Economic Consequences of Increased Bioenergy Demand

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Abstract:

Although wind, hydro and solar are the most discussed sources of renewable energy, countries will need to rely much more on biomass if they are to meet renewable energy targets. In this study, a global forest trade model is used to examine the global effects of expanded demand for wood pellets fired with coal in power plants. Positive mathematical programming is used to calibrate the model to 2011 bilateral trade flows. To assess the impact of increased demand for wood pellets on global forest products, we consider a scenario where demand for wood pellets doubles. Findings indicate that production of lumber and plywood is likely to increase in most of the 20 model regions, but outputs of fiberboard, particleboard and pulp will decline as these products must compete with wood pellets for residual fiber. Ultimately, policies promoting aggressive renewable energy targets cause wood pellet prices to more than double in our scenarios, which could increase the cost of generating electricity to such an extent that, in some regions, electricity producers will continue to use fossil fuels as their primary fuel, while some others might find it worthwhile to rely more on nuclear energy for base load power.

Keywords: Bioenergy, Modelling, Wood products, Forest sector, Trade, Vertical and Horizontal Markets

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INTRODUCTION

Countries around the world are legislating ever more stringent renewable energy policies, with European countries leading the way. As a result of aggressive government intervention, the energy sector will need to transition to sources that have much lower carbon dioxide (CO_2) emissions. While wind turbines and solar panels have traditionally been the face of such efforts, countries will need to rely to a much greater extent on biomass to meet their renewable energy targets. In particular, utilities are increasingly looking to co-fire biomass with coal to reduce the CO_2-emissions intensity of coal plants, as required in the legislation of some countries (e.g., Canada, U.S.). Consequently, some 230 coal-fired power plants worldwide have been retrofitted to co-fire with biomass on a commercial basis (IEA-ETSAP and IRENA Brief E21, 2013). As the number of coal plants converting to burn biomass increases, it has become worthwhile for timber-rich regions to ramp up production of wood biomass for energy purposes, especially production of wood pellets. As a result, global wood pellet production has increased from 1.7 million tonnes (Mt) in 2000 to 15.7 Mt in 2010, and is projected to reach 38 Mt by 2020 (Lamers et al. 2012).

Co-firing biomass in existing coal-fired power plants is appealing due to the low incremental investment required to retrofit established facilities and because energy produced from biomass is considered to be carbon neutral (IPCC 2006). Since much of the biomass to produce pellets comes from logs, the demand for wood fiber by the energy sector will impact the manufacture of wood products (lumber, plywood, pulp, oriented strand board, medium density fiber board, etc.). To the extent that wood pellets and lumber are joint outputs, an increase in the demand for sawmill residues will increase the value of logs and thereby the demand for logs. Importantly, increased demand for wood pellets will enhance competition for residual fiber, thereby impacting other wood processing sectors. In this study, we consider the impacts of changes in the demand for wood pellets on the overall forest sector.

Few studies have attempted to assess the implications of increased bioenergy demand on the global forest products sector. Exceptions include Raunikar et al. (2010) and Buongiorno et al. (2011), but these authors have looked specifically at roundwood use for cooking, heating or power production, collectively referred to as fuelwood. The authors conclude that increased bioenergy (fuelwood) demand results in the convergence of fuelwood and industrial roundwood prices, while the prices of other forest products, including sawnwood and panels, would rise significantly. In addition, an increase in bioenergy demand could result in an increase in the price of forestland, causing forest area to expand (Ince et al. 2011, 2012; Moiseyev et al. 2011).

The focus on fuelwood is misplaced, however, because the vast majority of fuelwood is used primarily in developing countries for subsistence – as a fuel for heating and cooking (FAO 2014). In contrast, the recent rise in bioenergy demand is a rich-country phenomenon that is characterized by increased international trade in wood products and is met by residuals from downstream manufacturing, much of which is increasingly converted to wood pellets (Figure 1).

In the current study, we analyze increased bioenergy demand sourced directly from the harvest of energy biomass and indirectly as residues from commercial roundwood harvests and manufacturing. A rising portion of this fiber is then processed into wood pellets as opposed to fuelwood. Given that many countries provide significant subsidies for bioenergy, understanding the true costs and benefits associated with such a policy is critical. Timber rich regions are likely to be significantly impacted by such a policy, as it results in adjustments to their production, consumption and trade patterns.

METHODS

Vertical and Horizontal Market Integration

To determine how increased demand for wood pellets impacts the rest of the forest products industry, we consider an integrated coniferous wood products trade model with upstream producers of logs and downstream users of wood products. The theoretical framework of the trade model, data sources and numerical implementation of the model are described in Johnston and van Kooten (2014). The theoretical foundations describe the costs, benefits and re-distributional impacts of any given policy – i.e., the economic surpluses, or welfare areas, that are measured. These consist of the areas under demand and supply functions, with the former constituting benefits and the latter costs. While the model in essence calculates the familiar consumer and producer surpluses, several assumptions are needed to make the model tractable; these are briefly described in what follows.

Downstream users include furniture makers, construction firms, pulp producers, electricity providers, and other industries that rely on wood products. The demands for wood products are derived demands from these downstream industries, while the demand for logs is derived from the demands of the log processing sector. In our model, the wood-processing sector consists of sawmilling (lumber), plywood manufacture, manufacture of particleboard and fiberboard, pulp production, and wood pellet production. In order to measure welfare changes that result from changes in policy, it is necessary to make some assumptions about markets upstream from log production (e.g., logging trucks, chain saws, fuel, labour, other logging equipment, silvicultural inputs) and downstream from lumber, plywood, board, pulp and wood pellet production (e.g., construction, furniture, paper and electricity). In particular, we assume that producers of logs face a perfectly elastic supply of inputs (fixed factor prices) and downstream users of manufactured wood products face a perfectly elastic demand for their products. That is, changes in the output of logs cannot affect the prices that log producers pay for inputs; likewise, changes in prices of lumber and residuals cannot impact housing, paper, energy, furniture and other final output prices. Finally, it is assumed that prices of other goods and service in the economy are not affected by changes in wood product prices.

The key to the current model is the availability of coniferous logs. Two categories of processors are assumed – those that directly affect the demand for logs and those that do so indirectly. Sawmilling is assumed to impact the log market directly through the production of three kinds of products – lumber, plywood and wood residuals (or residues). Manufacturers of particleboard, fiberboard, pulp and wood pellets (the four other wood processors in our model) can use whole logs but primarily rely on residues from sawmills. Logs are simply too valuable in the production of structural lumber and plywood to be used in the production of other wood products, although there are exceptions (e.g., pulp logs are not normally used for lumber). These secondary users of logs have an indirect impact on the demand for (saw) logs because, if the prices of secondary products rise, logs become more valuable to the sawmilling sector. This is because residues are a joint product with lumber and plywood. That is, if one of the products from sawmilling (residues) increases in price, sawmills will increase their demand for logs at the margin. Thus, whether directly, or indirectly, the demand for logs is derived through the demand for these downstream products, with the price of logs increasing with the demand for downstream products:

$$\frac{\partial D_{\log}(P_{\log}; p_k)}{\partial P_{\log}} < 0 \text{ and } \frac{\partial D_{\log}(P_{\log}; p_k)}{\partial p_k} > 0, \quad (1)$$

$$k \in \{\text{lumber, plywood, particleboard, fiberboard, pulp, pellets}\}$$

where $D_{log}(P_{log}; p_k)$ is the derived demand for logs by downstream producers of wood product k as a function of the price of k. Relation (1) indicates that the price of logs (P_{log}) will rise if the supply of logs is upward sloping, which is the case here. An increase in the price of logs will, in turn, shift the supply curve for downstream products upwards (reducing supply):

$$\frac{\partial S_k(p_k; P_{\log})}{\partial p_k} > 0 \text{ and } \frac{\partial S_k(p_k; P_{\log})}{\partial P_{\log}} < 0, \forall k, \qquad (2)$$

where S_k is the supply curve for downstream wood product k. Thus, an increase in the demand for any wood product k will increase the price of all other wood products (including the original product whose demand increased).

Suppose now that there is an increase in the demand for wood pellets as a result of subsidies to their use in coal-fired power plants (or due to legislation mandating their use in coal plants). This leads to an increase in the demand for sawmill residuals that, in turn, leads to somewhat greater output of lumber and increased demand for logs. It will also increase the demand for roadside wastes associated with harvest operations, but whether this increases removal of such wastes is questionable and a separate issue not considered here (see Niquidet et al. 2012). More importantly, an increase in the demand for wood pellets will result in the re-direction of residual fiber away from particleboard, fiberboard and pulp production to its use in coal plants (Stennes et al. 2010). These products are competitive with wood pellets, because fiber used to produce wood pellets cannot be used to produce particleboard, fiberboard or pulp. Therefore, $\frac{\partial S(p_s; p_c, P_{\log})}{\partial p_{pellet}} < 0, \forall s \in \{\text{particleboard, fiberboard, pulp}\}, c \in \{\text{lumber, plywood}\}$.

The impact of an increase in the demand for wood pellets on lumber and plywood markets is less certain. On the one hand, a higher price of wood pellets increases the value of logs through an increase in the derived demand for logs as indicated in relation (1). This inevitably leads to a reduction in the supply of lumber and plywood through relation (2). On the other hand, increased wood pellet demand also creates higher value for the wood residues produced jointly in the sawmilling sector. Because producers of lumber and plywood are able to sell wood residuals at a higher price, this lowers the cost of sawmilling, thereby increasing the supply for products that are complementary in production: $\frac{\partial S(p_c; p_s, P_{\log})}{\partial p_{pellet}} > 0$. The extent to which one effect dominates the other depends on the cross-price elasticities of demand between pellets and lumber, and between lumber and logs. Thus, it is an empirical issue.

By considering the interactions between the various horizontal and vertical markets, shifts in any one market may affect the others. In this analysis, a significant increase in wood pellet demand may increase competition for fiber (logs), resulting in significant impacts in the markets for other traditional wood products (see Raunikar et al. 2010; Buongiorno et al. 2011; Ince et al. 2011, 2012; Moiseyev et al. 2011). It should be emphasized, however, that wood product markets are not only connected through these vertical and horizontal chains within a given jurisdiction, but also among jurisdictions through international trade. Unraveling the impacts of increased wood pellet demand will ultimately require international considerations.

Global Trade Modeling

To determine the welfare (cost-benefit) impacts of increased global demand for wood pellets, we employ a global trade model for coniferous forest products that is described in detail in Johnston and van Kooten (2014). The model assumes that, while changes in countries' forest policies will affect prices of forest products, they have no discernible impact on the relative prices of goods and services elsewhere in the economy. As a spatial price equilibrium model, the trade model assumes that, in the absence of trade barriers and transaction costs, prices would be the same in every region as a result of spatial arbitrage. Differences in prices between regions are thus assumed to be the result of transaction costs, and include costs associated with transporting goods (e.g., freight, insurance, exchange rate conversion fees), plus tariffs and other non-tariff barriers. The numerical trade model is solved in an integrated Excel-R-GAMS environment.

In the model, Canada is divided into five regions – Atlantic Canada, Central Canada, Alberta, BC Interior and BC Coast. The United States is divided into three regions (South, North, West), and Asia is separated into China, Japan and Rest of Asia. Chile, Australia, New Zealand, Finland, Sweden and Russia are also separate regions, while the remaining regions comprise Rest of Europe, Rest of Latin America, and the Rest of the World (ROW). The model calculates production of coniferous logs and wood products and their consumption in each region, and bilateral region-to-region trade flows of the wood products as outlined in Figure 2.

The initial supply of industrial roundwood provides the fiber for a number of downstream products: sawnwood (lumber), plywood, particleboard, fiberboard, pulp and wood pellets. The production of sawnwood and plywood coincide with the production of residuals in the form of chips and sawdust that can be used to produce fiberboard, pulp and wood pellets. The harvest and process of industrial roundwood from the initial harvest produces residuals (roadside debris; tree tops, branches, other debris), which may also be used in the production of wood pellets (although this is not done here). Finally, industrial roundwood may be diverted to fuelwood (as indicated by the dashed line in Figure 2).

Each region is assumed to have a set of linear (inverse) demand and supply curves for each downstream product *k* (defined earlier):

$$P_d^k = \alpha_d^k - \beta_d^k q_d^k, \tag{3}$$

$$P_s^k = a_s^k + b_s^k q_s^k, \tag{4}$$

where d (=1, …, D) and s (=1, …, S) refer to demand and supply regions, respectively.

The objective of the forest trade model is to maximize the sum of the consumer surpluses and producer surpluses across all relevant markets. As previously mentioned, the demand for logs is derived from the demand for downstream products, so the consumer surplus in the log market is evaluated as the sum of the changes in producer surpluses in the downstream vertical markets. For downstream products that use logs as inputs in production, the consumer and producer surpluses are found by maximizing the sum of the areas under the D demand schedules (3) and subtracting the sum of the areas under the S supply schedules (4). These respective areas are given by:

$$B_d^k = \int_0^{q_d^k} (\alpha_d^k - \beta_d^k x)\,dx = \alpha_d^k q_d^k - \frac{1}{2}\beta_d^k q_d^{k^2}, \tag{5}$$

$$C_s^k = \int_0^{q_s^k} (a_s^k + b_x^k x)\,dx = a_s^k q_s^k + \frac{1}{2} b_s^k q_s^{k^2}, \tag{6}$$

where x is an integration variable, B_d^k is the total benefit (area under demand) in demand region d for product k, and C_s^k is the total cost (area under supply) in supply region s for product k.

In the market for industrial roundwood, the area above the price and below the demand curve is another measure for the sum of the producer surpluses found in the downstream markets, and thus does not need be counted. However, the producer surplus to the log producers needs to be included. Assume the supply, or marginal cost, of logs is in log producing region j is linear: r_j

$= m_j + n_j Q_j$, where Q_j is the quantity of logs in country j. Thus, the producer surplus from supply logs from any region j is given by:

$$R_j = r_j Q_j - \int_0^{Q_j} (m_j + n_j x)\, dx = \frac{1}{2} n_j Q_j^2 . \qquad (7)$$

Computation of the spatial price equilibrium model involves the sum of the necessary producer and consumer surpluses as outlined above, while subtracting transportation costs and associated taxes. Then the objective function to be maximized can be written as:

$$W = \sum_{d=1}^{D} \sum_{k=1}^{K} B_d^k - \sum_{s=1}^{S} \sum_{k=1}^{K} C_s^k + \sum_{j=1}^{J} R_j - \sum_{j=1}^{J} \sum_{s=1}^{S} \left(\delta T_{js} + t_{js} \right) Q_{js} - \sum_{s=1}^{S} \sum_{d=1}^{D} \sum_{k=1}^{K} \left(T_{sd}^k + t_{sd}^k \right) q_{sd}^k , \qquad (8)$$

where W refers to the overall wellbeing brought about through the global forest products industry, T is the cost ($/m^3) of transporting forest products from supply region s to demand region d for the case of k downstream products, and from log producing region j to log consuming region s for the case of industrial roundwood. The separation is important as δ is a parameter that takes into account the extra cost of transporting logs because they occupy more space per cubic meter than other wood products. Finally, t_{js} is the tax on logs ($/m^3) originating in log supply region j and sold to wood product producing region s, while t_{sd}^k is the tax on wood product k originating in supply region s, destined for demand region d.

Objective (8) is maximized subject to a series of biophysical and economic constraints relating to the availability of timber harvests, log supply, and wood product manufacturing limits (see Johnston and van Kooten 2014). The essential constraints are material flow and productivity constraints that ensure the total supply equals total demand for each country and each product.

The method used to calibrate the global trade model relies on positive mathematical programming (PMP) developed by Howitt (1995) and, in the case of spatial modeling, by Paris et al. (2011). For a detailed description of the particular application of PMP to the international trade of forest products see van Kooten and Johnston (2014), although the current model is calibrated for 2011 rather than 2010. Data come primarily from the Food and Agricultural Organization of the United Nations (FAO 2013), with supplementary information from the Government of Canada (2012), BC Statistics (2013), Random Lengths (various years), the University of Washington's Center for International Trade in Forest Products (CINTRAFOR), and the Global Forest Products Model (GFPM) at the University of Wisconsin (see Buongiorno et al., 2003). For a more detailed description of the data, see Johnston and van Kooten (2014).

Scenario Description

To assess the impact of increased global demand for wood pellets on the rest of the forest product industry, we consider a scenario where demand is doubled. To simulate such an increase in the demand for wood pellets, we assume a vertical increase in the demand curve for pellets in each region, which implies adjusting the demand intercept α_d^{pellet}. The significant producers of wood pellets during 2011 are provided in Table 1.

The forest spatial price equilibrium trade model for coniferous forest products was used to evaluate the effects of increased global wood pellet demand in each country, and the corresponding change in production, consumption and trade flows were endogenously determined. The model allows fiber inputs of industrial roundwood, chips and residuals to be used in the production of forest products, where increased competition for inputs will inevitably impact the remaining forest product industry.

RESULTS

Increasing the demand for wood pellets increases the derived demand for logs, resulting in higher prices as well as increased global production. The price of industrial roundwood is projected to increase by 1.1 percent globally, while the quantity demanded within a given region varies. For example, the quantity of industrial roundwood demanded in Canada is projected to increase by 1.4 percent as a result of doubling global wood pellet demand, while it is projected to increase by 1.7 percent in Europe.

The impact of increased wood pellet demand on the lumber and plywood markets was indeterminate and could only be determined numerically. The projected impact of doubling global wood pellet demand on the international lumber and plywood markets is presented in Table 2. Here, there is evidence that increased wood pellet demand is beneficial to these markets, as the residuals associated with lumber and plywood production become more valuable. In the lumber market, regional prices decline by 5.0 to 7.1 percent, while the quantities demanded and supplied increase in all regions. It is clear that consumers of lumber are made better off through increased consumption and reduced prices, while it remains unclear how producers of lumber will ultimately be affected as a result of increased production and lower selling prices.

The impact of increased wood pellet demand has a similar impact on the plywood market, yet the magnitudes of the changes are smaller compared to the lumber market. The fraction of residuals (i.e., chips and sawdust) associated with plywood and veneer production is lower compared to lumber, resulting in a smaller impact in the plywood market when these residuals increase in value. Further, some of the byproducts associated with veneer production have greater value when used in other markets (e.g., peeler cores). Nonetheless, increased wood pellet demand will positively impact consumers of plywood (Table 2), while again it is unclear how producers will be affected through increased production, but lower selling prices.

A significant increase in global wood pellet demand may be detrimental to products that compete for fiber with wood pellets, as shown in Table 3. The particleboard market utilizes chips, flakes, splinters and strands derived primarily from processing pulpwood. Direct completion for these residuals comes from wood pulp producers, as well in extreme cases with dedicated harvests of logs for energy. Wood pellets compete directly for residual fiber and pulp logs with traditional users such as particleboard and pulp. According to Table 3, doubling global demand for wood pellets will result in an increase in regional particleboard prices from 9.2 to 19.5 percent, with consumption and production falling from 2.8 to as much as 8.5 percent. Consumers are adversely impacted by this change as they now consume less because prices have increased. On the other hand, producers benefit from increased prices, but ultimately manufacture less particleboard.

Unlike particleboard manufacturing, fiberboard uses purchased wood residuals that are flat pressed to produce panels. These residuals are often sourced from sawmills and are an input used in wood pellet manufacturing. Clearly, increasing wood pellet demand will create additional competition for these wood residues, which traditionally have been relied upon for producing fiberboard. Doubling wood pellet demand will result in an increase in the price of fibreboard anywhere between 4.2 and 10.7 percent (Table 3). Consumption of fiberboard falls by approximately 4.1 to 8.5 percent. The combination of a price rise and reduced consumption leads to consumers being worse off. Again, it is unclear what effect increased wood pellet demand will ultimately have on producers of fiberboard as prices rise and production falls in all regions.

Finally, wood pellets will compete for fiber with the wood pulp industry that relies on pulpwood, wood chips and residues to be converted into pulp either mechanically or chemically.

In Table 3, doubling global wood pellet demand is projected to raise the price of wood pulp by 10.2 to 12.4 percent, while production and consumption declines across all regions. Consistent with the markets for particleboard and fiberboard, consumers lose through the rise in prices and reduced consumption, while it is again unclear how producers will be affected.

Although there are exceptions (salvage harvesting mountain pine beetle damaged timber in Canada), the wood pellet sector has traditionally utilized low-cost mill residuals as feedstock, but significant increases in production will require incorporation of more costly fiber from forest operations. This simulation shows that the wood pellet industry draws fiber away from traditional forest products. As indicated in Table 4, an increase in wood pellet demand will substantially increase the price of wood pellets by 111.1 to 157.5 percent. Thus, retrofitted power plants that co-fire pellets with coal will ultimately experience a dramatic increase in the price of fuel as future demand for wood pellets grows, while pellet supplying regions (primarily Canada, the U.S., Russia and Europe) will greatly benefit.

SUMMARY AND DISCUSSION

In this study we assessed the impact of increased demand for wood pellets on the global forest products industry using a global wood products trade model developed by Johnston and van Kooten (2014). The model integrates wood product markets vertically into upstream log markets and downstream markets for final commodities made from wood fiber, and horizontally across five types of wood products. Unlike other forest trade models, the model is calibrated to duplicate bi-lateral trade flows precisely (van Kooten and Johnston 2014).

From a bioenergy standpoint, one aspect of the research is the distinction between fuelwood and wood pellets. This is important for two reasons: First, fuelwood is used locally for subsistence living, while wood pellets are demanded globally for large-scale energy production (primarily in coal-fired plants). Second, as many countries have implemented aggressive renewable energy policies that require the use of wood pellets or their equivalent (e.g., torrefied wood pellets) to generate electricity, output of many other wood products is impacted, unlike with fuelwood. While some products are complements to wood pellets in production, namely sawnwood and plywood, others must compete with wood pellets for residual fiber (pulp, fiberboard, particleboard). This inevitably results in differing outcomes for these two product groups. Further, the demand for roundwood logs is impacted thereby potentially influencing silvicultural decisions. For example, if agricultural prices and policies remain unchanged, it is possible that in the long run agricultural land is converted to plantation forests to produce wood pellets.

Our results indicate that, if wood pellet demand reduces the costs of processing logs, there will also be an increase in the output of these products (lumber, plywood) that leads to an increase in the price of logs. This cost reduction occurs because the joint-product, namely wood residuals, generates extra value in production of lumber and/or plywood. Not only would more logs be brought to market as their price is higher (thus incentivizing a shift in land use towards forestry), but lumber and plywood output would increase benefitting consumers. On the other hand, the output of fiberboard, particleboard and pulp will decline because these products must compete with wood pellets for residual fiber, the price of which has gone up. The consumers of these products will suffer a loss in welfare.

Because wood pellet prices increase in all regions as a result of incentives or mandates to co-fire pellets with coal in power plants, there are unintended consequences. Some of these were discussed in the preceding paragraphs. But there is a more serious problem: Will wood pellet prices rise to a point where wood biomass in no longer an economical renewable source of energy? Many regions around the world have embarked on policies intended to reduce their CO_2 emissions by relying more on bioenergy to meet aggressive renewable energy targets. For example, the EU has mandated renewable energy targets to be achieved by the year 2030 (2030 Policy Framework for Climate and Energy), while many coal-fired power plants in the province of Ontario have been retrofitted to run off biomass in the near future (Ontario Green Energy Act). However, simultaneous implementation of such policies could well undermine this particular renewable energy strategy as wood pellet prices double or much more in our scenarios.

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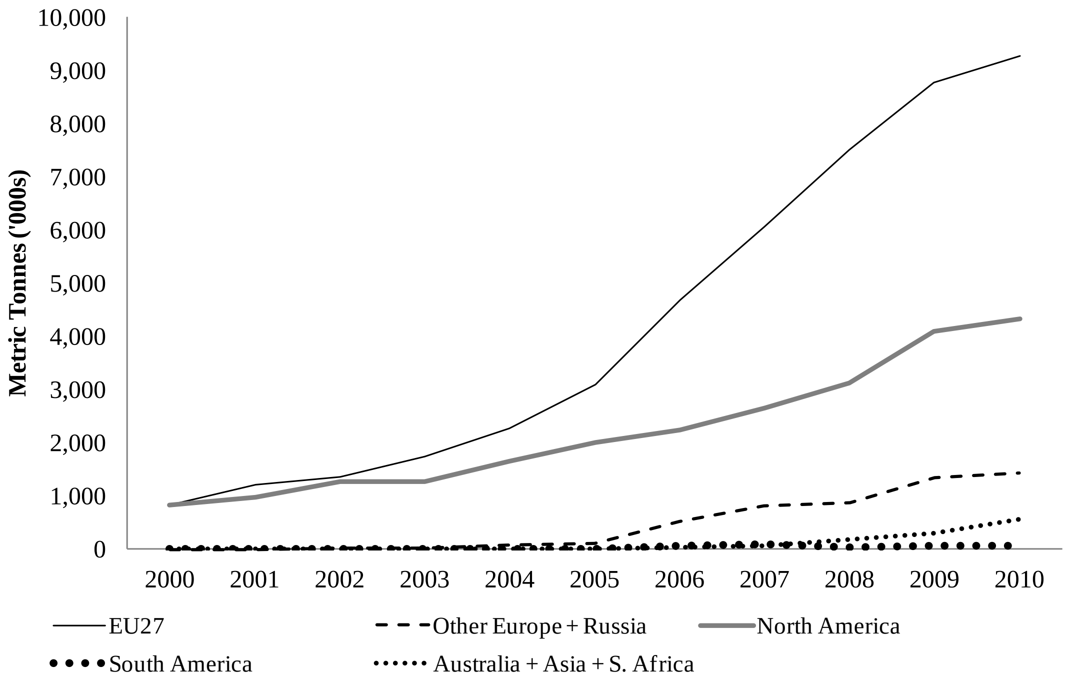

Figure 1: Global Wood Pellet Production, 2000-2010 (Source: FAO 2013)

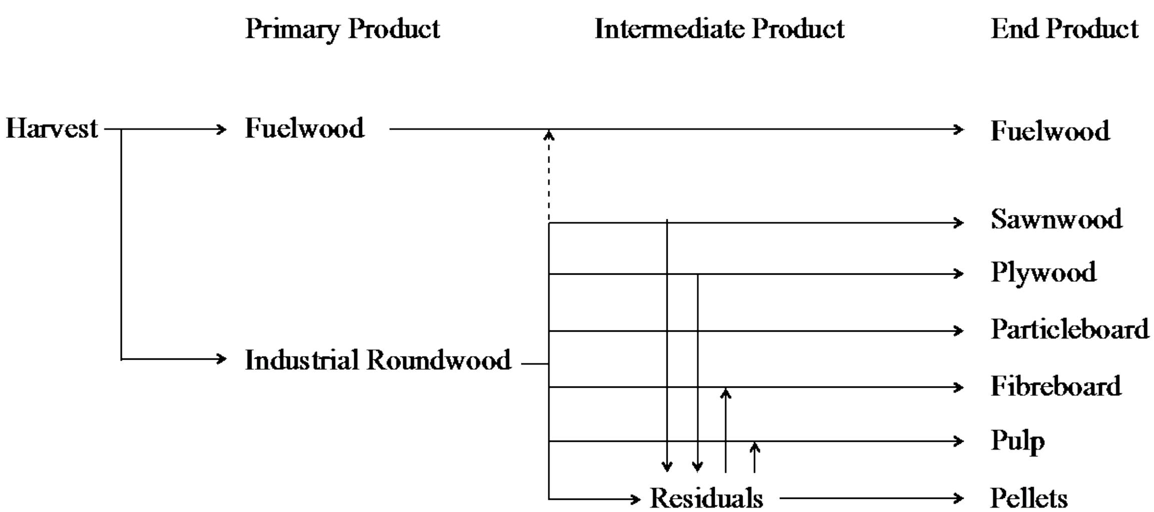

Figure 2: Forest Product Flow Chart

Table 1: Production and capacity for select wood pellet producing regions, 2011

Region	Pellet production ('000 tonnes)	Proportion of sawlogs + veneer logs coniferous (%)	Coniferous pellet production ('000 tonnes)[a]	Total pellet production capacity (tonnes/yr)
Alberta	82	93	76	145
Atlantic Canada	278	85	237	493
BC Interior	1,259	95	1,196	1,875
Rest of Canada	417	85	355	739
China	600	64	384	750
Russia	1,612	78	1,265	3,100
Sweden	1,340	99	1,332	2,500
US North	1,125	79	894	3,410
US South	1,355	79	1,076	3,500
US West	310	79	246	940
Rest of Europe	7,806	82	6,365	14,146
Rest of World	423	81	344	603
TOTAL	16,607		13,769	32,201

Sources: USDA (2013), CFS (2014), Johnston and van Kooten (2014), Lamers et al., (2012)

[a] Proportion of coniferous sawlogs + veneer logs multiplied by total wood pellet production

Table 2: Projected change in global sawnwood and plywood markets

	Change from base case (%):					
	Lumber			Plywood		
Region	P^d	Q^d	Q^s	P^d	Q^d	Q^s
Canada	-7.08	1.17	1.40	-0.96	0.58	1.39
US	-4.98	0.84	0.54	-0.81	0.48	0.65
Russia	-7.08	1.20	1.93	-1.14	0.67	1.04
Europe	-6.14	1.29	2.34	-0.72	0.35	1.26
ROW	-6.40	1.32	0.48	-0.89	0.51	0.53

Table 3: Projected change in global particleboard, fibreboard and wood pulp markets

	Change from base case (%):								
	Particleboard			Fibreboard			Wood pulp		
Region	P^d	Q^d	Q^s	P^d	Q^d	Q^s	P^d	Q^d	Q^s
Canada	18.20	-7.97	-7.73	7.66	-5.40	-7.62	11.11	-4.06	-7.46
US	9.24	-4.14	-2.95	10.73	-7.80	-4.64	12.15	-4.12	-3.90
Russia	19.54	-8.46	-3.47	7.72	-5.45	-5.15	12.44	-4.19	-4.68
Europe	11.26	-4.97	-8.46	4.16	-4.09	-8.50	10.18	-3.40	-3.80
ROW	12.88	-5.52	-2.76	7.80	-6.06	-5.67	12.20	-4.46	-3.10

Table 4: Projected change in global wood pellet markets

	Change from base case (%):		
Region	P^d	Q^d	Q^s
Canada	157.48	54.35	140.63
US	141.88	71.21	116.57
Russia	115.62	82.40	75.10
Europe	111.09	90.86	73.41
ROW	126.39	81.05	386.17