determinant of the matrix for an integrated home firm is larger than the determinant of the matrix for unintegrated firm, i.e. $|D^I| > |D^N|$. Solving for $\frac{dx_N^D}{dt}$ and $\frac{dx_N^B}{dt}$ gives the effect of tax as follows:

1. $\frac{dx_N^D}{dt} = \frac{r_{XX}x^B + 2r_X}{|D^I|} < 0$;
2. $\frac{dx_N^B}{dt} = \frac{-(r_{XX}x^B + r_X)}{|D^I|} > 0$.

As mentioned, $|D^I| > |D^N|$ and thus the effect of log export tax is smaller under vertical integration than under vertical separation.

B.8 Optimal policy for the home country when the domestic industries are integrated

The home government sets s and t to maximise (6.30) subject to the constraint $y_N^D \geq 0$ and $x_N^D \geq 0$. Let $L^I = W^I(s,t) + \lambda_1^I y_N^D(s) + \lambda_2^I x_N^D(t)$ where $\lambda_1^I, \lambda_2^I \geq 0$ are Lagrange multipliers. At the maximum, s and t satisfy the following FOCs:

$$\begin{aligned}
L_s^I &= \frac{dW^I}{ds} + \lambda_1^I \frac{dy_N^D}{ds} = 0; \\
L_t^I &= \frac{dW^I}{dt} + \lambda_2^I \frac{dx_N^D}{dt} = 0; \\
L_{\lambda_1^I}^I &= y_N^D \geq 0 \text{ where } \lambda_1^I y_N^D = 0; \\
L_{\lambda_2^I}^I &= x_N^D \geq 0 \text{ where } \lambda_2^I x_N^D = 0.
\end{aligned} \tag{B.29}$$

When $y_N^D > 0$, the Kuhn-Tucker condition requires that $\lambda_1^I = 0$ and, therefore, $L_s^I = \frac{dW^I}{ds}$. Similarly when $x_N^D > 0$, it must be that $\lambda_2^I = 0$ and so $L_t^I = \frac{dW^I}{dt}$. Assuming that SOCs, $\frac{d^2W^I}{ds\partial s} < 0, \frac{d^2W^I}{dt\partial t} < 0$ and $\frac{d^2W^I}{ds\partial s}\frac{d^2W^I}{dt\partial t} - (\frac{d^2W^I}{ds\partial t}\frac{d^2W^I}{dt\partial s}) > 0$ are satisfied, from (B.29), the optimal values of s and t are represented by

$$\begin{aligned}
\left.\frac{dW^I(s,t)}{ds}\right|_t &= \pi_s^D + \pi_{y^D}^D \frac{dy_N^D}{ds} - y^D - s\frac{dy_N^D}{ds} \\
&= y^D + p_Y \left(1 + \frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D \frac{dy_N^D}{ds} + (p + s - c^D - \mu^D m^D)\frac{dy_N^D}{ds} \\
&\quad + \tilde{r}_{y^D} x^D \frac{dy_N^D}{ds} - s\frac{dy_N^D}{ds} - y^D = 0.
\end{aligned} \tag{B.30}$$

$$\begin{aligned}
\left.\frac{dW^I(s,t)}{dt}\right|_s &= \pi_t^D + \pi_{x^D}^D \frac{dx_N^D}{dt} + x^D + t\frac{dx_N^D}{dt} \\
&= -x^D + \tilde{r}_X \left(1 + \frac{dx^B}{dx^D}\right) x^D \frac{dx_N^D}{dt} + (\tilde{r} - t - m^D)\frac{dx_N^D}{dt} \\
&\quad + p_Y y_r^A \tilde{r}_X \left(1 + \frac{dx^B}{dx^D}\right) \overline{y}^D \frac{dx_N^D}{dt} + t\frac{dx_N^D}{dt} + x^D \\
&= 0.
\end{aligned} \tag{B.31}$$

When $x_N^D > 0$ and $y_N^D > 0$, the FOCs for profit maximisation (6.24) and (6.28) hold so that (B.30) and (B.31) simplify to

$$\frac{dW^I}{ds} = -s\frac{dy_N^D}{ds} + p_Y \left(\frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D \frac{dy_N^D}{ds} + \tilde{r}_{y^D} x^D \frac{dy_N^D}{ds} = 0; \tag{B.32}$$

$$\frac{dW^I}{dt} = t\frac{dx_N^D}{dt} + \tilde{r}_X \left(\frac{dx^B}{dx^D}\right) x^D \frac{dx_N^D}{dt} + p_Y y_r^A \frac{dx^B}{dx^D} y^D \frac{dx_N^D}{dt} = 0. \tag{B.33}$$

which are (6.34) and (6.33) of the text, respectively.

When $x_N^D = 0$, $L_s^I = \frac{dW^I}{ds}$. $\frac{dW^I}{ds}$ simplifies to

$$\frac{dW^I}{ds} = -s\frac{dy_N^D}{ds} + p_Y \left(\frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}\right) y^D \frac{dy_N^D}{ds} = 0. \tag{B.34}$$

Rearranging in terms of s gives

$$s^I = p_Y \left(\frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D} \right) y^D > 0. \tag{B.35}$$

When $y_N^D = 0$, $L_t^I = \frac{dW^I}{dt}$. Using (6.14), $\frac{dW^I}{dt}$ simplifies to

$$\frac{dW^I}{dt} = t\frac{dx_N^D}{dt} + \tilde{r}_X \left(\frac{dx^B}{dx^D} \right) x^D \frac{dx_N^D}{dt} = 0. \tag{B.36}$$

Rearranging in terms of t gives

$$t^I = -\tilde{r}_X \frac{dx^B}{dx^D} x^D < 0. \tag{B.37}$$

B.9 Proof of Proposition 3

Substituting optimal trade policies in (6.34) and (6.33) into (6.24) and (6.28), respectively, give

$$\frac{d\pi^D}{dy^D} = \left. \frac{dW}{dy^D} \right|_{y^D} = 0; \tag{B.38}$$

$$\frac{d\pi^D}{dx^D} = \left. \frac{dW}{dx^D} \right|_{x^D} = 0. \tag{B.39}$$

Thus optimal trade policy brings about the planning optimum in the both markets.

Q.E.D.

Chapter 7

Disentangling the effect of quantitative restrictions in the Indonesian log and plywood sectors

7.1 Introduction

In the 1970's, the government of Indonesia began to embark on a "forest-based industrialisation" programme. Initial policy interventions included export taxes on logs. However, over the next two decades, the policy measures became much more draconian. The export taxes were escalated and were eventually replaced by a ban in 1984. Restrictions on log exports forced timber concessionaires to integrate forward into the downstream sectors. In addition to banning the log exports, the government imposed export quotas on plywood to reduce competition among domestic firms.

Table 7.1: Trade policy scenarios

	Plywood export quotas	No plywood export quotas
Log export ban	Scenario A	Scenario C
No log export ban	Scenario B	Scenario D/Scenario E*

* Vertical separation assumed.

The plywood association, APKINDO, was given the task of managing these quotas and overseeing various marketing arrangements for Indonesian plywood exports. In effect, the export quotas enabled Indonesian plywood producers to behave like a cartel. After the Asian financial crisis in 1997, both policies were abandoned to comply with IMF-World Bank conditionalities in return for their financial support. The reform programme put forward by these institutions consisted of measures to liberalise the forest sector with efficiency as a primary objective.

In this chapter, we extend the theoretical framework developed in Chapter 6 to analyse the impact of quantitative restrictions on Indonesian welfare. The two quantity-based trade policies analysed are: a log export ban[1] and plywood export quotas. We examine five policy scenarios as shown in Table 7.1. All scenarios assume vertical integration in the home industries with the exception of Scenario E.

Before the Asian financial crisis, quantitative restrictions were in place in both industries (Scenario A). Thereafter, IMF-World Bank conditionalities led to

[1]Although log export ban was replaced by a prohibitive tax in 1992, the effect of the latter is precisely the same as the export ban.

the liberalisation of both industries with some effort to de-link timber concessionaires from the downstream processors. We will analyse the impact of export liberalisation when vertical integration is left intact (Scenario D); and when industries are de-linked (Scenario E). By the last quarter of 2001, due to worsening rate of deforestation, Indonesia reinstated log export ban under the endorsement of the International Tropical Timber Organisation which led to policy Scenario C. To understand the impact of plywood export quotas, we will also analyse the situation when plywood quotas are operated without the log export ban (Scenario B).

We will examine the changes in Indonesian exports and producer surplus that arise from different policy combinations (from Scenario A to E); as well as the extent of divergence between firms' and the planning optimum. In addition, we will examine incentives for the home country government to use specific taxes and/or specific subsidies on exports instead of quantitative restrictions. In this way, the impact of quantitative restrictions and of export taxes and subsidies can be compared.

As shown in Chapter 6, when the home country is an exporter of two vertically related products, there are cross-industry effects that must be taken into account when maximising the combined industry profits. Therefore, the choice of exports of the home firms will diverge from the planning optimum if these cross-industry effects are neglected. We have also shown in Chapter 6 that commitment failure stemming from the Cournot conjectures may also be another reason for the divergence between home firms' choice of exports and the planning optimum. In addition to the distortions already described, with more than one home exporter per industry, there is a pro-competitive effect which distorts firms' exports from the planning optimum. While the commitment failure effect tends to depress both exports below the planning optimum; the pro-competitive effect tends to raise both exports; and the cross-industry effect tends to raise plywood exports, while lowering the log exports below the planning optimum.[2]

Without trade policy intervention (i.e. complete liberalisation of exports), the commitment failure, cross-industry effect and the pro-competitive effect distort log and plywood away from the planning optimum. As mentioned, these three effects act in opposing directions; therefore, they tend to offset each other. Only when they completely offset each other would the planning optimum be reached. Trade policy combinations considered help to correct some of these distortions but non of them eliminate all distortions. In this way, trade policies if implemented may move exports further away from the planning optimum.

Prior to the reform programme, plywood export quotas and log export ban were in place. When set optimally, plywood quotas can help to reduce competition among home plywood producers; internalise the cross-industry effect; and commit

[2]Intuitively exports of log have a negative effect on plywood profits at the margin since greater log exports imply more inputs to the foreign plywood producer. This in turn raises the total plywood supply which causes the terms of trade of plywood to fall. Increased exports of plywood, on the other hand, bring about a reduction of foreign plywood exports. At the log market equilibrium, the terms of trade of log export rises.

home firms to higher plywood outputs than those implied by the Cournot conjectures. A log export ban, on the other hand, is always inoptimal, unless the marginal loss from log export is greater than the marginal revenue for all positive values of log exports. However, empirical evidence by Gillis (1988), Barbier (1995) and Manurung and Buongiorno (1997) show that this is not the case. We show that when the marginal profit of log is positive at some positive value of log exports, a log export ban always results in plywood exports that are larger than the planning optimum.

Under complete export liberalisation, vertically integrated home firms will behave strategically, unlike nonintegrated firms. Two strategic effects are found: strategic accommodation and strategic pre-emption, where the latter is only present when there is more than one home firm exporting in each market. Since a vertically integrated firm maximises joint profits across industries, it will anticipate any negative impact on plywood profits stemming from its log export decision. It will strategically reduce log exports in order to lessen the negative cross-industry effect on plywood profits. Secondly, a vertically integrated firm has an incentive to raise log exports in order to reduce the market share or strategically pre-empt exports of the downstream rival at home. These strategic effects are found to offset some of the divergences that come with export liberalisation. Thus the choice of log and plywood exports depends to some extent on these strategic effects.

Our analysis of specific export taxes and subsidies on the two sectors shows that optimal taxes and subsidies correct some but not all three distortions mentioned. Specifically, they fail to correct the pro-competitive and the double marginalisation effect. Thus when implemented, optimal tax and/or subsidy bring about log exports that are larger than the planning optimum. The effect on plywood exports is ambiguous, since the pro-competitive effect and the double marginalisation effect work in opposite directions.

Similarly to Chapter 6, a model of vertically-linked (Cournot) oligopolies is used. We proceed with the basic model in which the planner's objective function is specified in Section 7.2. Thereafter, the five trade policy scenarios are examined in turn from Section 7.3 to 7.7. The welfare effects are analysed under each policy scenario. For scenarios D and E, we analyse incentives for the home government to use specific export taxes and subsidies. The results are summarised in Section 7.8, together with conclusions and a brief discussion of policy implications.

7.2 Model

Similarly to Chapter 6, three countries are involved in trade of two vertically related products: logs and plywood. The home country engages in exports of both goods, while country A exports the downstream product only, and country B exports the upstream product only. We assume that only one producer is present in country A and in country B, thus the terms country and firm are used interchangeably in these countries. As before, the home country, country A and country B represent Indonesia, its competitors in the downstream market, and its competitors in the upstream market respectively. The model presented in this chapter differs from Chapter 6 in that there are two home firms (denoted by 1 and 2). This structure allows us to analyse the impact of the plywood export quota system which was set up in Indonesia in the mid-1980's.

Given that the majority of plywood production in Indonesia between the 1980's and 1990's are destined for exports, we assume that all production is for export.[3] Similarly to Chapter 6, the objective of a social planner[4] is to choose the upstream and downstream export volumes to maximise the combined profits of the two industries. Continuing with the same notations from Chapter 6, let x^D denote the total upstream export and y^D denote the total downstream export from the home country. The export of each sector is made up of outputs from firm 1 and firm 2, denoting these by x^1, x^2 and y^1, y^2. Log and plywood exports from different sources are assumed to be homogenous. Denote the export of country A and country

[3]Exports accounted for approximately 80% of all plywood production in Indonesia during the 1980's.

[4]A social planner is assumed to be able to select policy variables (whether quotas, bans or taxes and subsidies) before firms make output decisions. In this way, we abstract from the time inconsistency problem and the planner behaves like a Stackelberg leader in a quantity competition.

B by y^A and x^B respectively. The social planner's problem is

$$\begin{aligned}
\max_{x^D=x^1+x^2, y^D=y^1+y^2} W &= \pi^1(x^1,y^1)+\pi^2(x^2,y^2) \\
&= (p(Y)-c^D)(y^1+y^2)+r(X)(x^1+x^2)-M^D(z^1+x^1) \\
&\quad -M^D(z^2+x^2) \\
&= (p(Y)-c^D)y^D+r(X)x^D-M^D(z^1+x^1) \\
&\quad -M^D(z^2+x^2). \qquad (7.1)
\end{aligned}$$

Subject to

$$\mu^A y^A(r,y^D) = x^1+x^2+x^B, \qquad (7.2)$$

where $p(Y)$ is the market price of plywood; $Y = y^1+y^2+y^A$ is the total plywood export; $r(X)$ is the international price of log; $X = x^1+x^2+x^B$ is the total log export; c^D is the constant marginal cost of the plywood firm, and $M^D(\cdot)$ is the total cost of log production at home which is a function of log output; $z^D = \mu^D y^D$ is the total log input into the downstream sector, where μ^D is the log-plywood conversion ratio.

Unlike the previous chapter, we assume decreasing returns to scale log production. This is done to avoid the unintuitive result found in standard Cournot models with constant marginal cost and zero fixed cost. Briefly, Salant et al. (1983) show that when a subset of firms in an industry merge under this condition, the profits of insider firms decline, while those of outsider firms increase. This result comes about because the model does not account for firms' sizes and therefore, ignores changes in size and market power associated with horizontal mergers. Decreasing returns to scale log production sidesteps this problem. Let the total cost of log production for each home firm be $M^D(x^i + z^i) = \alpha\frac{(x^i+z^i)^2}{2}$. It follows that firm 1 and 2 have symmetric costs and that the marginal cost of log production for each firm is $\alpha(x^i + z^i) = \alpha(x^i + \mu^D y^i)$.

Firms in each market are assumed to engage in Cournot competition. They make the following conjectures about the rivals' behaviour (same assumptions as in Chapter 6).

Assumption 1 When a firm sells an extra unit of intermediate good, it conjectures that the other intermediate good producer maintains its output constant (e.g. according to firm i, $\frac{dx^B}{dx^i} = \frac{dx^j}{dx^i} = 0$), and that the derived demand for the intermediate good (i.e. the final good production) responds to price changes (i.e. firm i assumes $\mu^A \frac{dy^A}{dx^i}\Big|_{x^j,x^B} = 1$).

Assumption 2 When a firm sells an extra unit of final good, it conjectures that the other final good producer does not change its output (e.g. according to firm i, $\frac{dy^A}{dy^i} = \frac{dy^j}{dy^i} = 0$) but that the supply of intermediate good is infinitely elastic (i.e. $\tilde{r}_Y = 0$, where $\tilde{r}$ is the equilibrium market price of log).

To understand the effect of plywood export quotas and log export ban, we examine the extent to which home firms' actions deviate from the planning optimum with and without these restrictions. Two other trade policies are also considered;

namely, a specific subsidy s on plywood exports and a specific tax t on log exports. When the quantitative restrictions are not in place, we examine whether specific taxes and/or subsidies can improve welfare. The governments in country A and B are assumed not to use any countervailing taxes.

As mentioned, the objective of the social planner is to choose the total upstream and downstream exports that maximise the combined profits of the two sectors, subject to the log market equilibrium. Assuming that the price of logs is greater than the marginal cost of making it, the central planner will produce plywood from local log supplies only. When exports are positive in both markets, the interconnection between the upstream and the downstream market matters; and a planner will choose total plywood and log exports to satisfy:

$$\left.\frac{dW}{dy^D}\right|_{x^D} = \frac{dp}{dy^D}y^D + p - c^D - \mu^D\alpha(\frac{x^D}{2} + \frac{z^D}{2}) + \frac{d\tilde{r}}{dy^D}x^D = 0, \tag{7.3}$$

where

$$\begin{aligned}
\frac{dp}{dy^D} &= p_Y\left(1 + \frac{dy^A}{dy^D}\right); \\
\frac{dy^A}{dy^D} &= \frac{\partial y^A}{\partial y^D} + y^A_r\left.\frac{d\tilde{r}}{dy^D}\right|_{x^D}; \\
\left.\frac{d\tilde{r}}{dy^D}\right|_{x^D} &= \tilde{r}_{y^D}.
\end{aligned}$$

And the planning choice of x^D is

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \frac{d\tilde{r}}{dx^D}x^D + \tilde{r} - \alpha(\frac{x^D}{2} + \frac{z^D}{2}) + \frac{dp}{dx^D}y^D = 0, \tag{7.4}$$

where

$$\frac{dp}{dx^D} = p_Y y_r^A \frac{d\tilde{r}}{dx^D};$$
$$\frac{d\tilde{r}}{dx^D} = \tilde{r}_X \left(1 + \frac{dx^B}{dx^D}\right),$$

where $\alpha(\frac{x^D}{2} + \frac{z^D}{2}) = \alpha(x^1 + z^1) = \alpha(x^2 + z^2)$. Condition (7.3) and (7.4) are similar to those given for the one-firm case of Chapter 6 (page 118). The only difference is that here we have increasing marginal cost.

As mentioned in the last Chapter, the cross-industry effects distinguish Condition (7.3) and (7.4) from the usual Stackelberg leader equilibrium condition. Consider the cross-industry effect from the plywood sector: as plywood exports from the home country rise, plywood exports from the foreign rival, i.e. y^A, decline. At the log market equilibrium, total log export supply falls resulting in a rise in the international price of log, so $\tilde{r}_{y^D} > 0$. It follows that there is a positive cross-industry effect from plywood exports.

Turning to the log sector: an increase in log exports imply greater availability of log inputs to the foreign plywood producer at lower prices, in turn the foreign plywood export supply rises. The rise in the total plywood supply causes the price of plywood to fall, thus there is a negative cross-industry effect from the log market which is represented by $\frac{dp}{dx^D} < 0$.

Proposition 5 follows on from Condition (7.3) and (7.4).

Proposition 5 *The social planner will export more downstream products and less upstream products when exports are vertically related than when they are non-related.*

Next we turn to the impact of trade policy intervention and ask whether they bring about export outcomes that are close to the planning optimum described.

7.3 Scenario A (Pre-reform policies) - Both quantitative restrictions are in place

We begin by considering a scenario that corresponds to the situation of Indonesia before the IMF reform programme. Here a ban is imposed on log exports and the plywood association allocates quotas over downstream exports. The latter implies that plywood exports can be set in line with the planner's objective. We assume that the home firms are vertically integrated unless otherwise stated.

Given that log exports are zero, i.e. $x^1 = x^2 = 0$, the planner's optimal choice of plywood exports is,

$$\begin{aligned} \left.\frac{dW}{dy^D}\right|_{x^1=x^2=0} &= W_{y^D} + W_{y^A}\frac{dy^A}{dy^D} \\ &= p - c^D - \mu^D\alpha(\frac{\mu^D y^D}{2}) + p_Y\left(1 + \frac{dy^A}{dy^D}\right)y^D = 0. \end{aligned} \tag{7.5}$$

How does this diverge from the unconstrained planning optimum? To find out, we examine how the planning y^D given in (7.5) changes with log exports, x^i where $i = 1, 2$. Let $\hat{W}_{y^D}$ be the optimal plywood quota when $x^1, x^2 > 0$. Assuming that the second-order conditions: $\frac{d^2W}{dx^i \partial x^i} < 0$, $\frac{d^2W}{dy^D \partial y^D} < 0$ and $\left(\frac{d^2W}{dx^i \partial x^i}\right)\left(\frac{d^2W}{dy^D \partial y^D}\right) -$

$\left(\frac{d^2W}{dx^i \partial y^D}\right)^2 > 0$ are satisfied, the optimal plywood quota is

$$\hat{W}_{y^D} \equiv \frac{dW}{dy^D} = W_{y^D} + W_{y^A}\frac{dy^A}{dy^D} + W_{x^1}\frac{dx^1}{dy^D} + W_{x^2}\frac{dx^2}{dy^D} + W_{x^B}\frac{dx^B}{dy^D} = 0. \quad (7.6)$$

Totally differentiating (7.6) with respect to y^D and x^i, we have

$$d\hat{W}_{y^D} = \frac{\partial \hat{W}_{y^D}}{\partial y^D} dy^D + \frac{\partial \hat{W}_{y^D}}{\partial x^i} dx^i = 0. \quad (7.7)$$

Rearranging this leads to

$$\frac{dy^D}{dx^i} = -\frac{\partial \hat{W}_{y^D}/\partial x^i}{\partial \hat{W}_{y^D}/\partial y^D}. \quad (7.8)$$

Assuming that $\frac{\partial \hat{W}_{y^D}}{\partial x^i} < 0$, it must be true that $\frac{dy^D}{dx^i} < 0$. Therefore, the planning optimal plywood quota declines as log export increases. Intuitively, a rise in log export supply enables the downstream rival to raise its exports. In turn, the home firm finds it optimal accommodate in the downstream market. Therefore, when a log export ban is in place, the plywood quota will be greater than the planning optimum given in (7.3). This leads to Proposition 6:

Proposition 6 *A log export ban and plywood quotas yield log exports that are below and plywood exports that are above the planning optimum.*

Note that Proposition 6 rests on the assumption that it is optimal to export both products. However, if Condition (7.4) is such that $\frac{dW}{dx^i}\big|_{y^D} < 0, \ \forall\, x^1, x^2 > 0$, so that the marginal loss is greater than the marginal profit accrued to the logging sector for all positive values of log exports (possibly due to large and negative cross-industry effect), then the planning optimum will coincide with Condition (7.5) and there should be no log exports. However, empirical evidence by Gillis (1988) and more recently by Barbier (1994) and Manurung and Buongiorno (1997) do not support this view.

Thus we will concentrate on the more relevant case where the planner's optimal exports are positive in both markets.

7.4 Scenario B - Plywood export quotas only, no log export ban

In this section we consider the scenario when log export ban is lifted but the plywood quota system remains. Since the plywood association has no control over log exports, the level of plywood exports must be set in anticipation of the export choice of log producers. Thus we have a sequential game whereby the downstream export decision is made first followed by the upstream export decision (the reverse of the sequence in Chapter 6). This is a hypothetical case with a rather unintuitive sequence of games. In general, governments in developing countries try to promote value-added exports; therefore, trade restrictions in the downstream industries (normally imposed to curb domestic competition) are usually administered together with trade restrictions on upstream sector exports. Nonetheless, this setup allows us to analyse the impact of plywood export quotas.

The subgame-perfect equilibrium in this case is found by solving the upstream export decision first, followed by the downstream export decision.

7.4.1 Equilibrium in the log market

The vertically integrated producers at home and the non-integrated log producer in country B solve the following problems, respectively:

$$\max_{x^i} \pi^i\big|_{y^i,y^j,x^B,x^j} = (p-c^D)y^i + rx^i - M^D(x^i+z^i); \tag{7.9}$$

$$\max_{x^B} \pi^B\big|_{y^i,y^j,x^i,x^j} = rx^B - M^B(x^B); \tag{7.10}$$

where $i = 1,2; i \neq j$; $z^i = \mu^D y^i; M^D(x^i+z^i) = \alpha\frac{(x^i+z^i)^2}{2}$; and the total cost of production for firm B is $M^B(x^B) = \alpha\frac{(x^B)^2}{2}$. The log producers choose the level of exports taking the plywood outputs y^1 and y^2 and rivals' outputs as given.

The Cournot-Nash log export levels are thus

$$\begin{aligned}
\left.\frac{d\pi^i}{dx^i}\right|_{y^i,y^j,x^j,x^B} &= \pi^i_{x^i} + \pi^i_{y^A}\frac{dy^A}{dx^i} \\
&= \left(\left.\frac{dr}{dx^i}\right|_{x^j,x^B} x^i + r - \alpha(x^i+\mu^D y^i)\right) + \left.\frac{dp}{dx^i}\right|_{x^j,x^B} y^i \\
&= 0;
\end{aligned} \tag{7.11}$$

$$\left.\frac{d\pi^B}{dx^B}\right|_{x^i,x^j} = \pi^B_{x^B} = \left.\frac{dr}{dx^B}\right|_{x^i,x^j} x^B + r - \alpha x^B = 0; \tag{7.12}$$

where $i = 1,2; i \neq j$; and $\frac{dr}{dx^i}\big|_{x^j,x^B} = \frac{dr}{dx^B}\big|_{x^i,x^j} = r_X$ and $\frac{dp}{dx^i}\big|_{x^j,x^B} = p_Y y^A_r r_X$.

The bracketed component in Condition (7.11) is the marginal revenue net of marginal cost, followed by the strategic effect. Since $\frac{dp}{dx^i}\big|_{x^j,x^B} y^i < 0$, the integrated upstream producers strategically accommodate in anticipation of the negative effect on their downstream profits. This leads to Lemma 2.

Lemma 2 *When log export ban is lifted but plywood quotas remain, a vertically integrated firm will strategically accommodate competitors in the log market.*

By symmetry of firm 1 and 2, we can combine Condition (7.11) and rewrite the Cournot-Nash conditions of the two home firms as

$$r_X\left(\frac{x^1+x^2}{2}\right)+r-\alpha\left(\frac{x^1+x^2+z^1+z^2}{2}\right)+\left.\frac{dp}{dx^1}\right|_{x^2,x^B}\left(\frac{y^1+y^2}{2}\right)=0. \quad (7.13)$$

From this, it is easy to see that the upstream exports will be greater with two home firms than with one. Lemma 3 states more formally the effect of competition within the home country.

Lemma 3 *The combined upstream exports from the home country are greater when domestic firms set outputs independently than when they collusively set outputs.*

Proof: To show this let $\tilde{x}$ and $\tilde{y}$ be the total output of log and plywood exports from the home country. Collusion implies the following Cournot-Nash condition: $r_X\tilde{x}+r-\alpha(\tilde{x}+\tilde{z})+\left.\frac{dp}{dx}\right|_{x^B}\tilde{y}=0$. If $x^1+x^2<\tilde{x}$ then firm 1 and 2 could gain from raising their log exports, thus the inequality is not feasible.

Consider when $x^1+x^2=\tilde{x}$ and $y^1+y^2=\tilde{y}$, from (7.13) the following must be true

$$r_X\left(\frac{\tilde{x}}{2}\right)+r-\alpha\left(\frac{\tilde{x}+\tilde{z}}{2}\right)+\left.\frac{dp}{dx^1}\right|_{x^2,x^B}\frac{\tilde{y}}{2}=0; \quad (7.14)$$

which contradicts the Cournot-Nash condition under collusion. Therefore, it must be that $x^1 + x^2 > \tilde{x}$. *Q.E.D.*

Condition (7.11) and (7.12) yield the Cournot-Nash log output as a function of plywood quota as follows: $x^1(y^D), x^2(y^D)$ and $x^B(y^D)$, where $y^D = y^1 + y^2$.

In the next section, we show that plywood export quotas can help to absorb some of the distortionary effects in the log market.

7.4.2 Equilibrium in the plywood market

At the market equilibrium, the demand for log input by the plywood firm in country A must be equal to the volume of logs imported into country A, i.e. $\mu^A y^A(r, y^D) = x^1(y^D) + x^2(y^D) + x^B(y^D)$. From the implicit function theorem, we find that the price of log falls as lof exports increase, $r_X < 0$ (see Appendix C.1 for the derivations).

Before we turn to the government's choice of export quotas, let us consider the plywood output choice for the foreign firm. Since firm .4 is unintegrated, it solves

$$\max_{y^A} \pi^A\Big|_{y^D} = (p(Y) - c^A - \mu^A r)y^A, \tag{7.15}$$

where y^A is the plywood export of the foreign firm; μ^A is the log-plywood conversion ratio; and r is the market price of log input.

The first-order condition for firm A is simply

$$\frac{d\pi^A}{dy^A}\Big|_{y^D} = \frac{dp}{dy^A}\Big|_{y^D} y^A + p - c^A - \mu^A r = 0, \tag{7.16}$$

where $\left.\frac{dp}{dy^A}\right|_{y^D} = p(Y)$.

What would be the choice of plywood for the home government given (7.11), (7.12) and (7.16)? Recall that the government's objective is to allocate the plywood quota so as to maximise the total surplus in both markets, where the total plywood quota y^D is allocated between firm 1 and 2. Given that firm 1 and 2 are symmetric, we assume that the plywood quotas are allocated to them equally, $y^1 = y^2 = \frac{y^D}{2}$. Thus the government solves the following problem,

$$W(y^D, y^A(y^D)) = \pi^1(y^1, x^1(y^D)) + \pi^2(y^2, x^2(y^D)), \tag{7.17}$$

subject to the log market equilibrium condition, $\mu^A y^A(y^D, r) = x^1(y^D) + x^2(y^D) + x^B(y^D)$.

Assuming that the second-order conditions $\frac{d^2W}{dx^D \partial x^D} < 0$, $\frac{d^2W}{dy^D \partial y^D} < 0$ and $\left(\frac{d^2W}{dx^D \partial x^D}\right)\left(\frac{d^2W}{dy^D \partial y^D}\right) - \left(\frac{d^2W}{dx^D \partial y^D}\right)\left(\frac{d^2W}{dy^D \partial x^D}\right) > 0$ are satisfied, the optimal plywood quota is

$$\begin{aligned}
\frac{dW}{dy^D} &= W_{y^D} + W_{y^A}\frac{dy^A}{dy^D} + W_{x^1}\frac{dx^1}{dy^D} + W_{x^2}\frac{dx^2}{dy^D} + W_{x^B}\frac{dx^B}{dy^D} \\
&= \frac{dp}{dy^D}y^D + p - c^D - \mu^D\alpha\left(\frac{\mu^D y^D + x^1 + x^2}{2}\right) + \frac{d\tilde{r}}{dy^D}(x^1 + x^2) \\
&\quad + \left(\frac{d\tilde{r}}{dx^1}x^1 + r - \alpha\left(\frac{\mu^D y^D}{2} + x^1\right)\right)\frac{dx^1}{dy^D} + \frac{dp}{dx^1}\frac{y^D}{2}\frac{dx^1}{dy^D} \\
&\quad + \left(\frac{d\tilde{r}}{dx^2}x^2 + r - \alpha\left(\frac{\mu^D y^D}{2} + x^2\right)\right)\frac{dx^2}{dy^D} + \frac{dp}{dx^2}\frac{y^D}{2}\frac{dx^2}{dy^D} = 0,
\end{aligned} \tag{7.18}$$

where

$$\begin{aligned}
\frac{dp}{dy^D} &= p_Y\left(1+\frac{dy^A}{dy^D}\right); \\
\frac{dy^A}{dy^D} &= \frac{\partial y^A}{\partial y^D}+y^A_{\tilde{r}}\frac{d\tilde{r}}{dy^D}; \\
\frac{d\tilde{r}}{dy^D} &= \tilde{r}_{y^D}; \\
\frac{dp}{dx^i} &= p_Y y^A_r \tilde{r}_X\left(1+\frac{\partial x^B}{\partial x^i}\right); \\
\frac{d\tilde{r}}{dx^i} &= \tilde{r}_X\left(1+\frac{\partial x^B}{\partial x^i}\right)
\end{aligned}$$

(see Appendix C.1 for the proof of $\tilde{r}_{y^D} > 0$).

Condition (7.18) is made up of the downstream marginal profit $W_{y^D}+W_{y^A}\frac{dy^A}{dy^D} > 0$ and the upstream marginal profit $W_{x^1}\frac{dx^1}{dy^D}+W_{x^2}\frac{dx^2}{dy^D}+W_{x^B}\frac{dx^B}{dy^D} < 0$. Recall from Scenario A that $\frac{dx^i}{dy^D} < 0$; intuitively as plywood exports from home rise, the foreign plywood exports contract and, therefore, the foreign demand for intermediate inputs falls. In this way, a rise in plywood exports will raise plywood profits but will simultaneously reduce the upstream profits through the reduction in exports. The optimal plywood quota, thus occurs at a point where the rise in profits from exporting one more unit of plywood just offsets the loss incurred on the log industry.

Using (7.11), (7.18) simplifies to

$$\begin{aligned}
\frac{dW}{dy^D} &= \frac{dp}{dy^D}y^D+p-c^D-\mu^D\alpha\left(\frac{\mu^D y^D+x^D}{2}\right)+\tilde{r}_{y^D}(x^1+x^2) \\
&\quad+\sum_i\left(\tilde{r}_X x^i+p_Y y^A_r\tilde{r}_X\frac{y^D}{2}\right)\frac{\partial x^B}{\partial x^i}\frac{dx^i}{dy^D}=0. \qquad (7.19)
\end{aligned}$$

Note that the plywood quota will be binding if and only if Condition (7.19) at the Cournot plywood choice is negative, i.e.

$$p_Y \frac{dy^A}{dy^D} - C^{pw} + \tilde{r}_{y^D}(x^1 + x^2) + \sum_i \left(\tilde{r}_X x^i + p_Y y_r^A \tilde{r}_X \frac{y^D}{2} \right) \frac{\partial x^B}{\partial x^i} \frac{dx^i}{dy^D} < 0. \quad (7.20)$$

Given that there are two firms in the plywood sector, the private (Cournot) choice of plywood will include the pro-competitive effect which tends to raise plywood exports above the government optimum, $-C^{pw} < 0$. In addition, there are cross-industry effects that the plywood quota takes into account but a Cournot exporter does not. These are positive terms of trade effect on log price due to a rise in plywood exports; and the commitment failure effect in the log market. The former raises the plywood quota, while the latter depresses the optimal plywood quota below the Cournot export choice.

Reports of the plywood situation in Indonesia prior to the formation of APKINDO or the plywood marketing board suggest that at the time the pro-competitive effect, i.e. $-C^{pw} < 0$ dominates. This would imply that Condition (7.20) is negative and, therefore, the plywood quota is binding. The rest of this section concentrates on the case when the plywood quota is binding.

How do log and plywood exports implied by (7.11) and (7.19) diverge from the planning optimum in (7.4) and (7.3)? (7.4) at the Cournot log export is,

$$\begin{aligned} \sum_i \left. \frac{dW}{dx^i} \right|_{y^D} &= \sum_i \left(\tilde{r}_X x^i + p_Y y_r^A \tilde{r}_X \frac{y^D}{2} \right) \frac{dx^B}{dx^i} \\ &= \left(\tilde{r}_X x^D + p_Y y_r^A \tilde{r}_X y^D \right) \frac{dx^B}{dx^D} - C^{log}. \end{aligned} \quad (7.21)$$

Two distortionary effects are at work in (7.21): the commitment failure effect and the pro-competitive effect. The former works directly as well as indirectly (through the strategic behaviour of integrated firms) to depress log exports. The latter refers to the result of Lemma 3 which shows that exports are greater with two home firms than with one. Since the commitment failure and the pro-competitive effect work in opposing directions, total log exports from the home country may be greater or less than the planning optimum.

Next, we consider the optimal plywood quota in (7.19) at the planning optimum. This is

$$\begin{aligned}\frac{dW}{dy^D} &= \sum_i \left(\tilde{r}_X x^i + p_Y y_r^A \tilde{r}_X \frac{y^D}{2}\right) \frac{\partial x^B}{\partial x^i} \frac{dx^i}{dy^D} \\ &= \left(\tilde{r}_X x^D + p_Y y_r^A \tilde{r}_X y^D\right) \frac{\partial x^B}{\partial x^D} \frac{dx^i}{dy^D} - C^{log} \frac{dx^i}{dy^D}. \qquad (7.22)\end{aligned}$$

Again two distortionary effects are found in the plywood sector: the commitment failure and the pro-competitive effect. These are directly linked to the distortions in the log sector. Because of the commitment failure in the log export sector, the government has an incentive to raise the plywood quotas to try and recoup some of the upstream profits lost to the foreign upstream rival. The pro-competitive effect from log exports, however, implies the opposite and calls for a reduction in the plywood export quota. Thus if the commitment failure effect dominates, the plywood quota will be larger and log exports will be smaller than the planning optimum. However, if the pro-competitive effect dominates, the plywood quota will be smaller and log export will be larger than the planning optimum. This leads to Proposition 7.

Proposition 7 *When the log export ban is lifted and plywood export quotas remain, two outcomes are possible. If the commitment failure in the log sector dominates, plywood exports are greater and log exports are lower than the planning optimum. If the pro-competitive effect in the log market dominates, however, log exports will be greater and plywood exports will be lower than the planning optimum.*

7.5 Scenario C - Log export ban only, no plywood export quotas

Since log exports are prohibited, vertically integrated firms choose the quantity of plywood export only. Given that home firms supply to one market each, there are no strategic effects.

The objective of vertically integrated home firms are given by

$$\max_{y^i} \pi^i\big|_{y^j,y^A,x^1=x^2=0} = (p-c^D)y^i - M^D(z^i), \tag{7.23}$$

where $i = 1,2; i \neq j$; $z^i = \mu^D y^i$; and $M^D(z^i) = \alpha\frac{(z^i)^2}{2}$.

The Cournot-Nash plywood exports are

$$\left.\frac{d\pi^i}{dy^i}\right|_{y^j,y^A,x^1=x^2=0} = p_Y y^i + p - c^D - \mu^D(\alpha\mu^D y^i) = 0, \tag{7.24}$$

where $i = 1,2; i \neq j$.

From Lemma 3, the pro-competitive effect is present in (7.24). Assuming that a log export ban is imposed, we contrast the outcome in the plywood sector when the quota scheme is present and when it is not, i.e. Scenario A with Scenario C. The two equilibria diverge in two ways: firstly the pro-competitive effect is present in (7.24) but not in (7.5); and secondly, there is a commitment failure in Scenario C which is not present in Scenario A.

Thus it is technically possible that plywood exports under optimally administered quota scheme are larger than the liberalised plywood exports. This would be the case if the commitment failure effect dominates the pro-competitive effect in the plywood sector. If the reverse is true then plywood exports under the quota scheme would be lower than liberalised plywood exports. This result is stated in Proposition 8.

Proposition 8 *Under the log export ban, the liberalised plywood exports will be larger than the plywood under the quota system if the pro-competitive effect in the plywood market dominates. However, they will be smaller than the plywood under the quota system if the commitment failure effect dominates.*

As mentioned, the pro-competitive effect dominated the Indonesian plywood industry.

7.6 Scenario D (Post-IMF reform policies) - No plywood quota, nor log export ban

The integrated firms at home are now free to set plywood and log exports themselves. Let g be the market price of logs in the home country. We assume that $g > \alpha(x^i + \mu^D y^i)$, so that the plywood processors at home source inputs internally. At the end of this section, we analyse the incentives for the home government to impose export tax and subsidy in the log and plywood market respectively (denote these instruments by t and s). For the sake of tractability, we include these trade policies throughout the analysis in this section.

As usual, the subgame-perfect equilibrium is found by solving the last stage game first.

7.6.1 Equilibrium in the plywood market

Given that the integrated producers at home use own log supplies in the plywood production, they maximise the joint profits given by

$$\max_{y^i, x^i} \pi^i = (p(Y) + s - c^D)y^i + (r - t)x^i - \alpha\frac{(x^i + \mu^D y^i)^2}{2}, \ \forall i = 1, 2. \tag{7.25}$$

The Cournot-Nash equilibrium condition for plywood exports of each home firm is

$$\left.\frac{d\pi^i}{dy^i}\right|_{y^j, y^A, x^i} = \pi^i_{y^i} = p_Y y^i + p + s - c^D - \mu^D\alpha(x^i + \mu^D y^i) = 0, \ \ \forall i = 1, 2. \tag{7.26}$$

Since the profit condition for firm A remains the same, the Cournot-Nash condition for plywood exports from A is (7.16).

From (7.25) and (7.16), the equilibrium plywood outputs can be expressed as an implicit function of r and s:

$$y_N^1 = y^1(r,s); y_N^2 = y^2(r,s); \text{ and } y_N^A = y^A(r,s), \tag{7.27}$$

where $\frac{dy_N^i}{ds} > 0, \ \forall i = 1,2$; and $\frac{dy_N^A}{ds} < 0$ (see Appendix C.2 for the derivations).

7.6.2 Equilibrium in the log market

In the equilibrium, firm A's derived demand for logs must be equal to the total supply of logs to its country, thus

$$\mu^A y_N^A(r, s, y_N^1(r,s), y_N^2(r,s)) = x^1 + x^2 + x^B, \tag{7.28}$$

where y_N^A, y_N^1 and y_N^2 are the Cournot outputs in the plywood market. Let $\Omega^A \equiv \mu^A y_N^A - x^1 - x^2 - x^B = 0$; by totally differentiating (7.26), (7.16) and Ω^A, we discern how the equilibrium log price, denoted by $\tilde{r}$, changes with log and plywood exports. These are

$$r_X < 0; \quad r_{y^i} > 0; \quad r_{y^A} < 0, \tag{7.29}$$

where $i = 1,2$ (see Appendix C.3 for the derivations).

Each home firm chooses x^i to maximise the joint profits from both its upstream and downstream operation, thus the first-order condition for each log producer at home is

$$\left.\frac{d\pi^i(x^i, y^A(x^i), y^j(x^i))}{dx^i}\right|_{x^j,x^B,y^i} = \left(\left.\frac{dr}{dx^i}\right|_{x^j,x^B} x^i + r - t - \alpha(x^i + \mu^D y^i)\right) + \left.\frac{dp}{dx^i}\right|_{x^j,x^B} y^i$$
$$= 0. \tag{7.30}$$

where

$$\left.\frac{dr}{dx^i}\right|_{x^j,x^B} = r_X;$$
$$\left.\frac{dp}{dx^i}\right|_{x^j,x^B} = p_Y y_r^A \tilde{r}_X + \left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right)\frac{dy^j}{dx^i}.$$

The effect of an increase in log production on profits is marginal revenue less marginal cost (see the terms inside brackets), plus the strategic term $\left.\frac{dp}{dx^i}\right|_{x^j,x^B} y^i$ which takes into account the effect of log export decision across sectors. The strategic term may be positive or negative depending on whether the strategic accommodation effect $p_Y y_r^A \tilde{r}_{x^i} < 0$ or the strategic pre-emption effect $\left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right)\frac{dy^j}{dx^i} > 0$ dominates. The first strategic term accounts for the negative impact of log exports on plywood profits through reduced terms of trade and plywood market share. Intuitively as log export rises, the foreign rival's plywood supply expands (as input cost declines) which in turn depresses the price of plywood. The second strategic term accounts for the loss inflicted upon the domestic rival by being aggressive in the log market. This is because the domestic rival loses some of its export share in the plywood market. This leads to Lemma 4.

Lemma 4 *When log and plywood industries are liberalised, a* vertically integrated *firm will accommodate rivals in the upstream market if the benefit from raising* *the downstream foreign rival's cost is greater than the benefit from pre-empting the domestic rival, i.e.* $-p_Y y_r^A \tilde{r}_X > \left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right) \frac{dy^j}{dx^i}$.

Conversely, it will act aggressively in the upstream market if the benefit from raising the cost of the downstream foreign rival is lower than the benefit from pre-empting the domestic rival i.e. $-p_Y y_r^A \tilde{r}_X < \left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right) \frac{dy^j}{dx^i}$.

Given that firm B's objective function remains the same, firm B's first-order condition is (7.12). Equation (7.30) and (7.12) yield the Cournot intermediate output as a function of log export tax. The comparative statics for the Cournot log exports are as follows: $\frac{dx_N^i}{dt} < 0$ and $\frac{dx_N^B}{dt} > 0$ $\forall i = 1, 2$ (see Appendix C.4 for the derivations).

How do the Cournot output choices diverge from the planning optimum? From Lemma 3, we know that domestic competition effect is present in both upstream and downstream market. To examine other distortionary effects, let us assume that $x^1 + x^2 = x^D$ and $y^1 + y^2 = y^D$ (i.e. abstracting from the domestic competition effect); Conditions (7.26) and (7.30) can thus be rewritten as

$$\sum_i \left.\frac{d\pi^i}{dy^i}\right|_{y^j, y^A, x^i} = p_Y y^D + p + s - c^D - \mu^D \alpha\left(\frac{x^D + \mu^D y^D}{2}\right) = 0; \tag{7.31}$$

$$\begin{aligned}\sum_i \left.\frac{d\pi^i}{dx^i}\right|_{x^j, x^B, y^i} &= \left(r_X x^D + r - t - \alpha\left(\frac{x^D + \mu^D y^D}{2}\right)\right) + p_Y y_r^A \tilde{r}_X y^D \\ &\quad + \left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right) \frac{dy^j}{dx^i} y^D = 0,\end{aligned} \tag{7.32}$$

$\forall i \neq j$.

The planning optimum (7.3) and (7.4) at the Cournot equilibrium without quantitative restrictions, when $x^1 + x^2 = x^D$ and $y^1 + y^2 = y^D$, are:

$$\left.\frac{dW}{dy^D}\right|_{x^D} = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D \tag{7.33}$$

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \tilde{r}_X \frac{\partial x^B}{\partial x^D} x^D + p_Y y_r^A \tilde{r}_X \frac{\partial x^B}{\partial x^D} y^D - \left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right) \frac{dy^j}{dx^i} y^D \tag{7.34}$$

where $\frac{dy^A}{dy^D} = \frac{\partial y^A}{\partial y^D} + y_r^A \tilde{r}_{y^D}$.

On top of the pro-competitive effect in each market, (7.34) shows three other distortionary effects that are pulling log exports from the planning optimum. The first effect is the commitment failure in the log market due to the Cournot conjectures ($\tilde{r}_X \frac{\partial x^B}{\partial x^D} x^D > 0$). The second and third distortions come from the strategic behaviour of the home firms in the upstream market. As mentioned, a vertically integrated home firm will strategically reduce its upstream exports to lessen the negative effect on downstream profits (i.e. strategic accommodation). However, due to the presence of commitment failure, the integrated firm over-compensates for the negative effect on downstream profits; thus $p_Y y_r^A \tilde{r}_X \frac{\partial x^B}{\partial x^D} y^D > 0$. On top of this, a vertically integrated home firm would strategically raise its upstream exports to pre-empt the exports of the domestic rival in the downstream market, i.e. $-\left(p_Y y_r^A \tilde{r}_{y^j} + p_Y\right) \frac{dy^j}{dx^i} y^D < 0$).

It follows that log exports will be larger than the planning optimum if the distortion brought about by the pre-emptive strategy and the pro-competitive effect dominate. However, plywood exports will be below the planning optimum if the *direct* and *indirect* commitment failure effect dominates.

Condition (7.33) shows that there are two effects on top of the pro-competitive effect that distort plywood away from the planning optimum. These are the commitment failure effect $p_Y \frac{dy^A}{dy^D} y^D > 0$, and the cross-industry effect $\tilde{r}_{y^D} x^D > 0$. While the pro-competitive effect raises plywood exports, the commitment failure and the cross-industry effect depress log exports below the planning optimum. This leads to Proposition 9.

Proposition 9 *When log and plywood exports are liberalised and home firms are vertically integrated, each export may be larger or smaller than the planning optimum. Specifically,*

1. *Liberalised log exports will be larger than the planning optimum if the pro-competitive and the pre-emptive effect dominate;*

2. *Liberalised log exports will be smaller than the planning optimum if the commitment failure effect dominates;*

3. *Liberalised plywood exports will be larger than the planning optimum if the pro-competitive effect dominates;*

4. *Liberalised plywood exports will be smaller than the planning optimum if the commitment failure and cross-industry effects dominate.*

In the next section, we examine whether these distortions can be corrected through specific export taxes and subsidies.

7.6.3 Optimal taxes and subsidies when industries are vertically integrated

In this section, we analyse the incentives for the Indonesian government to impose a specific tax on log t and a specific subsidy s on plywood once log export ban and plywood quotas have been lifted. Home government's objective with taxes and subsidies becomes,

$$\max_{t,s} W^d(t, x^i(t), s, y^i(s)) = \sum_i \left(\pi^i(t,s) - sy^i(s) + tx^i(t)\right). \tag{7.35}$$

Export taxes and subsidies

The government will choose t and s to maximise (7.35). The optimisation problem is laid out in Appendix C.5. (C.17) and (C.21) in Appendix C.5 yield optimal trade policies for both sectors as follows:

$$t^I = -\tilde{r}_X \frac{dx^B}{dx^1} x^1 - p_Y y_r^A \tilde{r}_X \frac{dx^B}{dx^i} + p_Y \left(1 + y_r^A \tilde{r}_{y^j}\right) \frac{dy^j}{dx^i}; \tag{7.36}$$

$$s^I = p_Y \frac{dy^A}{dy^i} y^i + \tilde{r}_{y^i} x^i > 0. \tag{7.37}$$

From (7.36) and (7.37), the sign of t^I is ambiguous but s^I is always positive. We summarise the optimal trade policy results in Proposition 10.

Proposition 10 *The home government should always subsidise plywood exports of a vertically integrated firm. However, the optimal trade policy for the upstream exports is ambiguous. Specifically when the commitment failure effect dominates,* *the upstream exports should be subsidised; however, when the strategic pre-emption effect dominates, then upstream exports should be taxed.*

When t^I and s^I are substituted into the Cournot equilibrium conditions, we find that optimal trade policies help to eliminate distortions stemming from the commitment and cross-industry effects in both sectors. However, the competition effect remains in both markets leading to too much log and plywood exports. This leads to Proposition 11.

Proposition 11 *Optimal taxes and subsidies on vertically integrated home firms result in excessive log and plywood exports, because the pro-competitive effect remains in both markets.*

7.7 Scenario E (Post-reform policies without vertical integration) - No log export ban, nor plywood export quotas

Consider now a scenario without vertical integration: let the downstream firms at home be $D1$ and $D2$, and let the upstream firms be $U1$ and $U2$. Intermediate inputs are supplied to downstream firms through market (i.e. any bargaining between each downstream firm and supplier is thus ruled out). Although there are potentially two sources of inputs for the downstream producers, we assume that the home producers source logs from local suppliers only (due to high transport costs etc.). We also assume that log harvesters at home differentiate between production for the local market and for exports which have been the case in Indonesia. Thus different prices are charged for each destination. As noted earlier, possible justifications for such market segmentation are differences in quality requirements, differentiated health and safety regulations, etc. Let g and r be the intermediate input prices at home and in country A, respectively. Again we analyse the incentives for the home government to impose specific taxes and subsidies on log and plywood exports in this section. We proceed by solving the second stage first.

7.7.1 Equilibrium in the plywood market

In stage two, unintegrated firms at home aim to maximise plywood profits and thus solve the following problem:

$$\max_{y^i, x^i} \pi^{Di} = (p(Y) + s - c^D - \mu^D g)y^i, \ \forall\, i = 1, 2. \tag{7.38}$$

Each firm determines the quantity of plywood to produce by taking the other firm's output and the input prices g and r as given. The first-order conditions for a Cournot-Nash equilibrium for home firms are

$$\pi^{Di}_{y^i} = p_Y y^i + p + s - c^D - \mu^D g = 0, \ \forall\, i = 1, 2. \tag{7.39}$$

In comparing (7.39) with (7.26), plywood exports under vertical separation is smaller than those under integration due to higher log input cost. The first-order condition for firm A is given by (7.16). From (7.39) and (7.16), the equilibrium plywood outputs can be expressed as an implicit function of r, g, and s:

$$y_N^1 = y^1(r,g,s); \quad y_N^2 = y^2(r,g,s); \quad y_N^A = y^A(r,g,s). \tag{7.40}$$

In turn, the comparative statics are: $\frac{dy_N^i}{ds} > 0, \quad \forall i = 1,2$; and $\frac{dy_N^A}{ds} < 0$ (since the effect of downstream export subsidy on home outputs is the same regardless of the vertical ownership structure, the derivations for $\frac{dy_N^i}{ds}$ and $\frac{dy_N^A}{ds}$ are also given in Appendix C.2).

7.7.2 Equilibrium in log markets

Turning to the intermediate good markets: unintegrated harvesters at home are assumed to supply intermediate inputs to both the home country and country A. Since logs supplied to these two markets are differentiated, the harvesters face two different prices. Let π^{U1} and π^{U2} be profits of unintegrated log harvesters at home, and π^B be the profit of log harvester in country B. The harvesters solve the following problems:

$$\max_{x^i,z^i} \pi^{Ui}\Big|_{x^B,x^j,z^j} = g(Z)z^i + (r(X)-t)x^i - \alpha\frac{(x^i+z^i)^2}{2} \ \forall\, i = 1,2; \tag{7.41}$$

subject to the log market equilibrium conditions in country A and the home country,

$$\begin{aligned} \mu^D(y_N^1(g) + y_N^2(g)) &= z^1 + z^2; && (7.42) \\ \mu^A y_N^A(r) &= x^1 + x^2 + x^B; && (7.43) \end{aligned}$$

where $Z = z^1 + z^2$ and $X = x^1 + x^2 + x^B$ are total log supplies to the downstream industry at home and in country A, respectively; and y_N^1, y_N^2 and y_N^A are the Cournot plywood outputs. Condition (7.42) and (7.43) in turn determine the equilibrium prices of intermediate goods: $\tilde{r}$ and $\tilde{g}$.

The first-order condition for the log harvester in country B is given by (7.12). The first-order conditions for a profit maximising choice of z^i and x^i by the domestic harvesters are

$$\begin{aligned}
\left.\frac{d\pi^{Ui}}{dz^i}\right|_{x^B,x^j,g} &= \pi_{z^i}^{Ui} + \pi_{y^i}^{Ui}\frac{dy^i}{dz^i} + \pi_{y^j}^{Ui}\frac{dy^j}{dz^i} + \pi_{y^A}^{Ui}\frac{dy^A}{dz^i} \\
&= (g_Z z^i + g - \alpha(z^i + x^i)) = 0; \qquad (7.44)\\
\left.\frac{d\pi^{Ui}}{dx^i}\right|_{x^B,z^j,r} &= \pi_{x^i}^{Ui} + \pi_{y^i}^{Ui}\frac{dy^i}{dx^i} + \pi_{y^j}^{Ui}\frac{dy^j}{dx^i} + \pi_{y^A}^{Ui}\frac{dy^A}{dx^i} \\
&= (r_X x^i + r - t - \alpha(z^i + x^i)) = 0, \qquad (7.45)
\end{aligned}$$

$\forall\, i = 1, 2$ where $j \neq i$. Since $\pi_{y^i}^{Ui} = \pi_{y^j}^{Ui} = \pi_{y^A}^{Ui} = 0$, all the strategic terms drop out. This leads to Lemma 5.

Lemma 5 *When log and plywood industries are liberalised, despite the first-mover position enjoyed by the upstream firms, the nonintegrated firms do not use it to their advantage.*

From (7.44), (7.45) and (7.12), the Cournot log outputs can be defined as a function of trade taxes and subsidies: $z_N^i(t), x_N^i(t)$, and $x_N^B(t)$. In turn, the comparative statics are: $\frac{dz_N^i}{dt} > 0; \frac{dx_N^i}{dt} < 0$ and $\frac{dx_N^B}{dt} > 0$, (see Appendix C.7 for the derivations).

How do the Cournot log and plywood equilibria differ from the planning optimum? Again for clarity, we abstract from the pro-competitive effect in both industries and assume that $x^1 + x^2 = x^D$ and $y^1 + y^2 = y^D$. Thus (7.39) and (7.45) can be rewritten as

$$\sum_i \pi^i_{y^i} = p_Y y^D + p - c^D - \mu^D g = 0; \tag{7.46}$$

$$\sum_i \pi^i_{x^i} = \tilde{r}_X x^D + r - t - \alpha(\frac{\mu^D y^D + x^D}{2}) = 0. \tag{7.47}$$

The planning optimum in (7.3) and (7.4) at the Cournot equilibrium when $x^1 + x^2 = x^D$ and $y^1 + y^2 = y^D$ and $s = t = 0$ becomes

$$\left.\frac{dW}{dy^D}\right|_{x^D} = \mu^D(g - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right)) + p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D; \tag{7.48}$$

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \tilde{r}_X \frac{\partial x^B}{\partial x^D} x^D + p_Y y^A_r \tilde{r}_X \left(1 + \frac{\partial x^B}{\partial x^D}\right) y^D. \tag{7.49}$$

On top of the pro-competitive effect in each market, Condition (7.48) and (7.49) show three other distortionary effects. Firstly, the double marginalisation problem in the plywood sector depresses plywood exports away from the planning optimum $\left(\mu^D(g - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right)) > 0\right)$. The second and third effect stem from the commitment failure and cross-industry effects. While the former tends to depress each export below the planning optimum $\left(p_Y \frac{dy^A}{dy^D} y^D > 0, \tilde{r}_X \frac{\partial x^B}{\partial x^D} x^D > 0\right)$, the latter tends to depress plywood exports $(\tilde{r}_{y^D} x^D > 0)$ but raises log exports $\left(p_Y y^A_r \tilde{r}_X \left(1 + \frac{\partial x^B}{\partial x^D}\right) y^D < 0\right)$. This leads to Proposition 12.

Proposition 12 *When log and plywood exports are liberalised and the home firms are vertically separated, each export may be larger or smaller than the planning optimum. Specifically,*

1. *Log exports will be larger than the planning optimum if the pro-competitive and the strategic pre-emption effects dominate;*

2. *Log exports will be smaller than the planning optimum if the commitment failure effect dominates;*

3. *Plywood exports will be larger than the planning optimum if the pro-competitive effect dominates;*

4. *Plywood exports will be smaller than the planning optimum if the commitment failure and cross-industry effects dominate.*

Next we examine whether these distortions can be corrected through specific taxes and subsidies on exports.

7.7.3 Optimal taxes and subsidies when industries are vertically separated

Again the home country's government objective with taxes and subsidies becomes

$$\max_{t,s} W^e(t, x_N^i(t), s, y_N^i(s)) = \sum_i \left(\pi^{Di}(s, y_N^i(s)) + \pi^{Ui}(t, x_N^i(t)) - s y_N^i(s) + t x_N^i(t)\right), \tag{7.50}$$

$\forall\, i = 1, 2.$

Export taxes and subsidies

The government will set t and s to maximise welfare given by (7.50). The optimisation problem is laid out in Appendix C.8. The value of optimally set t and s satisfy,

$$t^N = -\tilde{r}_X \frac{dx^B}{dx^i} x^i - \frac{dp}{dx^i} y^i; \tag{7.51}$$

$$s^N = p_Y \frac{dy^A}{dy^i} y^i + \tilde{r}_{y^i} x^i > 0, \tag{7.52}$$

where $i = 1, 2$ and $i \neq j$. According to (7.51), t^N may be positive or negative depending on whether the cross-industry effect or the commitment failure effect dominates. However, s^N is always positive. These results lead to Proposition 13.

Proposition 13 *The home government should always subsidise plywood exports of a vertically separated firm. However, the optimal trade policy for the upstream sector is ambiguous. Specifically, when the cross-industry effect dominates, the upstream exports should be taxed; however, when the commitment failure effect dominates, the upstream exports should be subsidised.*

Do t^N and s^N bring about the planning optimum? To find out, we substitute optimal trade policies into the Cournot conditions as follows:

$$\begin{aligned}
\sum_i \left.\frac{d\pi^i}{dy^i}\right|_{t,x^i} &= \sum_i \left(p_Y\left(1+\frac{dy^A}{dy^i}\right)y^i + \tilde{r}_{y^i}x^i - c^D - \mu^D g\right) \\
&= \left.\frac{dW}{dy^D}\right|_{x^D} + \mu^D\left(g - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right)\right) - C^{pw}; \qquad (7.53) \\
\sum_i \left.\frac{d\pi^i}{dx^i}\right|_{y^i} &= \sum_i \left(\tilde{r}_X\left(1+\frac{dx^B}{dx^i}\right)x^i + r - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right) + \frac{dp}{dy^i}y^1\right) \\
&= \left.\frac{dW}{dx^D}\right|_{y^D} - C^{log}. \qquad (7.54)
\end{aligned}$$

Comparing (7.53) and (7.54) with the planning optimum in (7.3) and (7.4), we find that the pro-competitive effect and the double marginalisation problem still remain. The pro-competitive effect raises log and plywood outputs beyond the planning optimum; while the double marginalisation effect depresses plywood exports. As a consequence, log exports are unambiguously greater than the optimum. However, the net effect on plywood exports is ambiguous. If the double marginalisation effect dominates, then plywood exports are below the planning optimum and vice versa if the the pro-competitive effect dominates. This leads to Proposition 14.

Proposition 14 *Optimal taxes and subsidies on vertically separated home firms result in excessive log exports. However, it may lead to too much or too little plywood exports depending on whether the pro-competitive effect or the double marginalisation effect dominates.*

7.8 Welfare comparisons between pre- and post-reform policies and conclusion

Three types of trade policies have been examined in this chapter: namely, log export ban; plywood export quotas and specific taxes and subsidies. As expected, different trade policy combinations give rise to different export levels and welfare effects. The sources of divergence from the planning optimal output under each policy scenario are summarised in Table 7.2. 7.3 and 7.4.

With full export liberalisation and de-linking of the upstream and down-stream industries, private choices diverge from the planner's optimum due to four distortionary effects:

1. Domestic competition in the log and plywood market;
2. Commitment failure problem (whereby rivals' Cournot conjecture places an upper-bound on home firms' exports);
3. Double marginalisation problem;
4. Failure to correctly internalise the cross-industry effects, i.e. firms fail to anticipate the negative or positive repercussion of its output decision on the related market.

While domestic competition tends to raise the Cournot exports in both markets above the planning optimum, the commitment failure tends to dampen exports in both markets. Double marginalisation, on the other hand, causes plywood exports to fall below the optimum; and lastly the cross-industry effect raises upstream exports, while depresses downstream exports below the planning optimum.

When the home firms are integrated, they behave strategically. We find that although some distortions are corrected through the strategic behaviour, new distortions are also generated. While an integrated home firm has an incentive to produce less upstream to compensate for some of the negative cross-industry effect on its downstream profits (i.e. strategically accommodate), it also has an incentive to produce more. This is because some of the negative cross-industry effect from the upstream production is borne by the domestic rival downstream. We also find that the commitment failure effect works through the strategic accommodation and potentially causes integrated firms to over-accommodate.

The trade policies considered help to offset some of these distortions, but in none of the scenarios are trade policies able to eliminate all the distortions. For example, while specific taxes and subsidies correct the commitment problem and induce firms to internalise cross-industry effects, they do not correct the distortions caused by domestic competition and double marginalisation. When log exports are liberalised, optimally distributed plywood export quotas, can prevent excessive domestic competition in the plywood market, compensate for the commitment problem in the log market, and commit home firms to higher plywood exports than those implied by the Cournot conjecture. However, plywood quotas alone cannot curb excessive domestic competition in the log market. Instead, the optimal plywood quota would take into account the distortionary effects present in the log market. Given that the liberalised log exports suffer from the commitment failure and the pro-competitive effect, and that a rise in one unit of plywood reduces the volume of log exports, i.e. $\frac{dx^D}{dy^D} < 0.$; the plywood quota should be raised to take into account the commitment failure in the log market and lowered to take into account the pro-competitive effect in the log market. In this way, the welfare maximising plywood quota will occur where the rise in the profit from exporting one more unit of plywood just offsets the loss incurred on the log industry.

We find that a log export ban is never optimal if, for some positive values of log exports, the marginal profit from log exceeds the marginal loss.

Similarly to the analysis of Chapter 6, we have shown that vertical integration eliminates the double marginalisation problem which would have otherwise depressed the downstream outputs. Since several effects are at work in distorting the export equilibrium away from the planning optimum, some of which tend to off-set each other, trade restrictions could potentially result in larger discrepancies between actual exports and the planning optimum.

Prior to the IMF reform programme, both plywood export quotas and log export ban were in place (Scenario A). As mentioned when set optimally, plywood quotas help to correct the ditortionary effects stemming from commitment failure and domestic competition. However, we find that the planning optimum cannot be reached under the log export ban. Table 7.2 shows that this policy combination leads to plywood exports that are above and log exports that are below the planning optimum.

For Scenario D which corresponds to partial-IMF reform programme (without vertical separation), complete liberalisation of both exports is found to unleash three distortionary effects; these are: the domestic competition effect; the commitment failure effect; and cross-industry effects. Given that these effects work in opposing directions, it remains ambiguous whether log and plywood exports will be greater or lower than the planner's optimum. If these effects more or less offset each other, then export liberalisation is likely to bring both export levels closer to the planning optimum and, therefore, raise Indonesian producer surplus. However, if this is not the case, then the effect of export liberalisation on the producer surplus is ambiguous.

We find that vertical integration is left intact after export liberalisation (Scenario D), home firms will behave strategically in two ways. Firstly, since a vertically integrated firm maximises joint profits across industries, it will anticipate any negative impact on profits across industry from its log export decision, and, therefore, it will accommodate rivals in the log market. Secondly, it will raise log exports in order to reduce the market share or pre-empt exports of the downtream rival at home. These strategic effects in turn offset some of the distortionary effects brought about by the export liberalisation. We find that log exports will be greater than the planning optimum if the pro-competitive effect and the strategic pre-emption effect dominate; but they will be smaller than the planning optimum if the strategic accommodation and commitment failure effect dominate. On the other than, plywood exports will be greater than the planning optimum if the pro-competitive effect dominates, but they will be smaller than the planning optimum if the commitment failure and cross-industry effect dominate (see Table 7.3 for more details).

If export liberalisation is accompanied by vertical separation (Scenario E), then we find that no strategic actions are taken, i.e. firms in each sector simply set exports where the marginal revenue is equal to marginal cost of production. However, the double mark-up brought about by vertical separation adds further distortions. We find that if the pro-competitive effect and the cross-industry effect dominate in the upstream market, then log exports will be larger than the planning optimum; however, if the commitment failure effect dominates, then log exports will be smaller than the planning optimum. In the downstream sector, plywood exports will be larger than the planning optimum if the pro-competitive effect dominates, but they will be smaller than the planning optimum if the double marginalisation effect, commitment failure and cross-industry effect dominate.

Since October 2001, Indonesian government has reinstated the log export ban (without the plywood export quota) in an effort to reduce deforestation (Scenario C). From Table 7.2, it is technically possible that plywood exports without the export quotas will be lower than the plywood exports under the quota system (Scenario

A). This would be the case if the commitment failure effect dominates the domestic competition effect. However, the rise in the terms of trade of Indonesian plywood after the setup of APKINDO (i.e. Indonesian plywood marketing board) would suggest that the pro-competitive effect from domestic competition dominated during the 1980's. Unless the domestic competition and the commitment effect completely offset each other in the plywood market, the producer surplus in Indonesia will decline from the pre-policy reform level.

What we have illustrated in this chapter is that there are several effects at work in distorting firms' export choice away from the planning optimum. Given that some of these effects offset each other, trade restrictions could potentially bring about greater discrepancies between actual exports and the planner's preferred choice.

Throughout the analysis we have concentrated on the effect of trade restrictions on the producer surplus, thus abstracting from the consideration of environmental benefits of the forest, consumer surplus, property rights etc. Such factors must be taken into account for a more complete analysis.

Table 7.2: The causes of divergence (in words) between the planning optimum and the Cournot log and plywood outputs under each policy scenario, where y^D and x^D are total plywood and log exports from the home country

	Vertical integration	
	Plywood quotas Scenario A	No plywood quotas Scenario C
Log export ban	1. Failure to realise positive profits from log exports ($x^D \downarrow, y^D \uparrow$) 2. Decline in unit cost of plywood production ($y^D \uparrow$)	1. Failure to realise positive profits from log exports ($x^D \downarrow$) 2. Decline in unit cost of plywood production ($y^D \uparrow$) 3. Pro-competitive effect in plywood market ($y^D \uparrow$) 4. Commitment problem in plywood market ($y^D \downarrow$)
	Scenario B	Scenario D
No log export ban	1. Pro-competitive effect in log market ($x^D \uparrow$) 2. Commitment failure in log market[a] ($x^D \downarrow$) 3. Cross-industry effect from log market[b] (pro-competitive effect in log market $y^D \downarrow$ commitment failure in log market $y^D \uparrow$)	1. Pro-competitive effect in log & plywood market ($x^D \uparrow$; $y^D \uparrow$) 2. Commitment failure in log & plywood market ($x^D \downarrow$; $y^D \downarrow$) 3. Cross-industry effect in plywood market ($y^D \downarrow$) 4. Strategic pre-emption in log market ($x^D \uparrow$) 5. Strategic accommodation in log market ($x^D \downarrow$)
	No vertical integration	
		Scenario E
No log export ban		1. Pro-competitive effect in log & plywood market ($x^D \uparrow$; $y^D \uparrow$) 2. Commitment problem in log & plywood market ($x^D \downarrow$; $y^D \downarrow$) 3. Cross-industry effect in log & plywood market ($x^D \uparrow$; $y^D \downarrow$) 4. double marginalisation effect ($y^D \downarrow$)

[a] Commitment failure enters directly and indirectly through the strategic (accommodation) effect.

[b] Given that log and plywood exports are strategic substitutes, i.e. $\pi^i_{y^i x^i} < 0$, the planning optimal plywood exports take into account the repercussion of log exports on plywood profits and vice versa. It follows that if log exports are not at the optimum, any distortionary effects present in the log sector will have a repercussion on the plywood sector.

Table 7.3: The extent that the first-order conditions under Scenario B and D diverge from the planning optimum

	Vertical integration Plywood quotas Scenario B	No plywood quotas Scenario D
No log export ban	log: $(\tilde{r}_X x^D + p_Y y_r^A \tilde{r}_X y^D)\frac{dx^B}{dx^D}$ $-C^{log}$ pw: $(\tilde{r}_X x^D + p_Y y_r^A \tilde{r}_X y^D)\frac{\partial x^B}{\partial x^i}\frac{dx^i}{dy^D}$ $-C^{log}\frac{dx^i}{dy^D}$ if pro-competitive effect dominates in log market $x^* < x^{b1} + x^{b2}$ $y^{b1} + y^{b2} < y^*$ if commitment failure effect dominates in log market $x^* > x^{b1} + x^{b2}$ $y^{b1} + y^{b2} > y^*$	log: $\tilde{r}_X \frac{\partial x^B}{\partial x^D} x^D + p_Y y_r^A \tilde{r}_X \left(1 + \frac{\partial x^B}{\partial x^D}\right) y^D$ $-C^{log}$ pw: $\mu^D(g - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right)) + p_Y \frac{dy^A}{dy^D} y^D$ $+\tilde{r}_{y^D} x^D - C^{pw}$ if pro-competitive effect dominates in both markets $x^* < x^{d1} + x^{d2}$ $y^* < y^{d1} + y^{d2}$ if strategic accommodation and commitment failure in the log market dominate $x^* > x^{d1} + x^{d2}$ if strategic pre-emption dominates $x^* < x^{d1} + x^{d2}$ if double marginalisation and commmitment failure dominate in the plywood market $y^* > y^{d1} + y^{d2}$

where $-C^{pw} < 0$ and $-C^{log} < 0$ represent the pro-competitive effect in the plywood and log industry respectively; $x^{a1}, x^{a2}, y^{a1}, y^{a2}$ are log and plywood outputs from Scenario A; $x^{b1}, x^{b2}, y^{b1}, y^{b2}$ are log and plywood outputs from Scenario B etc.

Table 7.4: The extent that the first-order conditions under Scenario D and E diverge from the planning optimum

	No plywood quotas	
		Scenario E (Vertical separation)
No log export ban		log: $\tilde{r}_X \frac{\partial x^B}{\partial x^D} x^D + p_Y y_r^A \tilde{r}_X \left(1 + \frac{\partial x^B}{\partial x^D}\right) y^D - C^{log}$ pw: $\mu^D(g - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right)) + p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D$ $-C^{pw}$ if competition effect dominates in both markets $x^* < x^{e1} + x^{e2}$ $y^* < y^{e1} + y^{e2}$ if commitment failure dominates in log market $x^* > x^{e1} + x^{e2}$ if commitment failure, cross-industry and double marginalisation effect dominate in plywood market $y^* > y^{e1} + y^{e2}$

	With optimal specific taxes and subsidies No plywood quotas	
	Scenario D (Vertical integration)	Scenario E (Vertical separation)
No log export ban	log: $-C^{log}$ pw: $-C^{pw}$ $x^* < x^{d1} + x^{d2}$ $y^* < y^{d1} + y^{d2}$	log: $-C^{log}$ pw: $\mu^D(g - \alpha\left(\frac{\mu^D y^D + x^D}{2}\right)) - C^{pw} \frac{dx^D}{dy^D}$ if competition effect dominates in both markets $x^* < x^{e1} + x^{e2}$ $y^* < y^{e1} + y^{e2}$ if double marginalisation effect dominates in the plywood market $x^* < x^{e1} + x^{e2}$ $y^* > y^{e1} + y^{e2}$

where $-C^{pw} < 0$ and $-C^{log} < 0$ represent the pro-competitive effect in the plywood and log industry respectively.

Appendix C

Appendix

C.1 Scenario B: How log export price changes as log export increases under the plywood quota system with integrated home firms

$\frac{d\bar{r}}{dx^i}$ must satisfy the log market equilibrium in country A and the FOCs for y_N^D (i.e. the government's choice of plywood quota) and y_N^A. Let $\Omega^A \equiv \mu^A y_N^A(y_N^D, \bar{r}) - X = 0$, where $X = 2x^i + x^B$. Totally differentiating this and the FOC for plywood exports give,

$$\begin{aligned}
\hat{W}_{y^D y^D} dy_N^D + \hat{W}_{y^D y^A} dy_N^A + \hat{W}_{y^D x^i} dx^i + \hat{W}_{y^D r} dr &= 0; &\text{(C.1)}\\
\pi^A_{y^A y^D} dy_N^D + \pi^A_{y^A y^A} dy_N^A + \pi^A_{y^A x^i} dx^i + \pi^A_{y^A r} dr &= 0; &\text{(C.2)}\\
\Omega^A_{y^D} dy_N^D + \Omega^A_{y^A} dy_N^A + \Omega^A_{x^i} dx^i + \Omega^A_r dr &= 0. &\text{(C.3)}
\end{aligned}$$

Since $\pi^A_{y^A x^i} = 0, \pi^A_{y^A r} = \mu^A; \Omega^A_{x^i} = -1; \Omega^A_{y^A} = \mu^A; \Omega^A_{y^D} = \mu^A \partial y^A / \partial y^D$ and $\Omega^A_r = \mu^A y^A_r$, these equations can be simplified to

$$\begin{pmatrix} \hat{W}_{y^D y^D} & \hat{W}_{y^D y^A} & \hat{W}_{y^D x^i} \\ \pi^A_{y^A y^D} & \pi^A_{y^A y^A} & 0 \\ \mu^A \partial y^A/\partial y^D & \mu^A & -1 \end{pmatrix} \begin{pmatrix} dy_N^D \\ dy_N^A \\ dx^i \end{pmatrix} = \begin{pmatrix} \hat{W}_{y^D r} dr \\ \mu^A dr \\ -\mu^A y^A_r dr \end{pmatrix}. \qquad \text{(C.4)}$$

Since we assume that the equilibrium is locally strictly stable, the determinant of the matrix above is positive, i.e. $|B_1| = \hat{W}_{y^D x^i}(\pi^A_{y^A y^D}\mu^A - \pi^A_{y^A y^A}\mu^A \partial y^A/\partial y^D) - (\hat{W}_{y^D y^D}\pi^A_{y^A y^A} - \pi^A_{y^A y^D}\hat{W}_{y^D y^A}) < 0$. Solving for $\frac{dy_N^D}{dr}$, $\frac{dy_N^A}{dr}$ and $\frac{dX}{dr}$ give:

1. $\frac{dy_N^D}{d\bar{r}} = \frac{\hat{W}_{y^D x^i}(\mu^A \mu^A + \pi^A_{y^A y^A}\mu^A y^A_r) - (\hat{W}_{y^D r}\pi^A_{y^A y^A} - \mu^A \hat{W}_{y^D y^A})}{|B_1|} > 0;$

2. $\frac{dy_N^A}{d\bar{r}} = \frac{\hat{W}_{y^D x^i}(\mu^A y^A_r \pi^A_{y^A y^D} - \mu^A \mu^A \partial y^A/\partial y^D)}{|B_1|} < 0;$

3. $\frac{dX}{d\bar{r}} = \frac{\hat{W}_{y^D r}\mu^A(\pi^A_{y^A y^D} - \pi^A_{y^A y^A}\partial y^A/\partial y^D) - \mu^A y^A_r[\hat{W}_{y^D y^D}\pi^A_{y^A y^A} - \pi^A_{y^A y^D}\hat{W}_{y^D y^A}]}{|B_1|}$
$- \frac{(\mu^A)^2[\hat{W}_{y^D y^D} - (\partial y^A/\partial y^D)\hat{W}_{y^D y^A}]}{|B_1|} < 0.$

C.2 Scenario D: Effect of plywood export subsidy with two vertically integrated home firms

The impact of a subsidy shock on plywood exports under vertical integration is found by totally differentiating the FOCs in the plywood market:

$$\left(\pi^i_{y^iy^i} + \pi^i_{y^iy^j}\right) dy^i_N + \pi^i_{y^iy^A} dy^A_N + \pi^i_{y^is} ds = 0; \tag{C.5}$$

$$\pi^A_{y^Ay^i} dy^i_N + \pi^A_{y^Ay^A} dy^A_N + \pi^A_{y^As} ds = 0. \tag{C.6}$$

Since $\pi^i_{y^is} = 1$ and $\pi^A_{y^As} = 0$, these equations can be simplified to

$$\begin{pmatrix} \left(\pi^i_{y^iy^i} + \pi^i_{y^iy^j}\right) & \pi^i_{y^iy^A} \\ \pi^A_{y^Ay^i} & \pi^A_{y^Ay^A} \end{pmatrix} \begin{pmatrix} dy^i_N \\ dy^A_N \end{pmatrix} = \begin{pmatrix} -1ds \\ 0 \end{pmatrix}. \tag{C.7}$$

Since we assume that the equilibrium is locally strictly stable, the determinant of the matrix above is positive, i.e. $|D| = (\pi^i_{y^iy^i} + \pi^i_{y^iy^j})\pi^A_{y^Ay^A} - \pi^i_{y^iy^A}\pi^A_{y^Ay^i} > 0$. Solving for $\frac{dy^i_N}{ds}$ and $\frac{dy^A_N}{ds}$ gives the effect of subsidy as follows:

1. $\frac{dy^i_N}{ds} = \frac{-\pi^A_{y^Ay^A}}{|D|} > 0$;
2. $\frac{dy^A_N}{ds} = \frac{\pi^A_{y^Ay^i}}{|D|} < 0$.

C.3 Scenario D: How log export price changes as log export increases - for vertically integrated home firms

$\frac{d\bar{r}(y^1_N, y^2_N, x^1, x^2, x^B)}{dx^1}$ must satisfy the log market equilibrium and the FOC for y^A, y^1 and y^2. Let $\Omega^A \equiv \mu^A y^A(y^1_N, y^2_N, r) - X = 0$, where $X = x^1 + x^2 + x^B$. By symmetry of firm y^i and y^j, y^i_N and y^j_N are equivalent, totally differentiating independent FOCs and Ω^A give

$$(\pi^i_{y^iy^i} + \pi^i_{y^jy^i})dy^i_N + \pi^i_{y^iy^A}dy^A_N + \pi^i_{y^iX}dX + \pi^i_{y^ir}dr = 0 \tag{C.8}$$

$$\pi^A_{y^Ay^i}dy^i_N + \pi^A_{y^Ay^A}dy^A_N + \pi^A_{y^AX}dX + \pi^A_{y^Ar}dr = 0 \tag{C.9}$$

$$\Omega^A_{y^i}dy^i_N + \Omega^A_{y^A}dy^A_N + \Omega^A_X dX + \Omega^A_r dr = 0 \tag{C.10}$$

Since $\pi^i_{y^iX} = 0; \pi^i_{y^ir} = 0; \pi^A_{y^AX} = 0; \pi^A_{y^Ar} = -mu^A; \Omega^A_{y^i} = \mu^A\frac{\partial y^A}{\partial y^i}; \Omega^A_{y^A} = \mu^A; \Omega^A_X = -1$; and $\Omega^A_r = \mu^A y^A_r$, these equations can be simplified to

$$\begin{pmatrix} (\pi^i_{y^iy^i} + \pi^i_{y^iy^j}) & \pi^i_{y^iy^A} & \pi^i_{y^iX} \\ \pi^A_{y^Ay^i} & \pi^A_{y^Ay^A} & 0 \\ \mu^A\partial y^A/\partial y^i & \mu^A & -1 \end{pmatrix} \begin{pmatrix} dy^i_N \\ dy^A_N \\ dX \end{pmatrix} = \begin{pmatrix} 0 \\ \mu^A dr \\ -\mu^A y^A_r dr \end{pmatrix}. \tag{C.11}$$

Since we assume that the equilibrium is locally strictly stable, the determinant of the matrix above is negative, i.e. $|B_2| = -((\pi^i_{y^iy^i} + \pi^i_{y^iy^j})\pi^A_{y^Ay^A} - \pi^A_{y^Ay^i}\pi^i_{y^iy^A}) < 0$. Solving for $\frac{dy^i_N}{dr}$, $\frac{dy^A_N}{dr}$ and $\frac{dX}{dr}$ give the effect of tax as follows:

1. $\frac{dy^i_N}{dr} = -\frac{\mu^A \pi^i_{y^i y^A}}{|B_2|} > 0;$

2. $\frac{dy^A_N}{dr} = \frac{-(\pi^i_{y^i y^i} + \pi^i_{y^i y^j})}{|B_2|} < 0.$

3. $\frac{dX}{dr} = \frac{(\mu^A)^2((\pi^i_{y^i y^i} + \pi^i_{y^i y^j}) - \pi^i_{y^i y^A}\partial y^A/\partial y^i) - \mu^A y^A_r(\pi^A_{y^A y^A}(\pi^i_{y^i y^i} + \pi^i_{y^i y^j}) - \pi^A_{y^A y^i}\pi^i_{y^i y^A})}{|B_2|} < 0.$

Note that the change in the equilibrium price of log also affects y^1_N, y^2_N, y^A_N and X in vertically separated sectors in the same way.

C.4 Scenario D: Effect of log export tax with two vertically integrated home firms

The impact of a tax shock on log exports under vertical integration is found by totally differentiating the FOCs in the log market in country A:

$$\begin{aligned}
(\frac{d^2\pi^i}{dx^i\partial x^i} + \frac{d^2\pi^i}{dx^i\partial x^j})dx^i_N + \frac{d^2\pi^i}{dx^i\partial x^B}dx^B_N + \pi^i_{x^i t}dt &= 0; &\text{(C.12)}\\
\pi^B_{x^B x^i}dx^i + \pi^B_{x^B x^B}dx^B + \pi^B_{x^B t}dt &= 0. &\text{(C.13)}
\end{aligned}$$

Since $\frac{d^2\pi^i}{dx^i\partial t} = -1$ and $\pi^B_{x^B t} = 0$, these equations can be simplified to

$$\begin{pmatrix} \left(\frac{d^2\pi^i}{dx^i\partial x^i} + \frac{d^2\pi^i}{dx^i\partial x^j}\right) & \frac{d^2\pi^i}{dx^i\partial x^B} \\ \pi^B_{x^B x^i} & \pi^B_{x^B x^B} \end{pmatrix} \begin{pmatrix} dx^i_N \\ dx^B_N \end{pmatrix} = \begin{pmatrix} 1dt \\ 0 \end{pmatrix}. \tag{C.14}$$

Since we assume that the equilibrium is locally strictly stable, the determinant of the matrix above is positive, i.e. $|D_1| = (\frac{d^2\pi^i}{dx^i\partial x^i} + \frac{d^2\pi^i}{dx^i\partial x^i})\pi^B_{x^B x^B} - \pi^B_{x^B x^i}\frac{d^2\pi^i}{dx^i\partial x^B} > 0$. Solving for $\frac{dx^i_N}{dt}$ and $\frac{dx^B_N}{dt}$ gives the effect of tax as follows:

1. $\frac{dx^i_N}{dt} = \frac{\pi^B_{x^B x^B}}{|D_1|} < 0;$

2. $\frac{dx^B_N}{dt} = \frac{-\pi^B_{x^B x^i}}{|D_1|} > 0.$

C.5 Scenario D: Optimal export tax and subsidy for vertically integrated home firms

The exporting country sets t and s to maximise welfare $W^d(t, x^i_N(t), s, y^i_N(s))$ in (7.35).

Optimal trade policy in the log sector:

The optimal log export policy is,

$$\begin{aligned}\left.\frac{dW^d(t,x^i(t))}{dt}\right|_s &= W_t^d + W_{x^i}^d\frac{dx_N^i}{dt}\\ &= 2\Big(-x^i + \frac{d\tilde{r}}{dx^i}x^i\frac{dx_N^i}{dt} + (\tilde{r}-t-m^D)\frac{dx_N^i}{dt} + \frac{dp}{dx^i}y^i\frac{dx_N^i}{dt}\\ &\quad +t\frac{dx_N^i}{dt} + x^i\Big) = 0, \end{aligned} \tag{C.15}$$

where

$$\begin{aligned}\frac{d\tilde{r}}{dx^i} &= \tilde{r}_X\Big(1+\frac{dx^B}{dx^i}\Big);\\ \frac{dp}{dx^i} &= p_Y y_r^A\frac{d\tilde{r}}{dx^i}.\end{aligned}$$

From (7.30), (C.15) simplifies to

$$t\frac{dx_N^i}{dt} = -\tilde{r}_X\frac{dx^B}{dx^i}x^i\frac{dx_N^i}{dt} - p_Y y_r^A\tilde{r}_X\frac{dx^B}{dx^i}\frac{dx_N^i}{dt} + p_Y\left(1+y_r^A\tilde{r}_{y^j}\right)\frac{dy^j}{dx^i}\frac{dx_N^i}{dt}. \tag{C.16}$$

Dividing through by $\frac{dx_N^D}{dt}$ gives,

$$t^I = -\tilde{r}_X\frac{dx^B}{dx^1}x^1 - p_Y y_r^A\tilde{r}_X\frac{dx^B}{dx^i} + p_Y\left(1+y_r^A\tilde{r}_{y^j}\right)\frac{dy^j}{dx^i}. \tag{C.17}$$

While the first two components which correct the commitment failure are negative, the last component correcting the strategic pre-emption effect is positive. Therefore, the optimal trade policy on plywood may be a tax or a subsidy depending on which effect dominates.

Optimal trade policy in the plywood sector:

$$\begin{aligned}\left.\frac{dW^d(s,y_N^i(s))}{ds}\right|_t &= W_s^d + W_{y_N^i}^d\frac{dy_N^i}{ds}\\ &= 2\Big(y^i + \frac{dp}{dy^i}y^i\frac{dy_N^i}{ds} + (p+s-c^D-\mu^D(\frac{\mu^D y^D}{2}+x^i))\frac{dy_N^i}{ds}+\\ &\quad \left.\frac{d\tilde{r}}{dy^i}\right|_{x^i} x^i\frac{dy_N^i}{ds} - s\frac{dy_N^i}{ds} - y^i\Big) = 0, \end{aligned} \tag{C.18}$$

where

$$\begin{aligned}
\frac{dp}{dy^i} &= p_Y\left(1+\frac{dy^A}{dy^i}\right); \\
\frac{dy^A}{dy^i} &= \frac{\partial y^A}{\partial y^i} + y^A_{\tilde{r}}\left.\frac{d\tilde{r}}{dy^i}\right|_{x^i}; \\
\left.\frac{d\tilde{r}}{dy^i}\right|_{x^i} &= \tilde{r}_{y^i}.
\end{aligned} \tag{C.19}$$

From (7.26), (C.18) simplifies to

$$s\frac{dy^i_N}{ds} = p_Y\frac{dy^A}{dy^i}y^i\frac{dy^i_N}{ds} + \tilde{r}_{y^i}x^i\frac{dy^i_N}{ds}. \tag{C.20}$$

Dividing through by $\frac{dy^1}{ds}$ gives,

$$s^I = p_Y\frac{dy^A}{dy^i}y^i + \tilde{r}_{y^i}x^i > 0. \tag{C.21}$$

Thus the it is optimal to subsidise plywood under vertical integration.

C.6 Scenario D: Proof of Proposition 11

$$\begin{aligned}
\sum_i\frac{d\pi^i}{dy^i} &= \sum_i\left(p_Y y^i + p_Y\frac{dy^A}{dy^i}y^i + \tilde{r}_{y^i}x^i - c^D - \alpha(x^i+\mu^D y^i)\right) \\
&= \left.\frac{dW}{dy^D}\right|_{x^D} - C^{pw};
\end{aligned} \tag{C.22}$$

$$\begin{aligned}
\sum_i\frac{d\pi^i}{dx^i} &= \sum_i\left(\tilde{r}_X\left(1+\frac{dx^B}{dx^i}\right)x^i + \tilde{r} - \alpha(x^i+\mu^D y^i) + +p_Y y^A_{\tilde{r}}\tilde{r}_X\left(1+\frac{dx^B}{dx^i}\right)y^i\right) \\
&= \left.\frac{dW}{dx^D}\right|_{y^D} - C^{log}.
\end{aligned} \tag{C.23}$$

C.7 Effect of log export tax with two vertically separated home firms

Again, we derive the effect of export tax on log exports by totally differentiating the Cournot FOCs for x^i and x^B. Assuming that the equilibrium is locally strictly stable, the determinant of these conditions is $|D_2| = (\pi^i_{x^ix^i}+\pi^i_{x^ix^i})\pi^B_{x^Bx^B} - \pi^B_{x^Bx^i}\pi^i_{x^ix^B} > 0$. Solving for $\frac{dx^i_N}{dt}$ and $\frac{dx^B_N}{dt}$ gives the effect of tax as follows:

1. $\frac{dx^i_N}{dt} = \frac{\pi^B_{x^Bx^B}}{|D_2|} < 0$;

2. $\frac{dx_N^B}{dt} = \frac{-\pi^B_{x^B x^i}}{|D_2|} > 0.$

Note that $|D_1|$, i.e. the determinant under vertical integration, is greater than $|D_2|$ because of the strategic component $\frac{\partial(dp/dx^i|_{x^j,x^B})}{\partial x^i} y^i$. Thus the impact of export tax on log exports of non-integrated firms will be greater than the impact on integrated firms.

C.8 Scenario E: Optimal export taxes and subsidies when home firms are separated

This time the exporting country sets t and s to maximise welfare $W^e(t, x_N^i(t), s, y_N^i(s))$ in (7.50). Again the planner chooses the optimal trade policy for the first stage game, i.e. the upstream game, followed by the optimal trade policy for the downstream game (taking the optimal upstream policy as given).

Optimal trade policy in the log sector:

$$
\begin{aligned}
\left.\frac{dW^e(t,x(t))}{dt}\right|_s &= W_t^e + W_{x^i}^e \frac{dx_N^i}{dt} \\
&= 2\left(-x^i + \left.\frac{d\tilde{r}}{dx^i}\right|_{y^i} x^i \frac{dx_N^i}{dt} + (\tilde{r} - t - \alpha(x^i + \mu^D y^i))\frac{dx_N^i}{dt} + \frac{dp}{dx^i} y^i \frac{dx_N^i}{dt}\right. \\
&\quad \left. + t\frac{dx_N^i}{dt} + x^i\right) = 0,
\end{aligned}
\tag{C.24}
$$

where

$$
\begin{aligned}
\left.\frac{d\tilde{r}}{dx^i}\right|_{y^i} &= \tilde{r}_X\left(1 + \frac{dx^B}{dx^1}\right); \\
\frac{dp}{dx^i} &= p_Y y_{\tilde{r}}^A \left.\frac{d\tilde{r}}{dx^i}\right|_{y^i}.
\end{aligned}
$$

From (7.45), (C.24) simplifies to

$$
t\frac{dx_N^i}{dt} = -\tilde{r}_X \frac{dx^B}{dx^i} x^i \frac{dx_N^i}{dt} - \frac{dp}{dx^i} y^i \frac{dx_N^i}{dt}. \tag{C.25}
$$

Dividing through by $\frac{dx_N^1}{dt}$ gives,

$$
t^N = -\tilde{r}_X \frac{dx^B}{dx^i} x^i - \frac{dp}{dx^i} y^i. \tag{C.26}
$$

Optimal trade policy on plywood sector:

$$
\begin{aligned}
\left.\frac{dW^e(s,y^1(s))}{ds}\right|_t &= W_s^e + W_{y^i}^e \frac{dy_N^i}{ds} \\
&= 2\left(y^i + p_Y\left(1+\frac{dy^A}{dy^i}\right)y^i\frac{dy_N^i}{ds} + (p+s-c^D-\mu^D g)\frac{dy_N^i}{ds} + \frac{d\tilde{r}}{dy^i}x^i\frac{dy_N^i}{ds}\right. \\
&\quad \left. -s\frac{dy_N^i}{ds} - y^i\right) = 0. \qquad \text{(C.27)}
\end{aligned}
$$

From (7.39), (C.27) simplifies to

$$
s\frac{dy_N^i}{ds} = p_Y\frac{dy^A}{dy^i}y^i\frac{dy_N^i}{ds} + \tilde{r}_{y^i}x^i\frac{dy_N^i}{ds}. \qquad \text{(C.28)}
$$

Dividing through by $\frac{dy_N^i}{ds}$ gives,

$$
s^N = p_Y\frac{dy^A}{dy^i}y^i + \tilde{r}_{y^i}x^i > 0. \qquad \text{(C.29)}
$$

Thus it is optimal to subsidise plywood under vertical seaparation.

C.9 Scenario E: Proof of Proposition 14

$$
\begin{aligned}
\sum_i \left.\frac{d\pi^i}{dy^i}\right|_{t,x^i} &= \sum_i\left(p_Y\left(1+\frac{dy^A}{dy^i}\right)y^i + \tilde{r}_{y^i}x^i - c^D - \mu^D g\right) \\
&= \left.\frac{dW}{dy^D}\right|_{x^D} + \mu^D(g-\alpha(x^i+\mu^D y^i)) - C^{pw} \qquad \text{(C.30)} \\
\sum_i \left.\frac{d\pi^i}{dx^i}\right|_{y^i} &= \sum_i\left(\tilde{r}_X\left(1+\frac{dx^B}{dx^i}\right)x^i + r - \alpha(x^i+\mu^D y^i) + \frac{dp}{dy^i}y^1\right) \\
&= \left.\frac{dW}{dx^D}\right|_{y^D} - C^{log}, \qquad \text{(C.31)}
\end{aligned}
$$

where

$$
\frac{dp}{dy^i} = p_Y y_r^A \tilde{r}_X\left(1+\frac{dx^B}{dx^i}\right).
$$

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