

## EFFECT OF NON-TARIFF BARRIERS ON SECONDARY PROCESSED WOOD PRODUCT TRADE: NEW ZEALAND EXPORTS TO THE UNITED STATES, CHINA AND JAPAN

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### ABSTRACT

Secondary processed wood products – builder’s carpentry and joinery, mouldings and millwork, wooden furniture, and prefabricated buildings – have grown significantly in importance in the global trade of wood products. At the same time there has been increased use of non-tariff barriers to restrict their trade. These barriers could have an important impact on the trade of secondary processed products, as well as the production, consumption and trade of wood products used in their manufacture. This paper describes the development of an economic model of the international trade of secondary processed wood products within the structure of the spatial equilibrium Global Forest Products Model. The model was used to assess the effect of removing non-tariff barriers to New Zealand exports of prefabricated housing, and builder’s carpentry and joinery to three key trading partners; the United States, China and Japan. New Zealand exporters would benefit the most from removal of non-tariff barriers that account for the greatest proportion of production costs, i.e., higher design values and engineering certificates for prefabricated houses exported to Japan. The calculated increase in trade value from improved market access is, however, a modest 0 to 9.2% of New Zealand’s total wood products trade by 2030.

**Key words:** secondary processed wood products, non-tariff barriers, trade, spatial equilibrium model, econometrics

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## INTRODUCTION

Although secondary processed wood products (SPWPs) are a small proportion of the production of all wood products, they have grown in their importance in global trade (Desclos, 2000). While the value, in real terms, of primary wood products trade declined by 0.9% pa between 1995 and 2005, the trade of builder's carpentry and joinery, wooden furniture, and prefabricated buildings has grown at 31.4% pa (FAO, 2006). The value of the wooden furniture trade grew 33.7% pa, builder's carpentry and joinery 27.8% pa, and prefabricated buildings 22.6% pa over the same period. As a result of these increases, there has been growing interest by wood producing countries, including New Zealand, in further processing of primary wood products (such as industrial roundwood, sawntimber and wood panels) destined for export, by producing secondary processed wood products. This is recognised as a means of increasing the value of wood product exports as well as encouraging domestic industries and employment (FAO, 2000; Schultz & Gorley, 2006).

The total value of imports of prefabricated houses by Japan and China, and wooden doors by Japan and the United States from 1990 – 2006 is shown in Figure 1. These products contain a high added-value component and, in the case of prefabricated houses, include New Zealand radiata pine in a way that showcases its appropriate use in a variety of wood products that are not well represented in other exports. Consequently, New Zealand is interested in new market opportunities for these types of products.

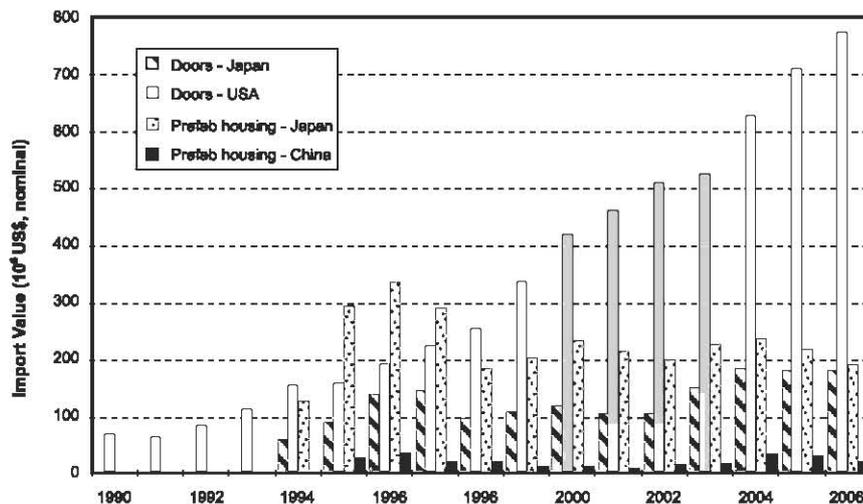


FIGURE 1: Value of total imports of selected SPWP products (US\$ million, nominal) by Japan, China, and the United States. Source: GTIS (2006).

China's total imports of prefabricated houses grew at 18.7% pa from 2001 to 2006, supported by its rapidly developing economy and growing number of middle income earners. Although Japan's imports of prefabricated houses remained steady over this period, the Japanese market remains important for New Zealand due to its size (Figure 1), supported by the country's large housing market, its strong affinity for wood, and high domestic building costs. Japan's wooden door imports grew at 9.4% pa from 2001 to 2006 and the United States' wooden door imports grew at 8.7% pa (GTIS, 2006). New Zealand's share of these markets has been small, but has experienced periods of strong growth (Figure 2). The value of New Zealand exports of wooden doors to Japan increased by 8.7% pa between 1996 and 2001, and those to the United States increased by 29.4% pa. China's prefabricated housing imports from New Zealand grew 17.8% pa over the same period. Japan's prefabricated housing imports from New Zealand declined 22.1% pa during the same period. More recently New Zealand exports of these products to China, Japan and the United States have declined due to the strong New Zealand dollar and high freight costs (Katz, 2008).

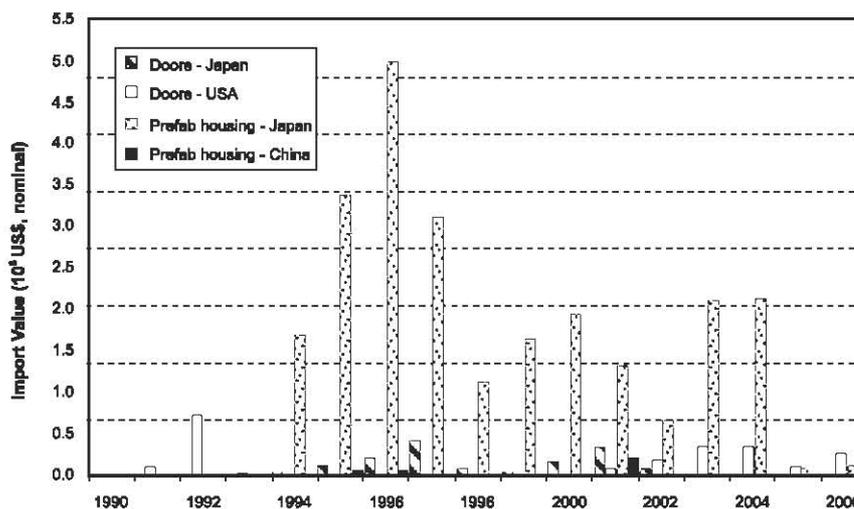


FIGURE 2: Value of imports of selected SPWP products from New Zealand (US\$ million, nominal) by Japan, China, and the United States. Source: GTIS (2006).

In an attempt to increase exports of secondary processed wood products, various countries have sought to reduce the competition between imports and domestic substitutes by trying to eliminate tariff and non-tariff barriers (NTB), such as discriminatory codes and standards (NZFRI, 1999). There have been several international disputes regarding the trade of secondary processed wood products. For example, in 2005 the United States imposed anti-dumping duties on imports of wooden furniture from China (USTR, 2006). The use of NTBs to restrict trade of wood products has also been rising (NZFRI, 1999; Eastin & Fukuda, 2001). This trend may continue where manufacturing employment is declining and pressure on governments to protect domestic manufacturing is rising (Cohen, et al. 2003).

Figure 3 summarizes the main theoretical principle underlying the effect of removing a non-tariff barrier on secondary processed products. The figure symbolizes the import demand ( $D_I$ ) and export supply ( $S_X$ ) of a secondary processed product, in a world with only two countries in a particular year. Two equilibrium states are shown: one with the non-tariff barrier; and the other without the barrier.

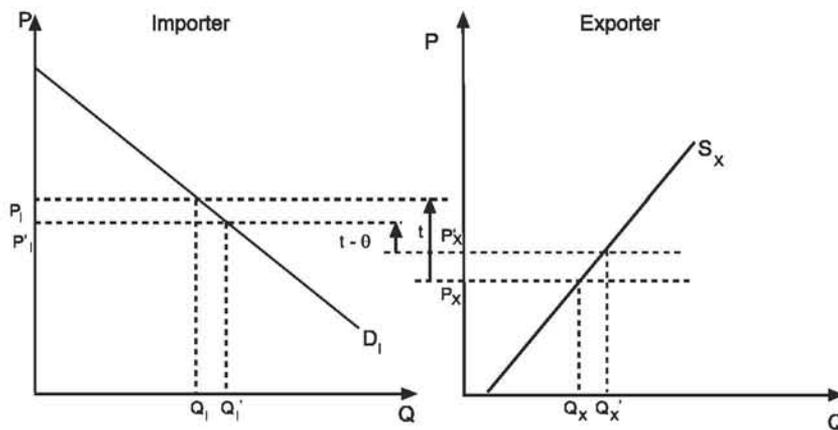


FIGURE 3: Competitive equilibrium with two countries and one product, with and without non-tariff barrier ( $\theta$ ). P refers to product price, Q to product quantity in importing, I, and exporting, X, country where  $t$  is transport cost,  $D_I$  is the import demand curve and  $S_X$  export supply curve.

With the NTB, the price of the SPWP in the importer country is  $P_1$ . At that price, given the import demand schedule symbolized by the line  $D_I$ , the quantity imported is  $Q_1$ . In the exporter country, given the export supply schedule  $S_X$ , the price is  $P_X$ , and the export quantity is  $Q_X$ . At equilibrium, the importer price is equal to the exporter price plus the unit transport cost (which includes the cost of the NTB):  $P_1 = P_X + t$ , and the net trade of the exporter is the opposite of the net trade of the importer:  $Q_1 = -Q_X$ .

With the removal of the NTB,  $\theta$ , the exporter's cost of transporting the SPWP to the importer decreases to  $t - \theta$ . The effect of removing the NTB is to decrease the price in the importing country to  $P'_1$  and increase the quantity imported to  $Q'_1$ . The price increases in the exporting country to  $P'_X$  and export quantity increases to  $Q'_X$ , resulting in increased trade:  $Q'_1 = -Q'_X$ .

Consumer expenditures, i.e., how much consumers must pay for the SPWP in the importer country changes from  $P_1 Q_1$ , with the NTB, to  $P'_1 Q'_1$  without the NTB. Producer revenue in the exporter country increases from  $P_X Q_X$  to  $P'_X Q'_X$ . The effect of the elimination of the NTB on producer revenues and consumer expenditures depends in part on the elasticities of export supply and import demand with respect to price. For example, in

Figure 3, removing the NTB would increase consumer expenditures in the importing country. Producer revenue in the exporting country, though, would always increase.

In general, past economic models of forest sector production, consumption and trade have not included SPWPs. Thus, they cannot predict the effect of barriers to trade, or other policies affecting SPWPs. The CINTRAFOR Global Trade Model (Kallio et al., 1987; Cardellicchio et al., 1989; Perez-Garcia, 1996) and EFI-GTM (Solberg et al., 2003) deals with industrial roundwood, sawnwood and wood pulp. The Timber Assessment Market Model (Adams & Haynes, 1996) covers industrial roundwood, sawnwood, and wood based panels. The Global Forest Products Model (GFPM, Buongiorno et al., 2003) includes products from fuelwood to wood-based panels to paper. In this paper we expand the GFPM to cover the trade of SPWPs.

A lack of internationally comparable statistics on SPWP production is one possible reason for their exclusion in forest sector models. The approach presented below deals with this data limitation by focusing on trade for which customs data, based on international definitions, are available (Michie & Wardle, 1998, United Nations, 2006). This model is then applied to determine the impact of removal of non-tariff barriers to New Zealand prefabricated housing and wooden door exports to three key countries, China, Japan and the United States. The impact of NTBs in these specific areas was estimated using New Zealand exporter survey data on the production costs associated with meeting non-tariff barriers (Katz, 2006; Katz, 2008). The paper concludes with a discussion of the results and their implications.

## MATERIALS AND METHODS

### Model Structure

The SPWPs represented in the model were: builder's carpentry and joinery, mouldings and millwork, wooden furniture, and prefabricated buildings (Table 1). Figure 4 shows how SPWPs continue the product flow described by the GFPM, as they are made of sawnwood, plywood, particleboard, and fibreboard.

It was not possible to represent the total production, consumption, and trade of SPWPs, as for the other products of the GFPM, due to a lack of production data. Instead, we modelled only the net-imports and net-exports of SPWPs, while still adhering to the GFPM structure. Thus, the import demand of net importing countries was represented by an econometric equation that related the quantity of SPWPs imported to country income and product price. The export supply of net-exporting countries was represented by manufacturing activities: input-output coefficients and related manufacturing costs that describe how sawnwood and wood-based panels are used in producing SPWPs for export. The rest of this section describes how SPWPs were incorporated in the GFPM structure. Subsequent sections describe the derivation and estimation of the econometric equations and input-output coefficients.

TABLE 1: Secondary processed wood products represented in the GFPM

Product	HS Code <sup>1</sup> (1992 Edition)	Years	Countries	Usable observations
Builder's carpentry and joinery	4418.10, .20, .30, .40, .50, .90	1962-2004	174	5285
Mouldings and millwork	4409	1988-2004	140	709
Wooden furniture	9403.30, .40, .50, .60	1999-2004	174	1023
Prefabricated buildings	9406	1988-2004	150	935

<sup>1</sup> the Harmonised Commodity Description and Coding System is an internationally standardised system for classifying traded products (Wikipedia, 2008).

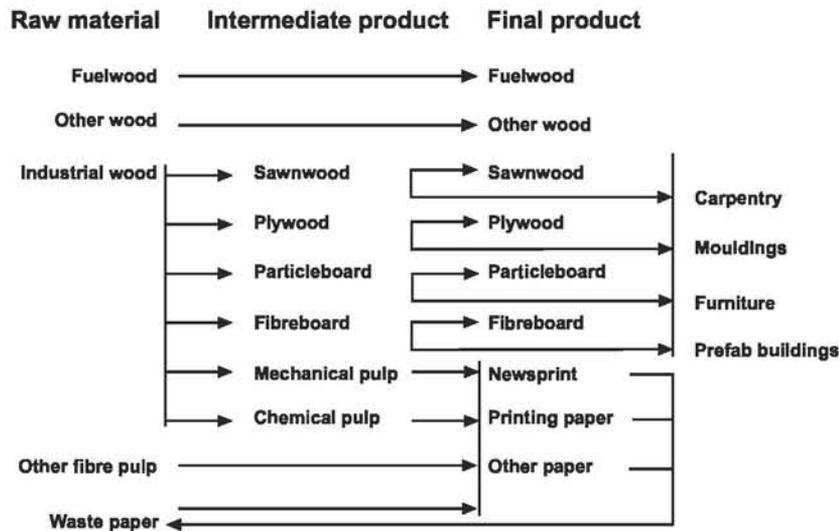


FIGURE 4: The product flow of the GFPM has been extended to represent the part of the domestic consumption of sawnwood, plywood, particleboard, and fibreboard which is used to manufacture exports of builder's carpentry and joinery, mouldings and mill work, wooden furniture, and prefabricated buildings.

The GFPM objective function is the sum of producer and consumer surplus in the global forest sector in any given year (Buongiorno et al., 2003). The part of the objective function incorporating the manufacture of exported SPWPs, their transport, and the demand for imports is:

$$\max Z = \sum_i \sum_k \int_0^{D_{ik}} P_{ik} (D_{ik}) dD_{ik} - \sum_i \sum_k Y_{ik} m_{ik} (Y_{ik}) - \sum_i \sum_j \sum_k c_{ijk} T_{ijk} \quad [1]$$

where  $i, j$  = country,  $k$  = secondary processed product (builder's carpentry and joinery, mouldings and millwork, wooden furniture and prefabricated buildings),  $P$  = price in U.S. dollars of constant value,  $D$  = product import demand,  $Y$  = quantity manufactured for export,  $m$  = cost of manufacture,  $T$  = quantity transported, and  $c$  = cost of transportation. All variables and parameters refer to a particular year. The submodel for SPWPs deals with net trade. Therefore,  $Y = 0$  if a country is a net importer and  $D$  is net imports, and  $D = 0$  if a country is a net exporter, and  $Y$  is net exports.

Import demand for each SPWP has a constant elasticity with respect to price:

$$D_{ik} = D_{ik}^* \left( \frac{P_{ik}}{P_{ik,-1}} \right)^{\delta_{ik}} \quad [2]$$

where  $D^*$  = current import demand at last year's price  $P_{-1}$ , and  $\delta$  = price elasticity of import demand.  $D^*$  depends on last year's import demand, and on the current gross domestic product (GDP) growth (Equation [7]).

The cost of manufacture of each SPWP has a constant elasticity with respect to production:

$$m_{ik} = m_{ik}^* \left( \frac{Y_{ik}}{Y_{ik,-1}} \right)^{s_{ik}} \quad [3]$$

where  $m^*$  = current manufacturing cost at last year's output ( $Y_{-1}$ ), and  $s$  = elasticity of manufacturing cost with respect to output.  $m^*$  depends on last year's manufacturing cost.

For each intermediate product,  $q$ , used in manufacturing SPWPs,  $k$ , the amount of product imported and manufactured,  $k$ , must be equal to the sum of domestic demand, quantity used in the manufacture of SPWPs in the same country, and exports:

$$\sum_j T_{jiq} + Y_{iq} - D_{iq} - \sum_k a_{iqk} Y_{ik} - \sum_j T_{ijq} = 0 \quad \forall i, q \quad [4]$$

where  $i, j$  = country,  $a_{iqk}$  = input-output coefficient; input of product  $q$  per unit of secondary processed product  $k$ .

Furthermore, for each SPWP,  $k$ , the amount of product imported and manufactured must be equal to the sum of domestic demand and exports:

$$\sum_j T_{jik} + Y_{ik} - D_{ik} - \sum_j T_{ijk} = 0 \quad \forall i,k \quad [5]$$

where  $Y_{ik} = 0$  for net-importers, and  $D_{ik} = 0$  for net-exporters. The shadow prices of the material balance constraints (Equations [4] and [5]) give the market clearing prices,  $P$ , of intermediate products and SPWPs, respectively.

Trade is driven by the economic growth of countries and their relative competitive advantages, within bounds that simulate inertia in trade patterns; it takes time for new markets to be established or existing markets to expand (Table 2):

$$T_{ijk}^L \leq T_{ijk} \leq T_{ijk}^U \quad [6]$$

where the superscripts  $L$  and  $U$  refer to the lower and upper bounds respectively (Equation [9]).

TABLE 2: Secondary processed wood product trade parameters for Japan, China and the United States in the GFPM

Country	Product	<i>Ad-valorem</i> Tariff (%)	Freight Cost <sup>1</sup> (US\$/t)	Trade Inertia Bounds (ε)
Japan	Builder's carpentry and joinery	1.43	111	0.052
	Mouldings and millwork	1.15	432	0.068
	Wooden furniture	0.00	300	0.049
	Prefabricated housing	0.00	300	0.119
China	Builder's carpentry and joinery	9.63	111	0.052
	Mouldings and millwork	8.83	432	0.068
	Wooden furniture	11.00	300	0.049
	Prefabricated housing	14.80	300	0.119
United States	Builder's carpentry and joinery	0.26	111	0.052
	Mouldings and millwork	0.46	432	0.068
	Wooden furniture	0.00	300	0.049
	Prefabricated housing	0.31	300	0.119

<sup>1</sup> Freight costs were assumed to be the same for each country in the absence of reliable empirical data

Yearly changes in the market equilibrium conditions are described by the following equations (unless otherwise indicated, variables and parameters refer to one country, one commodity, and one year). The import demand curves for SPWPs shift over time, due to economic growth, according to:

$$D^* = D_{-1}(1 + \alpha_Y g_Y) \quad [7]$$

where  $g_Y$  = GDP annual growth rate,  $\alpha_Y$  = elasticity.

The input-output coefficients,  $a_{ijk}$  in Equation [4], may change exogenously over time to reflect technical change. Similarly, the manufacturing cost curve (Equation [3]) may shift over time.

The transport cost for commodity  $k$  from country  $i$  to country  $j$  in any given year includes the cost of freight, import tariff (applied to the c.i.f. price<sup>1</sup>), and export tariff:

$$C_{ijk} = f_{ijk} + t_{jk}^I (f_{ijk} + P_{ik,-1}) + t_{jk}^X P_{ik,-1} \quad [8]$$

where  $c$  = transport cost per unit of volume,  $f$  = freight cost per unit of volume,  $t^I$  = import *ad-valorem* tariff,  $P_{-1}$  = last year's equilibrium export price, and  $t^X$  = export *ad-valorem* tariff. The import and export tariffs and freight costs may change exogenously over time; representing tariff, para-tariff, and non-tariff barriers to trade.

The bounds on trade depend on past trade:

$$\begin{aligned} T^L &= T_{-1} (1 - \varepsilon) \\ T^U &= T_{-1} (1 + \varepsilon) \end{aligned} \quad [9]$$

where  $\varepsilon$  = upper or lower bound on relative change in trade flow.

Implementation of the model of SPWP trade in the GFPM required estimation of import demand equations (Equations [2] and [7]) and manufacturing activities (Equations [3] and [4]) for builder's carpentry and joinery, mouldings and millwork, wooden furniture, and prefabricated buildings. The next sections describe the methods and data used in this estimation.

<sup>1</sup>c.i.f. (cost-insurance-freight) price of imports is the selling price including the cost of the goods, the freight or transport costs, and the cost of marine insurance.

### Import Demand Equations for SPWPs

The derived demand for imports is based on a generalized Cobb-Douglas production function for each country:

$$Y_t = a Q_t^{\beta_1} O_t^{\beta_2} \quad [10]$$

where  $a$  is a constant,  $Y$  is output,  $Q$  is imports of the product of interest, and  $O$  is the quantity of all other inputs, including labour, energy, etc, in year  $t$ . Each  $\beta$  represents a constant elasticity. The associated cost function is:

$$C_t = P_{tq} Q_t + P_{to} O_t \quad [11]$$

where  $C_t$  is the cost of producing  $Y_t$ ,  $P_{tq}$  is the price of the imported product, and  $P_{to}$  the price of all other inputs used to produce  $Y_t$ .

Assuming firms that use imports minimize costs, subject to the production function [10], the conditional import demand for each product is (Varian, 1992, p. 59):

$$Q_t = a_0 \left( \frac{P_{tq}}{P_{to}} \right)^{a_1} Y_t^{a_2} \quad [12]$$

where the real price elasticity ( $a_1$ ) is expected to be negative, while the output elasticity ( $a_2$ ) is positive. The empirical model corresponding to [12] is, after logarithmic transformation:

$$\ln(Q_t) = a_0 + a_1 \ln \left( \frac{P_{tq}}{P_{to}} \right) + a_2 \ln(Y_t) + \varepsilon_t \quad [13]$$

where  $\varepsilon_t$  is an error term. This model is similar to those used in previous studies, for example Turner and Buongiorno (2004).

The theory may be refined by recognising that "economic behavior is inherently dynamic" (Nerlove, 2002, p. 5). In particular, the partial adjustment hypothesis leads to the following empirical model (Johnston, 1984, p. 349):

$$\ln(Q_t) = a_0' + \gamma a_1 \ln \left( \frac{P_{tq}}{P_{to}} \right) + \gamma a_2 \ln(Y_t) + (1 - \gamma) \ln(Q_{t-1}) + \varepsilon_t' \quad [14]$$

Where the magnitude of  $0 \leq \gamma \leq 1$  determines the speed of adjustment of imports to new levels of price and output.

## SPWP Manufacturing Activities

The export supply of SPWPs in net-exporting countries was represented by input-output coefficients (the amount of input per unit of export) and associated manufacturing costs. For each product,  $q$ , the input-output coefficient,  $a_{iqk}$  in Equation [4], was estimated as:

$$a_{iqk} = \frac{\theta_{iqk} D_{iq}}{\sum_j T_{ijk}} \quad [15]$$

where  $\theta_{iqk}$  is the proportion of country  $i$ 's total consumption of intermediate product,  $D_{iq}$ , that is consumed in the manufacture of secondary processed product  $k$  for net-export. The numerator of Equation [15] is the volume of intermediate product  $q$  consumed in the manufacture of SPWP for net-export. The denominator is the sum of net-exports of the SPWP to various countries.

In the GFPM, the manufacturing cost is the cost of the inputs i.e. labour, energy, capital, etc., excluding the cost of raw materials explicitly recognised in the model:

$$m_{ik} = P_{ik} - \sum_q a_{iqk} P_{iq} \quad [16]$$

where  $P_{iq}$  is the per unit price of intermediate product  $q$  in country  $i$ . Equation [16] assumes a long-run equilibrium such that there is no pure profit beyond a competitive return to capital.

## Future Scenarios

The GFPM incorporating SPWPs was used to assess several scenarios representing elimination of non-tariff barriers to New Zealand exports of SPWPs to the United States, China and Japan. All scenarios were compared with a base scenario that made the same assumptions as those of Turner et al. (2006), also prepared with the GFPM.

The projections obtained from the model's base scenario of world imports of secondary processed products suggest that they would continue to grow from 2006 to 2030, but at a slower rate than in the past decade due to slower projected economic growth. This increased demand would be met by expanded exports of wooden furniture from China, Vietnam and Brazil, of mouldings, and builder's carpentry and joinery from Canada, Brazil and Sweden, and prefabricated buildings from Canada. The base scenario implies that New Zealand average annual net-exports of builder's carpentry and joinery would increase by 98 000 t (152%) from 2006 to 2030, mouldings and millwork net exports

would decrease by 58 300 t (71%), and prefabricated housing net exports would decrease by 800 t (80%).

The other scenarios examined consisted in removing NTBs in 2003 and comparing the new projections with those obtained with the base scenario. Four other scenarios were modelled to assess the combined impact of non-tariff barriers for prefabricated housing in Japan and China, for both low and high costs per house, and for wooden doors in the US (Table 3).

TABLE 3: Non-tariff barriers (NTB) affecting New Zealand exports.  
Source: Katz (2006, 2008)

Country	Product	NTB	Production cost (US\$/t)	Freight cost (US\$/t)	NTB Cost (%)	NTB Cost (US\$/t)
Japan	Prefabricated housing	Engineering certificate	2,363		7.0 – 13.0	165 – 307
		Fire code	2,363		3.0 – 5.0	71 – 118
		Higher design values	2,363		20.0	473
		Bureaucracy		300	1.0	3
		All NTBs	2,363		30.0 – 38.0	712 – 901
China	Prefabricated housing	Lack of IP protection	2,363		1.0 – 2.0	24 – 47
		Treatment of radiata pine	2,363		1.5	35
		All NTBs	2,363		2.5 – 3.5	59 – 83
United States	Wooden doors	Fire rating	1,377		3.0	41

## DATA AND ESTIMATION

### Import Demand Equations for SPWPs

Pooled cross-section and time-series data were used to estimate the import demand equations (Equations [13] and [14]). Data on annual imports and unit value of imports for builder's carpentry and joinery, mouldings and millwork, wooden furniture, and prefabricated buildings for different years and countries (Table 1) were obtained from the EFI/WFSE Trade Flow Database (Michie & Wardle, 1998) – builder's carpentry and joinery, and wooden furniture – and UN Comtrade (United Nations, 2006) – mouldings

and millwork, and prefabricated buildings. For countries without data on import quantity in United Nations (2006), the trade-weighted average import unit value was used to calculate the import quantity from the reported import value.

Real import prices were calculated from c.i.f. unit values in nominal US dollars. These nominal prices were converted to real US dollars using the US GDP deflator (base year 2000) from the World Development Indicators database (World Bank, 2006). The measure of output was real GDP in US dollars (World Bank, 2006). Summary statistics are in Table 4.

TABLE 4: Summary statistics for import volume, real import price and real gross domestic product (GDP)

			Standard deviation		
			All	Within countries	Between countries
Product		Mean			
Builder's carpentry and joinery	Imports (10 <sup>3</sup> t)	10.4	58.3	43.8	44.0
	Price (US\$/t)	2440.45	1264.05	1193.73	440.78
	GDP (10 <sup>6</sup> US\$)	145	669	228	562
Mouldings and millwork	Imports (10 <sup>3</sup> t)	33.9	100.4	38.7	59.8
	Price (US\$/t)	1239.36	380.12	313.99	139.97
	GDP (10 <sup>6</sup> US\$)	484	1390	179	869
Wooden furniture	Imports (10 <sup>3</sup> t)	57.9	285.6	62.2	276.7
	Price (US\$/t)	2346.05	794.28	541.01	582.42
	GDP (10 <sup>6</sup> US\$)	189	879	39	871
Prefabricated buildings	Imports (10 <sup>3</sup> t)	18.2	47.2	16.5	30.6
	Price (US\$/t)	1964.46	1075.20	849.46	471.52
	GDP (10 <sup>6</sup> US\$)	424	1280	179	819

With these data, Equations [13] and [14] were estimated by five different methods: ordinary least squares; fixed effects; random effects; first differencing (Wooldridge, 2006, p. 485-498); and the generalized method of moments of Arellano and Bond (1991). The results were compared in terms of the theoretical expectations, the magnitude of the serial correlation (since a high serial correlation suggests misspecification), and the root mean square error (RMSE). The dynamic model with random effects was judged best in that, for the four products considered, the price and income elasticities had the expected sign and reasonable magnitude, the serial correlation was not statistically

significant, or small, in absolute value, and the RMSE was the smallest of all the formulations and estimation methods, indicating that the model was the most precise fit to the data.

The resulting empirical equation parameters are in Table 5. All the price elasticities had the expected negative sign, and the income elasticities had the expected positive sign. All elasticities were statistically significant ( $\rho < 0.01$ ). The elasticities with respect to lagged imports were also significant, suggesting a superiority of the dynamic formulation. Serial correlation was not statistically significant, or small in absolute value when significant, suggesting no major misspecification.

Long-run elasticities (Table 5), where imports have adjusted completely to price or output changes, were calculated from short-run elasticities with Equation [14]. In the long run, the demand for imports tended to be elastic with respect to price, for all four products. It was elastic with respect to GDP for builder's carpentry and joinery, and mouldings and millwork, but not for furniture and prefabricated buildings. The short-run elasticities with respect to lagged imports suggest that it takes three to seven years for imports to adjust to a permanent 1% increase in GDP or price.

TABLE 5: Import demand equation parameters for secondary processed wood products, estimated with a dynamic model with random effects

Variable	Product			
	Builder's carpentry and joinery	Mouldings and millwork	Wooden furniture	Prefabricated buildings
$\ln P$	-0.45 (0.03)**	-0.54 (0.13)**	-0.90 (0.08)**	-0.52 (0.10)**
$\ln Y$	0.53 (0.03)**	0.56 (0.09)**	0.56 (0.06)**	0.44 (0.06)**
$\ln q_{-1}$	0.57 (0.01)**	0.46 (0.04)**	0.34 (0.03)**	0.47 (0.03)**
$\rho$	-0.16 (0.02)**	0.18 (0.09)*	0.12 (0.07)	-0.13 (0.07)
RMSE	0.98	0.53	0.44	0.58
DF	5165	442	845	622
Long-run elasticity				
$P$	-1.05	-1.00	-1.36	-0.98
$Y$	1.23	1.04	0.85	0.83

$P$  = real import price,  $Y$  = real gross domestic product,  $q_{-1}$  = imports lagged one year,  $\rho$  = autocorrelation of residuals, RMSE = root mean square error, DF = degrees of freedom, \* = statistically significant at 0.05 level, \*\* = statistically significant at 0.01 level.

## SPWP Manufacturing Activities

The proportions  $\theta_{gk}$  in Equation [15] were obtained from expert opinion (Gerard Horgan, Ministry of Agriculture and Forestry, pers. comm. and Andres Katz, Alphametrik, pers. comm.). Apparent consumption of intermediate products for the model base year, 2002, for each country was calculated from FAO (2006) production and trade data. Trade of SPWPs for 2002 were from the EFI/WFSE Trade Flow Database (Michie & Wardle, 1998) – builder’s carpentry and joinery, and wooden furniture – and UN Comtrade (United Nations, 2006) – mouldings and millwork, and prefabricated buildings.

The prices of intermediate and secondary processed products were the corresponding net-importer and net-exporter unit values. For countries that were net-exporters, the price was calculated as the world export unit value; the total value of exports divided by the quantity exported from the EFI/WFSE Trade Flow Database or UN Comtrade. For countries that were net-importers, the price was the world export price plus the transport cost (Equation [8]).

## Base-year Data<sup>2</sup>

The GFPM used to introduce the SPWPs and to make the projections started from the version used in Turner et al. (2006). The modified model makes projections for 180 countries, 14 wood products, and four SPWPs, from 2003 to 2030.

As in Turner et al. (2006), the base-year data (2002) on production, consumption, trade and prices by country and product were from FAO (2006). For the SPWPs, the base-year trade data were from the EFI/WFSE Trade Flow Database (Michie & Wardle, 1998) and UN Comtrade (United Nations, 2006).

Most trade flows in the GFPM are between each country and the world market. For this study, bilateral trade flows were added for trade among New Zealand’s major markets and competitors<sup>3</sup>, to allow analysis of non-tariff barriers affecting New Zealand SPWP exports.

The cost of transporting wood products includes freight costs and *ad-valorem* import tariffs (Equation [8]). The 2002 tariff rates were from UNCTAD TRAINS online database. Tariffs for SPWPs are in Table 2, and tariffs for all other products are from Turner et al. (2006). Freight costs, estimated as the difference between world export and

<sup>2</sup>The mathematical specification of the GFPM version used in this application is in Zhu et al., (2006). Turner et al. (2006) provides a full description of model assumptions. The complete model data are available from the authors upon request.

<sup>3</sup>Australia, Brazil, Canada, Chile, China, Finland, Germany, India, Indonesia, Italy, Japan, South Korea, Malaysia, New Zealand, Oman, Philippines, Russian Federation, Saudi Arabia, Sweden, Thailand, United Arab Emirates, United Kingdom, United States of America, Vietnam, and Yemen.

import unit values from Michie and Wardle (1998) and United Nations (2006), were US\$111/t for builder's carpentry and joinery, US\$432/t for mouldings, US\$300/t for wooden furniture, and US\$300/t for prefabricated buildings. Freight costs were assumed to be the same for each country in the absence of reliable empirical data.

## Future Scenarios

A change in production cost due to removal of NTBs applies only to New Zealand exports to a specific market. In the GFPM, this was simulated by decreasing the transport cost. For example, Japanese prefabricated house engineering certificates are at least 7% (US\$165/t) of the New Zealand production cost (prefabricated house value) of US\$2,363/t, due to costs of finding a qualified architect or engineer to confirm the design values and have the design approved by the local authority (Katz, 2008). This was deducted from the New Zealand-Japan prefabricated housing freight cost of US\$300/t, to give a freight cost of US\$135/t after NTB removal. The additional cost of production and/ or transport due to NTBs on New Zealand exports of prefabricated buildings and wooden doors were derived from exporter surveys (Table 3) (Katz, 2006, Katz, 2008).

NTBs on exports of New Zealand prefabricated houses to Japan stem from added bureaucracy, engineering certification requirements, Japanese fire codes, and higher design costs (Katz, 2008) (Table 3). The cost from added bureaucracy was estimated at 1% of the cost of the house (f.o.b.)<sup>4</sup>. The cost of acquiring a Japanese engineering certificate added approximately 7% – 13% to the cost of the house, due to costs of finding a qualified architect or engineer to confirm the design values and have the design approved by the local authority. Complying with Japanese fire codes added approximately 3% to 5% to production costs. Requirements for higher load factors and earthquake resistance were estimated to add another 20%.

NTBs on exports of New Zealand prefabricated houses to China stemmed from a lack of protection of intellectual property, and timber treatment (Katz, 2008) (Table 3). To safeguard their intellectual property New Zealand exporters may have an additional person on the building site in China. This was estimated to add approximately 1% – 2% to the cost of house production. The cost of light organic solvent preservative treatment to comply with the new building code would add about 1.5% to the cost of the house production.

The main NTB to New Zealand wooden door exporters is the cost of meeting fire rating requirements in the United States. In addition to the cost of testing, producing a door with a 120 minute/m fire rating increases production costs by 20%. The GFPM includes wooden doors in the trade of builder's carpentry and joinery. For United States imports

<sup>4</sup>f.o.b. (free-on-board) basic price of exports of goods (plus loading charges) excluding the charges incurred in transporting the goods from one country to another.

from New Zealand, 15% of builder's carpentry and joinery is wooden doors (GTIS, 2006). The cost of production associated with the NTB was therefore estimated at  $15\% \times 20\% = 3\%$  (Table 3).

The benefit to the New Zealand prefabricated housing, and builder's carpentry and joinery industries of NTB removal was assessed by the present value of the change in export value between the base scenario, with the non-tariff barrier, and the scenario without the non-tariff barrier. The present value was calculated from 2002 to 2030 with an 8% pa discount rate.

## RESULTS AND DISCUSSION

The magnitude of change in the value of New Zealand's prefabricated housing, and builder's carpentry and joinery exports due to NTB removal is influenced by the change in export price and quantity. As suggested by theory (Figure 3), the effect of NTB removal in all cases was to simultaneously increase the price exporters received and the quantity they exported (Table 6).

TABLE 6: Effect of removing non-tariff barriers (NTB) on New Zealand average product price, quantity exported, and present value of exports, from 2002 to 2030

Country	Product	NTB	Price change (US\$/t)	Export quantity change ( $10^3$ t/yr)	Change in present value of export ( $10^6$ US\$)
Japan	Prefabricated housing	Engineering certificate	35.7 – 43.7	5.8 – 11.5	89.8 – 176.6
		Fire code	8.8 – 22.7	0.6 – 2.5	14.7 – 46.7
		Higher design values	52.2	21.5	326.3
		Bureaucracy	-0.4	0.0	-0.6
		All NTBs	60.9 – 67.8	29.9 – 36.5	458.6 – 563.1
China	Prefabricated housing	Lack of IP protection	0.3 – -0.1	0.0 – 0.0	0.7 – -0.4
		Treatment of radiata pine	0.3	0.0	0.6
		All NTBs	0.4 – 0.0	0.0 – 0.0	0.1 – -0.4
United States	Wooden doors	Fire rating	0.2	1.4	12.6

The greatest benefit to New Zealand exporters would arise from reducing the production costs associated with Japan's higher design values for prefabricated houses, which would result in an increase of US\$326 million in the present value of exports up to 2030. Where costs associated with obtaining engineering certificates for Japanese prefabricated housing are large (13% of production costs, see Table 3), the present value stemming from higher exports and prices due to NTB removal was US\$177 million. If all NTBs to Japanese imports of prefabricated houses from New Zealand identified were removed the net present value of imports would increase by up to US\$563 million.

For NTBs affecting New Zealand prefabricated housing exports to China, and builder's carpentry and joinery exports to the United States, the gains from non-tariff barrier removal were small, ranging from negligible for lack of intellectual property protection in China, to US\$12.6 million for fire rating requirements on United States wooden door imports (Table 6).

The modest increase in New Zealand exports of SPWPs following NTB removal (Table 6) meant there was little change (less than 1% in annual average) in New Zealand's production and export of other wood products. There was a small increase in production, and decrease in exports, of industrial roundwood and sawnwood to meet increased demand for sawnwood in production of prefabricated houses. Concurrently, the production and export of wood-based panels and wood pulp were slightly reduced.

Beyond the impact on New Zealand exporters, the effect of NTB removal was a decrease in exports of prefabricated houses from Canada, Italy and Sweden by an amount equal to the increase in New Zealand exports. Thus, the volume of Japan and China's imports of prefabricated houses was unchanged. In all scenarios, Canadian exports were reduced the most; by as much as 35,100 t pa (6.4%) when all NTBs to Japan's prefabricated housing imports from New Zealand were removed.

An often cited reason for encouraging exports of secondary processed products is that they will add value to wood product trade overall. Table 7 shows the estimated change in the value of New Zealand's net-trade (exports minus imports) of secondary processed products, other processed and primary wood products, and all wood products. Removal of NTBs does increase the value of secondary processed product exports. However, this increase is partially offset by decreased exports of other wood products that are utilised in the production of the secondary processed products. Overall though, removal of non-tariff barriers on prefabricated housing, and builder's carpentry and joinery results in an increase in the value of New Zealand total wood products net-trade. In percentage terms, however, the increase by 2030 is modest, ranging from 0% were all barriers to China's imports of prefabricated housing removed, to 9.2% were all barriers to Japan's imports of prefabricated housing removed.

This suggests that substantial growth in secondary processed product exports would be required to significantly increase the value of New Zealand wood industry total exports. In 2004 and 2005, the value of New Zealand's secondary processed product exports was

only 4.0% of New Zealand's US\$2.1 billion average annual total wood product exports (GTIS, 2006).

As with all economic models, the accuracy of the predictions depends on both the data and the assumptions used in the models. There are four areas of uncertainty in the model and analysis presented in this paper: (i) the GFPM structure and parameter estimates (demand and supply elasticities, input-output coefficients, etc.); (ii) the model base-year data; (iii) the exogenous assumptions used to make projections; and (iv) the assumed magnitude of the NTBs.

TABLE 7: Change in the net trade of New Zealand's secondary processed products (SPWP) and other wood products in 2030 due to non-tariff barrier (NTB) removal

Country	Product	NTB	SPWPs 10 <sup>6</sup> US\$	Other Wood Products 10 <sup>6</sup> US\$	Total 10 <sup>6</sup> US\$	Total %
Japan	Prefabricated housing	Engineering certificate	42.1 – 86.6	-3.4 – -6.6	38.8 – 80.0	1.4 – 2.9
		Fire code	1.9 – 8.0	-2.4 – -3.2	-0.5 – 4.8	0.0 – 0.2
		Higher design values	161.7	-10.1	151.6	5.5
		Bureaucracy	0.5	-0.2	0.3	0.0
		All NTBs	223.4 – 271.3	-15.9 – -15.8	207.5 – 255.5	7.5 – 9.2
China	Prefabricated housing	Lack of IP protection	1.7 – 2.2	-2.6 – -1.0	-0.8 – 1.2	0.0 – 0.0
		Treatment of radiata pine	0.0	-1.8	-1.7	-0.1
		All NTBs	0.6 – 1.7	-2.3 – -1.8	-1.6 – -0.1	-0.1 – 0.0
United States	Wooden doors	Fire rating	4.4	-2.4	2.1	0.1

Though the structure and parameter estimates of the GFPM with SPWPs have not been validated, earlier versions of the GFPM have been, with tests of mean absolute relative errors of predictions from 1980 to 2000. These tests show that the model replicates the observed trends, if not the year to year detail. Projections of consumption and production are more accurate than those of trade; and regional projections are more accurate than those for individual countries (Buongiorno et al., 2003, Turner, 2004).

The base-year production, consumption, trade and price data used in the GFPM are from FAO (2007). Although they contain inaccuracies, these are the only internationally comparable data. To address the inaccuracies, the GFPM base-year data were calibrated by solving the goal programming problem described in Buongiorno et al., (2001) and Zhu et al., (2007). This calibration process adjusted production data so that the amounts of materials used in a country and the amounts of products manufactured were consistent with a priori knowledge regarding manufacturing techniques.

Exogenous assumptions, such as country economic growth, changes in tariffs, and technical change in manufacturing, were used to make GFPM projections to 2030. While uncertainty in these assumptions can be reflected by changing the scenarios, we have used the scenario developed by Turner et al. (2006). That study compared GFPM predicted trends against expert opinion of the trends to develop a robust base scenario. The assumed changes in production and transport costs due to NTBs reported by Katz (2006 & 2008) are not precise. Reflecting this, a range of values was used to represent NTB magnitude (Table 3).

Better statistics on wood product production, consumption and trade, especially for secondary processed wood products, and better knowledge of non tariff barriers, will lead to improved models of the global forestry sector. Meanwhile, the results presented here should prove useful as a first approximation of the effects of non-tariff trade barriers on New Zealand forest product exports.

## CONCLUSIONS

An extended model of secondary processed wood products trade was developed within the structure of the GFPM, with explicit links to the sawnwood and wood-based panels sectors, and the rest of the forest economy. The approach concentrated on representing net-imports and net-exports of secondary processed wood products, thus circumventing the lack of international data on production. The model we developed provided a fuller description of the global wood industry than was otherwise available. Our model also enabled the impact of policies, such as trade liberalisation and non-tariff barriers, on the trade of secondary processed wood products, and consequently on other parts of the industry, to be analysed.

The import demand of net importing countries was represented by econometric equations, relating quantity imported to country GDP and product price. The equations were estimated with pooled cross-section and time-series data using the random effects method. The export supply of net-exporting countries was represented by manufacturing activities: input-output coefficients and related manufacturing costs that describe how sawnwood and wood-based panels are used in making secondary processed products for export.

This extended GFPM was applied to assess scenarios representing the elimination of non-tariff barriers to New Zealand exports of SPWPs to the United States, China and

Japan. Reducing the costs due to Japan's high design specifications for prefabricated housing would cause the largest increase in the present value of prefabricated housing exports; US\$326 million over the period 2002 to 2030. However, in deciding which, if any, barriers to address, the New Zealand forest industry and policy makers will need to weigh the potential benefits of NTB removal against the cost of negotiating their removal and the likelihood of successful negotiations.

Removal of non-tariff barriers on prefabricated housing, and builder's carpentry and joinery led to an increase in the value of New Zealand total wood products trade, but the increase was a modest 0 to 9.2% by 2030. Thus, it appears that policy measures to stimulate the growth of forest sector exports should not be focused on secondary processed products only, but also on exports of traditional, less processed products, such as wood-based panels, sawnwood, and even industrial roundwood.

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## REFERENCES

- Adams, D. M., & Haynes, R. W. (1996). The 1993 timber assessment market model: structure, projections, and policy simulations. *General Technical Report GTR-PNW-368*. Oregon: USDA Forest Service Pacific Northwest Research Station.
- Arellano, M. & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58, 277-297.
- Buongiorno, J., Liu, C. S., & Turner, J. A. (2001). Estimating international wood and fiber utilization accounts in the presence of measurement errors. *Journal of Forest Economics*, 7(2), 101-124.
- Buongiorno, J., Zhu, S., Zhang, D., Turner, J.A., & Tomberlin, D. (2003). *The Global Forest Products Model: Structure, estimation and applications*. San Diego: Academic Press.
- Cardellicchio, P. A., Youn, Y. C., Adams, D. M., Joo, R.W., & Chmelik, J. (1989). A preliminary analysis of timber and timber products production, consumption, trade and prices in the pacific rim until 2000. *CINTRAFOR Working Paper 22*. Seattle, WA: CINTRAFOR, University of Washington.
- Cohen, D. H., Muto, N., & Kozak, R. A. (2003). Non-tariff measures: A global context for the changing international competitiveness of the Canadian softwood lumber industry. *The Forestry Chronicle*, 79(5), 917-927.
- Desclos, P-M. (2000). Markets for secondary processed wood products, 1990-2000. *Geneva Timber and Forest Discussion Paper ECE/TIM/DP/21*. Geneva: United Nations.
- Eastin, I., & Fukuda, J. (2001). The impact of regulatory change on the international competitiveness of the Canadian softwood lumber industry. *The Forestry Chronicle*, 77(2), 315-323.
- Food and Agriculture Organization (FAO). (2000). Asia and the Pacific National Forestry Programmes. *Update 34*. Rome: Food and Agriculture Organization.
- Food and Agriculture Organization (FAO). (2006). *FAOStat online statistical databases*. FAO Rome. Retrieved August 10, 2006, from <http://faostat.fao.org>.
- Global Trade Information Services (GTIS). (2006). *World trade atlas trade information system*. Version 4.4c. Columbia, SC: Global Trade Information Services, Inc.
- Johnston, J. (1984). *Econometric methods* (3rd ed.). New York: McGraw-Hill.
- Kallio, M., Dykstra, D. P., & Binkley, C. S. (1987). *The global forest sector: An analytical perspective*. Chichester, UK: John Wiley & Sons.
- Katz, A. (2006). *Non tariff barriers for finished wood product exports Japan, China and US. Part II: Door manufacturers*. A report prepared for Scion by Alphametrik Ltd. Auckland, New Zealand: Alphametrik Ltd.
- Katz, A. (2008). Are non tariff barriers important in exports of finished wood products to Japan, China and the US? The case of prefabricated houses. *New Zealand Journal of Forestry*, 52(5), 12-19.
- Michie, B., & Wardle, P. (1998). UNSTAT trade data as basis for analysis and projection of forest products trade flows. *EFI Working Paper 17*. Finland: European Forest Institute.

- Nerlove, M. (2002). *Essays in panel data econometrics*. Cambridge, UK: Cambridge University Press.
- New Zealand Forest Research Institute (NZFRI). (1999). *Study of non-tariff measures in the forest products sector*. Singapore: Committee on Trade and Investment, APEC. Retrieved April 14, 2004, from [www.apec.org/apec/publications/all\\_publications/committee\\_on\\_trade.html](http://www.apec.org/apec/publications/all_publications/committee_on_trade.html).
- Perez-Garcia, J. M. (1996). Meeting the needs of policy makers: Experiences with a global forest sector model in the policy arena. In L. Lonnstedt (Ed.), *Proc. of Project Group P.6.11 FORSEA meetings at the Twentieth IUFRO World Congress, Tampere, Finland, 6-12 August 1995*. (pp. 99-110). Tampere: IUFRO.
- Schultz, R., & Gorley, A. (2006). What is a value-added forest sector? Why is it important to competitiveness in British Columbia? *B.C. Forum on Forest Economics and Policy Synthesis Paper: SP 05-01*. 19 pp.
- Solberg, B., Moiseyev, A., & Kallio, M. I. (2003). Economic impacts of accelerating forest growth in Europe. *Forest Policy and Economics*, 5, 151-171.
- Turner, J. A. (2004). *Trade liberalization and forest resources: A global modeling approach*. Dissertation submitted in partial fulfilment of the requirements for the PhD (Forestry). Madison, WI: Department of Forest Ecology and Management, University of Wisconsin-Madison.
- Turner, J. A., & Buongiorno, J. (2004). Estimating price and income elasticities of demand for imports of forest products from panel data. *Scandinavian Journal of Forest Research*, 19, 358-373.
- Turner, J.A., Buongiorno, J., Maplesden, F.M., Zhu, S., Bates, S., & Li, R. (2006). World wood industries outlook: 2005-2030. *Forest Research Bulletin 230*. Rotorua, New Zealand: Scion.
- United Nations. (2006). *UN commodity trade statistics database (UN Comtrade)*. United Nations Statistics Division. Retrieved August 16, 2006, from <http://unstats.un.org/unsd/comtrade/>
- United States Trade Representative (USTR). (2006). *2006 National Trade Estimate Report on Foreign Trade Barriers. China*. Retrieved December 1, 2006, from [http://www.ustr.gov/Document\\_Library/Reports\\_Publications/2006/2006\\_NTE\\_Report/Section\\_Index.html?htm](http://www.ustr.gov/Document_Library/Reports_Publications/2006/2006_NTE_Report/Section_Index.html?htm).
- Varian, H.R. (1992). *Microeconomic analysis* (3rd ed.). New York: Norton.
- Wikipedia, (2008, 27 August). *Harmonised System*. Retrieved from [http://en.wikipedia.org/wiki/Harmonised\\_System](http://en.wikipedia.org/wiki/Harmonised_System).
- Wooldridge, J.M. (2006). *Introduction to econometrics: A modern approach*. (3rd ed.), Mason, OH: Thomson South-Western.
- World Bank. (2006). *World development indicators (CD-ROM)*. Washington, D.C.: World Bank.
- Zhu, S., Buongiorno, J., Turner, J.A., & Li, R. (2006). Using the global forest products model. *Staff Paper Series # 58*. Madison, WI: Department of Forest Ecology and Management, University of Wisconsin.
- Zhu, S., Buongiorno, J., Turner, J. A., & Li, R. (2007). Calibrating and updating the global forest products model. *Staff Paper Series # 61*. Madison, WI: Department of Forest Ecology and Management, University of Wisconsin.

