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Can Indonesia Gain from Log Export Barriers?

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Abstract

We use a model of sequential duopoly to examine the effect of vertical ownership structure on firms' outputs and profit shares in the international market for raw and processed tropical timber products. The model provides insights that can be applied to the Indonesian logging and plywood industry; shedding light on the appropriate policy responses.

We find that when industries are integrated, the government should subsidise both exports. Thus, despite log and plywood being strategic substitutes, log export barriers make Indonesia worse off. When industries are separated, however, plywood exports should be subsidised but the optimal trade policy on log exports depends on two effects. If the commitment failure effect (as in Brander and Spencer (1985)) dominates then log exports should be subsidised, however, if the negative cross-industry effect dominates then log exports should be taxed.

Keywords: Trade with imperfect competition; Vertical integration; Forest products
JEL Classifications: F19; D43; L22; L73

1 Introduction

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.

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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 paper uses strategic trade policy theory to examine this. Since vertical ownership structure (i.e. separation vs. integration) affects the optimal trade policy outcome, its effect is also analysed. This paper 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 trade 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

[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 paper 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.

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-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 assumes that the firm is a monopoly in one of the markets and derives results accordingly. This industrial structure is not appropriate for the forest sector, which is characterised by vertically related oligoplistic 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. Government 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. Similarly to Greenhut and Ohta (1979), Salinger (1988) and Abiru et al. (1998), the log producers are assumed to move first followed by the final good producers. Thus we can solve the model in two

[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.

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 the double marginalisation effect; the commitment failure effect and the 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 which is due to commitment failure arises from the Cournot conjecture of domestic firms, which does not properly reflect the competitors' behaviour. Subsequently it does not take advantage of the fact that a competitor would accommodate if it behaves aggressively in the market. The third distortion refers to the repercussion of export decisions across vertically related industries. We find that a rise in plywood export 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

[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.

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 the log export from the home country ultimately reduces 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 in fact over-compensates for the cross-industry effect 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 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 paper is organised as follows: Section 2 presents the model setup. The optimal outputs and trade policy under nonintegration are presented in Section 3; while those for the integrated case are presented in Section 4. Section 5 contrasts the implications of different ownership structures. Section 6 concludes and discusses policy implications.

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 some conjecture 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 can make more profits from downstream sales than from upstream sales and that, therefore, they 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

[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.

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. 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 paper 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; and his objective function is thus

$$\max_{x^D, y^D} \; W = (p(Y) - c^D)y^D - m^D z^D + (r(X) - m^D)x^D, \tag{1}$$

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 (denoted 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 (1) gives

$$\max_{x^D, y^D} \; W = (p(Y) - c^D - \mu^D m^D)y^D + (\tilde{r}(X) - m^D)(\mu^A y^A(\tilde{r}, y^D) - x^B(x^D)), \tag{2}$$

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

$$\left.\frac{dW}{dy^D}\right|_{x^D} = \frac{dp}{dy^D}y^D + p - c^D - \mu^D m^D + \frac{d\tilde{r}}{dy^D}x^D = 0, \tag{3}$$

where

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

The choice of x^D, in turn, is

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \frac{d\tilde{r}}{dx^D}x^D + \tilde{r} - m^D + \frac{dp}{dx^D}y^D = 0, \tag{4}$$

where

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

$\frac{d\tilde{r}}{dy^D}$ and $\frac{dp}{dx^D}$ in (3) and (4) represent the cross-industry effects from log exports 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.

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 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.

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:

$$\max_{y^D} \ \pi^{D2}(y^D)\Big|_{y^A,g} = (p(Y) + s - c^D - \mu^D g)y^D. \tag{5}$$

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

$$\max_{y^A} \ \pi^{A}(y^A)\Big|_{y^D,r} = (p(Y) - c^A - \mu^A r)y^A. \tag{6}$$

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 (FOCs) for a Cournot-Nash equilibrium in the plywood market are

$$\left.\frac{d\pi^{D2}}{dy^D}\right|_{y^A} = \pi^{D2}_{y^D} = \left.\frac{dp}{dy^D}\right|_{y^A} y^D + p + s - c^D - \mu^D g = 0, \tag{7}$$

$$\left.\frac{d\pi^{A}}{dy^A}\right|_{y^D} = \pi^{A}_{y^A} = \left.\frac{dp}{dy^A}\right|_{y^D} y^A + p - c^A - \mu^D r = 0. \tag{8}$$

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

From (7) and (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

$$y^D_N = y^D(r, g, s); \quad y^A_N = y^A(r, g, s). \tag{9}$$

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 (7) and (8), we discern how the plywood outputs vary with export subsidy (see Appendix 1 for derivations):

$$\frac{dy^D_N}{ds} = -\frac{\pi^A_{y^A y^A}}{H} > 0; \ \frac{dy^A_N}{ds} = \frac{\pi^A_{y^A y^D}}{H} < 0. \tag{10}$$

From (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.

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:

$$\max_{x^D, z^D} \pi^{D1}\Big|_{x^B} = (g(Z) - m^D)z^D + (r(X) - t - m^D)x^D; \tag{11}$$

$$\max_{x^B} \pi^B\Big|_{x^D} = (r(X) - m^B)x^B; \tag{12}$$

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 (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 (9), using $\mu^D y_N^D(r, g, s) = z^D$.

By totally differentiating (7), (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 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 (7), (8) and the log market equilibrium

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

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 supply of log are found to have a negative effect on the domestic price of log, i.e. $\frac{d\tilde{g}}{dZ} < 0$ (see Appendix 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 z^D and x^D by the domestic harvester is thus

$$\begin{aligned} \left.\frac{d\pi^{D1}}{dz^D}\right|_{x^B,x^D} &= \pi^{D1}_{z^D} + \pi^{D1}_{y^D}\frac{dy^D}{dz^D} + \pi^{D1}_{y^A}\frac{dy^A}{dz^D} \\ &= \left.\frac{d\tilde{g}}{dz^D}\right|_{x^D,x^B} z^D + g - m^D = 0; \qquad (13) \\ \left.\frac{d\pi^{D1}}{dx^D}\right|_{x^B,z^D} &= \pi^{D1}_{x^D} + \pi^{D1}_{y^D}\frac{dy^D}{dx^D} + \pi^{D1}_{y^A}\frac{dy^A}{dx^D} \\ &= \left.\frac{d\tilde{r}}{dx^D}\right|_{x^B z^D} x^D + r - t - m^D = 0, \qquad (14) \end{aligned}$$

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

Since $\pi^{D1}_{y^D} = 0$ from (7), the only strategic effect in (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 (13) and (14).

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

$$\pi^B = (r(X) - m^B)x^B, \qquad (15)$$

subject to the log market equilibrium condition.

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

$$\left.\frac{d\pi^B}{dx^B}\right|_{x^D,z^D} = \left.\frac{d\tilde{r}}{dx^B}\right|_{x^D z^D} x^B + r - m^B = 0, \qquad (16)$$

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

(14) and (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 (13), (14) and (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 (14) and (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 4 for the derivations).

$$\frac{dx_N^D}{dt} = \frac{\pi^{D1}_{x^B x^B}}{|D^N|} < 0; \text{ and } \frac{dx_N^B}{dt} = -\frac{\pi^B_{x^B x^D}}{|D^N|} > 0. \tag{17}$$

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.

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

$$\begin{aligned} W^N(s,t,y_N^D(s),x_N^D(t)) &= \pi^{D1}(t,x_N^D(t)) + \pi^{D2}(s,y_N^D(s)) - sy_N^D(s) \\ &\quad + tx_N^D(t). \end{aligned} \tag{18}$$

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 (3) and (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 externatities across industries.[7]

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

Proof: See Appendix 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 (19) and (20) contrast the action of the nonintegrated suppliers under Cournot duopoly with the planning optimum. From (7), (13) and (14), at the Cournot equilibrium with $s = t = 0$, (3) and (4) become

$$\left.\frac{dW}{dy^D}\right|_{x^D} = \mu^D(g - m^D) + p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D; \tag{19}$$

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D \tag{20}$$

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

[6] Although Spencer and Jones (1991,92) examine the optimal tax strategies in vertically related industries, they assume that the upstream firm has monopoly power and so arrive to 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.

The divergence from a planning choice of y^D comes from three effects: (i) double marginalisation; (ii) commitment failure; (iii) cross-industry externality. The double marginalisation effect comes from the mark-up on the intermediate supplies, which tends to depress the downstream exports (i.e. double marginalisation). The second component of (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 (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 tend to 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 (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 (20) have opposing signs, whether log export should be curbed or promoted depends on the sign of the net effect.

3.4 Export taxes and subsidies under non-integration

The exporting country will set s and t to maximise welfare in (18). The optimisation problem is laid out in Appendix 5. Note that when the value of export is zero in one industry, the optimal trade policy coincides with Brander and Spencer (1985)'s.[8] When both exports are positive, the optimal export policy in the log and plywood market are as follows,

$$t^N = -\tilde{r}_X \left(\frac{dx^B}{dx^D} \right) x^D - \frac{dp}{dx^D} y^D; \tag{21}$$

$$s^N = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D. \tag{22}$$

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 (21) and (22) with the divergences stated in (20) and (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.

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 (7) and (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.

[8]See Condition (55) and (57) in Appendix 5.

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 5.

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.

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:

$$\max_{y^D,x^D} \pi^D = (p(Y) + s - c^D - \mu^D m^D)y^D + (r(X) - t - m^D)x^D. \tag{23}$$

The maximisation problem of the unintegrated foreign plywood firm remains the same as (6). The first-order conditions stemming from Cournot-Nash competition in the plywood market are:

$$\left.\frac{d\pi^D}{dy^D}\right|_{y^A,x^D,x^B} = \pi^D_{y^D} = p_Y y^D + p + s - c^D - \mu^D m^D = 0; \tag{24}$$

$$\left.\frac{d\pi^D}{dy^A}\right|_{y^D,x^D,x^B} = \pi^A_{y^A} = p_Y y^A + p - c^A - \mu^A r = 0. \tag{25}$$

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 (24) is greater than that in (7).

From (24) and (25), the equilibrium plywood outputs can be expressed as a function of r and s:

$$y_N^D = y^D(r, s); \quad y_N^A = y^A(r, s). \tag{26}$$

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

$$\frac{dy_N^D}{ds} = \frac{-\pi^A_{y^A y^A}}{H} > 0; \; \frac{dy_N^A}{ds} = \frac{\pi^A_{y^A y^D}}{H} < 0; \tag{27}$$

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

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

$$\begin{aligned} \left.\frac{d\pi^D}{dx^D}\right|_{x^B} &= \pi^D_{x^D} + \pi^D_{y^D}\left.\frac{dy^D}{dx^D}\right|_{x^B} + \pi^D_{y^A}\left.\frac{dy^A}{dx^D}\right|_{x^B} \\ &= \tilde{r}_X x^D + r - t - m^D + p_Y\left.\frac{dy^A}{dx^D}\right|_{x^B} y^D = 0, \end{aligned} \tag{28}$$

where $\pi^D_{y^D} = 0$ from (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 would accommodate rivals in the intermediate good market more than an unintegrated firm.*

Proof: Since the strategic component in (28) is always negative, the rest of (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 of as its intermediate good 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 (16) in the previous section. From (28) and (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 $|D^I| = (r_{x^Dx^D}x^D + 2r_{x^D} + p_{x^Dx^D})(r_{x^Bx^B}x^B + 2r_{x^B}) - (r_{x^Dx^B}x^D + r_{x^B} + p_{x^Dx^B})(r_{x^Bx^D}x^B + r_{x^D}) > 0$, the impact of an increase in log export tax on x^D and x^B are summarised below (see Appendix 7 for the derivations):

$$\frac{dx^D}{dt} = \frac{r_{x^Bx^B}x^B + 2r_{x^B}}{|D^I|} < 0; \quad \frac{dx^B}{dt} = \frac{-(r_{x^Bx^D}x^B + r_{x^D})}{|D^I|} > 0; \tag{29}$$

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

4.3 Optimal export policy under vertical integration

The welfare in the home country with integrated industry is

$$W(s, t, y^D(s), x^D(s)) = \pi^D(s, t, y^D_N(s), x^D_N(t)) - sy^D_N(s) + tx^D_N(t). \tag{30}$$

As explained in Section 3.4, the optimal policy does not correct the double marginalisation problem. However, when $r > m^D$, the integrated firm sources all intermediate supplies

[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.

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.*

Proof: See Appendix 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 (3) and (4). In a Cournot equilibrium with $s = t = 0$, (3) and (4) become:

$$\left.\frac{dW}{dy^D}\right|_{x^D} = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D > 0; \tag{31}$$

$$\left.\frac{dW}{dx^D}\right|_{y^D} = \tilde{r}_X \frac{dx^B}{dx^D} x^D + p_Y y^A_{\tilde{r}} \tilde{r}_{x^B} \frac{dx^B}{dx^D} y^D > 0. \tag{32}$$

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 (31), the commitment failure $p_Y \frac{dy^A}{dy^D} y^D > 0$ and the cross-industry effects $\tilde{r}_{y^D} x^D > 0$ 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.

4.4 Export taxes and subsidies

Again the exporting country sets s and t to maximise welfare given in (30).

When both exports are positive, the optimal export subsidy and tax satisfy (66) and (67) in Appendix 8. Rearranging gives

$$s^I = p_Y \frac{dy^A}{dy^D} y^D + \tilde{r}_{y^D} x^D > 0; \tag{33}$$

$$t^I = -\tilde{r}_X \frac{dx^B}{dx^D} x^D - p_Y y^A_{\tilde{r}} \tilde{r}_{x^B} \frac{dx^B}{dx^D} y^D < 0. \tag{34}$$

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 (28) and (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 the *direct* and *indirect* commitment failure.

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 1 sets out the extent to which Cournot equilibrium exports under each ownership structure deviate from the planning optimum, with and without trade policy; while Table 2 sets out the preferred ownership structure when optimal trade policy is not available.

From Table 1, when optimal trade policy can be implemented, vertical integration is the

Table 1: The divergence between the planner's choice and the Cournot log and plywood outputs 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 effect dominates, i.e. $\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D < 0$.

Table 2: Without optimal trade policy, which vertical structure yields exports closest to the planning optimum?

<table>
<tr><th></th><th>Cross-industry effect dominates</th><th>Commitment failure dominates</th></tr>
<tr><td>log</td><td>$\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D < 0$

Integration - if the commitment failure is also small</td><td>$\tilde{r}_X \frac{dx^B}{dx^D} x^D + \frac{dp}{dx^D} y^D > 0$

Nonintegration - since the cross-industry effect counteracts some of the commitment failure effect</td></tr>
<tr><td>plywood</td><td colspan="2">$0 < p_Y \frac{dy^A}{dy^D} y^D$ and $0 < \tilde{r}_{y^D} x^D$

Since the cross-industry effect and the commitment effect have the same sign in the plywood industry, integration is always preferred, since $y^N < y^I < y^*$</td></tr>
</table>

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 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 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 mark-ups 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 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 also 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 downstream sector 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 have 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

The appendix is available from the author upon request.

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