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Price trends and volatility scenarios for designing forest sector transformation

Kyle Lochhead [a,*], Saeed Ghafghazi [a,b], Petr Havlik [c], Nicklas Forsell [c], Michael Obersteiner [c], Gary Bull [a], Warren Mabee [b]

[a] Department of Forest Resources Management, Faculty of Forestry, University of British Columbia, 2424 Main Mall, Vancouver, V6T 1Z4, Canada
[b] Institute for Energy and Environmental Policy, Queen's University, Robert Sutherland Hall 423, Kingston, K7L 2P1, Canada
[c] Ecosystem Services and Management, International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria

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ABSTRACT

Potential scenarios for the forest bioeconomy are heavily reliant on price assumptions; in particular, any abrupt changes in prices have a profound impact on the relevancy of any sector analysis. The objective of this paper was to demonstrate a new forest sector approach for incorporating price uncertainties in order to improve our assessment of investment decision making alternatives. Methodologically, we linked a multivariate generalized autoregressive conditional heteroscedasticity model (mGARCH (1,1)) with three global land use scenarios that are of strategic importance to the forest bioeconomy. The three scenarios were formulated as i) a business as usual scenario, ii) a high biomass usage scenario and iii) a no-growth scenario. Our results indicate an upward trend in prices over time for all three scenarios and for most woody biomass commodities. Under all scenarios, price volatility in the forest sector would be smaller than that for the fossil fuel energy (i.e. oil and natural gas). Price volatilities from fossil fuel markets are positively influencing woody biomass price volatility and positively influencing pulp volatility. These results are discussed in the context of a case study describing investment alternatives for a district heating facility with options for: woody biomass, natural gas, or heating oil.

1. Introduction

Many countries are developing national energy strategies or policies that are aimed to reduce their dependency on fossil fuels and at the same time, increase renewable energy use. Biomass is an important renewable energy option, since it is transportable, can be stored, and if produced and used on a sustainable basis, will contribute to greenhouse gas (GHG) emissions reduction targets (IPCC, 2007). In particular, the forest sector has embraced the potential to play a role in the emerging woody bioenergy and bioproducts market as a means of diversifying markets and production (Hurmekoski and Hetemäki, 2013).

In response to these drivers, the emerging forest sector has undergone structural changes (Bael and Sedjo, 2006; Palma et al., 2010; Nilsson, 2015). One of the key determinants of change is finding profitability, in what is widely regarded as an underperforming industrial sector, in how forest residues and wood waste are processed and used. Many firms see the expansion of woody biomass energy production as a means to recover value (Lauri et al., 2014).

The economics of forest residue and wood waste biomass is poorly understood in most countries due to the lack of information on: feedstock supply, trade flow, transportation logistics, and the biomass price (Roos et al., 1999). Availability and price of biomass are largely determined by the performance of competing sectors, biomass transportation systems, biomass supply sources, accessibility, and scale and system of production (Graham, 2007). Canadian biomass supply chains, for example, rely on the wood fiber made available through processing residues from solid wood or pulp and paper products or logging residue left at harvest sites which makes these sub sectors important determinants of biomass supply costs and volumes (Yemshanov et al., 2014). On the other hand, the price of biomass is highly dependent on other energy markets such as the price of oil and natural gas. For example, logs and energy markets are highly correlated (Hartl and Knoke, 2014), or it is shown that energy markets encourage volatility in various biomass feedstock markets (Onour and Sergi, 2011; Wu et al., 2011) and that these 'volatility spillovers' or 'price transmissions' have increased since the emergence of the biofuels industry (Serra and Zilberman, 2013). Added to this are price uncertainties associated with frequent changes in policy and regulatory environments (Moiseyev et al., 2011; Lauri et al., 2012). This complex set of interrelated system of price movements and global environmental policies challenges economic analysis of the forest sector to forecast price and price changes (Kangas et al., 2011; Solberg et al., 2014).

Perhaps the most challenging elements of economic forecasting, in general, are capturing price movements and its volatility through time

* Corresponding author at: 2201 - 2424 Main Mall, Vancouver, BC, Canada V6T 1Z4. Tel.: +1 604 822 5689.
E-mail address: kyle.lochhead@live.forestry.ubc.ca (K. Lochhead).

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and space. Traditionally, price shocks, volatility and the transmission of volatility to other commodities are not commonly considered in forest sector based studies; in contrast the agricultural sector has considered volatility and correlated price movements (e.g. Saghaian, 2010; Onour and Sergi, 2011; Valin et al., 2014; von Lampe et al., 2014). Of particular interest have been studies assessing the cointegration of oil and ethanol derived from corn or sugar cane (Wu et al., 2011) because evidence of these price movements can be indicative of a strong cointegration of wood based energy carriers that substitute oil in the production of heating and transport fuels. Work by Kristöfel et al. (2014) has shown through univariate generalized autoregressive conditional heteroscedasticity (GARCH) models that price volatility for several woody biomass markets have increased within the last decade which provides greater implications for woody biomass market development.

Investments in district heating systems are of particular interest to furthering the development of woody biomass markets In Europe, utilization of woody biomass for residential and district heating has created a global demand of over 10 million tonnes per annum (Sikkema et al., 2011). In North America, however, woody biomass-based residential heating is an area of interest for reducing GHG emissions associated with the fossil fuels commonly used for residential heating such as heating oil or natural gas (Ghafghazi et al., 2010). For instance, many northern communities in Canada rely on heating oil or diesel to supply heat and energy. The associated costs are high given the fuel needs to be transported by truck, barge or air, as well supply is often disrupted by uncertain weather conditions (Stephen et al., 2016). Assessing alternative energy sources is an important component for investment decision making in district heating systems (Ghafghazi et al., 2010).

It can be commonly seen in studies focusing on assessments of forest-based bioenergy and bioproduct technologies investment, that naïve and simplistic approaches have been employed to project prices of considered forest products. For instance, in studies of bioenergy investments, Chau et al. (2009), Rentizelas et al. (2009), and Chong et al. (2011) applied a constant fuel cost or constant annual fuel inflation rate over the life of the energy system.

The inability to capture uncertain abrupt changes in price movements, otherwise known as price volatility, can lead to delays in the investment process (Pindyck, 1999) or creates opportunities for defensive investments (Henriques and Sadorsky, 2011), and as a result, lead to sub-optimal decision making of investments. For example, price volatility in fossil fuel markets was a 'megaforce' shaping the sustainability of the European pulp and paper industry (Pätäri et al., 2015). Limited financial resources in conjunction with price uncertainty have become barriers for changing the strategic focus of a capital-intensive forest industry (Näyhä and Pesonen, 2014). Therefore a better understanding of the determinants of price volatility remains a critical area of research since it is a pivotal variable for developing forest sector scenarios.

The purpose of this study is to demonstrate an approach to integrate price volatility into forest sector scenario analysis. In this study, we relied on the use of time series models parameterized with historical commodity prices. An important characteristic of price-time series data is the high, clustered variability; but this negates the use of statistical modeling approaches assuming independent and identically distributed errors. As an alternative we used a multivariate GARCH (mGARCH) model which allows for clustered, correlated price volatilities to move together over time and across markets (Engle and Kroner, 1995).

We focus the remainder of this paper on combining price trend scenarios of biomass potentials in world energy consumption and the corresponding price volatility needed for high resolution economic analysis. The organization of the paper follows as; i) the methods used to develop the biomass scenarios and price volatility model; and ii) the results and a discussion of the biomass scenario modeling incorporating price volatility. We conclude by demonstrating the usefulness of this approach using a case study of investment ranking in district heating facilities that consider options for energy sources including: natural gas, heating oil, or woody biomass.

2. Methods

2.1. Biomass scenarios

Scenario analysis is a method for dealing with price uncertainties by using combinations of qualitative descriptions of future outcomes and the quantitative modeling of global drivers. Each scenario includes definitions of problem boundaries, current and future conditions, driving processes, and assumptions of critical uncertainties (Swart et al., 2005). Scenarios describing the future potential of biomass energy are continually being developed (Nakićenović et al., 1998; Hoogwijk et al., 2005; Kraxner et al., 2013; Lauri et al., 2014) and many of these scenarios are designed to reflect environmental constraints and capacities on the supply of biomass, land use conversion, global environmental and commodities polices and commodity trade. We argue that scenario analysis provides a means to describe potential contributions of biomass energy to global energy consumption in the next century, when scenarios are designed to account for the complex set of interacting factors.

The quantitative elements of scenario development typically rely on structural modeling using partial or general equilibrium methods (Serra and Zilberman, 2013). These methods have enabled the development of scenarios to describe, for example, trade impacts of an expanding wood-energy market (Ince et al., 2011), green-house gas effects of biomass electricity expansion (Latta et al., 2013), and forest sector outlooks (Northway et al., 2009; Hurmekoski and Hetemäki, 2013). It is our view that these structural models provide valuable insights into the determinants of long-term commodity price movements. However, there is a problem with informational resolution which leaves investors having to rely on coarse representations of short term price processes. Combining the trends of future prices obtained from such structural models with price volatility analysis (the mGARCH model) would provide the resolution required for short term decision making.

In this study, a global land use model called the Global Biosphere Management Model (GLOBIOM, Havlík et al., 2011; Havlík et al., 2014) was used to develop price scenarios for biomass commodities. The GLOBIOM quantifies the competition for land use between agriculture, forestry, and bioenergy, which are the main land-based production sectors. GLOBIOM uses a global recursive dynamic partial equilibrium modeling structure, that covers 30 world regions, 18 agricultural crop types, a range of livestock production activities, forest products, first- and second-generation bioenergy, and water (Sauer et al., 2010). Production in the model is spatially explicit, taking land and weather characteristics into account. The market equilibrium is gained by maximizing the sum of producer and consumer surplus subject to various constraints regarding resources, technology, and policies. Its simulation period can be adjusted to from 2000 to 2100 with 10-year-step intervals. For more technical information and references on GLOBIOM see www.globiom.org.

Three scenarios were developed, including a business as usual scenario, high biomass usage scenario and a no growth scenario. These scenarios outline key drivers that might differentiate the effectiveness of potential business strategies for a transitioning forest industry to the year 2030. The assumptions are a combination of WWF (World Wide Fund for Nature, formerly named World Wildlife Fund) Living Forests Report (Taylor, 2011) and an assumption by us on GDP growth per capita. All currencies are expressed in 2010 US dollars and other currencies or other base years were converted using the Organization for Economic Co-operation and Development (OECD) deflators and exchange rates where necessary (OECD STATS, 2015).

2.1.1. Business as usual scenario

The business as usual scenario is a projection of what the world could look like if consumer behavior continues on the path of historic trends. It anticipates land-use changes due to demands for land to supply a growing global human population with food, fiber and fuel, and