BIOMASS AND BIOENERGY 35 (2011) 415–420

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BIOMASS & BIOENERGY

Forest biomass and Armington elasticities in Europe

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ARTICLE INFO

Article history:
Received 29 January 2010
Received in revised form
17 August 2010
Accepted 20 August 2010
Available online 15 September 2010

Keywords:
Forestry
Energy policy
Forest models
Roundwood
Chips & particles
Wood residues

ABSTRACT

The purpose of this paper is to provide estimated Armington elasticities for selected European countries and for three forest biomass commodities of main interest in many energy models: roundwood, chips & particles and wood residues. The Armington elasticity is based on the assumption that a specific forest biomass commodity is differentiated by its origin. The statistically significant estimated Armington elasticities range from 0.52 for roundwood in Hungary to approximately 4.53 for roundwood in Estonia. On average, the statistically significant Armington elasticity for chips & particles over all countries is 1.7 and for wood residues and roundwood 1.3 and 1.5, respectively. These elasticities can provide benchmark values for simulation models trying to assess trade patterns of forest biomass commodities and energy policy effects for European countries or for the EU as a whole.

1. Introduction

The trade with forest biomass within Europe has increased by a factor of five between 1997 and 2005 [1]. The increasing trade has been fuelled not only by economic growth and by the integration of the European markets but also by an increasing substitution towards biofuels in the energy systems due to high fossil fuel prices. However, more importantly, the trend towards a higher environmental awareness and an increasing support for renewable energy has been one of the main drivers of the increasing trade of forest biomass. Efforts to address environmental concerns often involve changes in environmental policies towards increasing the share of renewable energy, of which forest biomass has come to play a vital part. Nevertheless, currently most roundwood is used as feedstock within the country of production [2].

Forest biomass is increasingly used in e.g. large-scale energy applications, such as combined heat and power (CHP) and power plants. In addition, pilot and demonstration plants for the production of transportation fuels using wood as main feedstock are under development. Major issues arising from the growing importance of forest biomass trade include e.g., competition effects for users (both domestically and internationally), biodiversity protection, global warming and forest sustainability. The factors influencing the level of trade include income growth, improvements in forestry practice, harvesting and manufacturing technologies and costs, transportation costs, uniform classification of traded commodities, domestic use in relation to availability and the implementation of climate and energy policies stimulating an increasing utilisation of renewable energy. In addition, the degree to which domestically produced forest biomass can be substituted for imported forest biomass is an important factor determining the trade level. A measure capturing such substitution possibilities is the Armington elasticity of substitution (henceforth shortened to Armington elasticity). More

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0961-9534/$ – see front matter
doi:10.1016/j.biombioe.2010.08.050

specifically, Armington elasticity is an economic parameter commonly used in e.g., international trade models and measures the degree of substitution between imported and domestic goods due to changes in the relative price of those two goods. It is based on the assumption that products traded internationally are differentiated by country of origin [3].

The purpose of this paper is to provide estimated Armington elasticities for selected European countries and for three forest commodities of main interest in many energy models: roundwood, chips & particles and wood residues. Gallaway et al. [4] point out that the Armington assumption is important in the international trade literature for a number of reasons. (1) The magnitude of the Armington elasticity is important when assessing the border effect. International borders are apparently reducing trade flows amongst countries but the extent depends on the degree of substitutability between domestic and imported goods [5]. (2) The Armington elasticity plays a key role in applied modelling that is often used to *ex ante* assess impacts of policy changes or other exogenous shocks. Indeed, applied partial and general equilibrium models are almost universally sensitive to the magnitude of the Armington elasticities. While the Armington assumption considerably simplifies the task of parameterising an economic trade model, the Armington elasticity is a key behavioural parameter that drives the results.

2. Method

In general, the elasticity of substitution between two products depends on the degree of product differentiation. The greater the differentiation, the lower the elasticity of substitution between the products. Product differentiation entails at least two dimensions. Firstly, goods are considered imperfect substitutes when they are physically different. Secondly, product differentiation can also involve differentiation by e.g., availability in time, convenience of purchase, after-sales service bundled with the good or even consumers' perceptions of inherent unobservable quality [6]. These factors not related to physical characteristics may play a particularly strong role in product differentiation. In fact, the perception of product differentiation is relatively strong in some instances, even when distinguishing between the two products is difficult. Furthermore, differences in information and transactions cost linked with different suppliers affect the level of differentiation. Importing commodities could mean extra transaction costs and risks due to: (1) extra administrative work (2) exchange rate risk (3) the possibility of protection and disruption of supplies (4) delayed shipments because of extensive transportation (5) possibly fewer resources for after-sales service [6]. These factors differentiate otherwise identical goods, as well as create a systematic home bias and lower elasticities of substitution.

A number of studies of international trade have found evidence of preference bias for the home product over the foreign product that increases the product differentiation. For instance, Trefler [7] finds that home bias is statistically and economically significant in explaining trade flows between countries. McCallum [5] uses a gravity trade model to analyse trade flows between U.S. states and Canadian provinces. Despite fairly similar culture, language, and institutions between these two countries, McCallum [5] finds a surprisingly large border effect. He also finds that province-to-province trade is over twenty times larger than trade between provinces and states. Helliwell [8] largely confirms McCallum's results using similar data when focusing specifically on Quebec. Finally, Wei [9] finds home bias in trade flows amongst OECD countries.

McDaniel and Balistreri [10] summarise three robust findings from the literature. First, long-term estimates of Armington elasticities are larger than short-term estimates. That suggests that substitution between domestically produced and imported goods is easily made in the long-term compared to in the short-term. Second, more disaggregated analyses find higher elasticities, which indicate that aggregation matters and interacts with the Armington specification. Finally, single equation time-series approaches identify smaller responses relative to cross-sectional estimation that include a consideration of supply conditions and a broader interpretation of industrial organization.

2.1. *The model*

As previously stated, the Armington elasticity is based on the assumption that a specific forest biomass commodity is differentiated solely by its origin. This suggests that a representative consumer of the forest biomass regards domestically produced and import as substitute. Given that the consumer has a well-behaved utility function, the consumption decision is consistent with neoclassical utility optimisation.

At a conceptual level, Armington models typically specify a constant elasticity of substitution utility function (CES) over the domestically produced and imported goods, in this case different categories of forest biomass. Following [11,4,12] the CES function can be specified as:

$$Q = \alpha\left[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \quad (1)$$

where M is the imported quantity of a specific forest biomass commodity, D is the domestic production equivalent, σ is the Armington elasticity of substitution between domestically produced and imported forest biomass and finally α and β are calibrated parameters. Reinert and Roland-Holst [11] suggest that σ also can be interpreted as the compensated price elasticity of import demand. The solution to the optimisation problem is to choose a combination of imported and domestically produced forest biomass commodities whose ratio satisfies the first-order condition (see [12] for a formal derivation of the first-order condition).

$$\frac{M}{D} = \left[\frac{\beta}{1-\beta}\frac{p^{\mathrm{D}}}{p^{\mathrm{M}}}\right]^{\sigma} \quad (2)$$

where p^{D} and p^{M} is the domestic and import price respectively. Assuming that the choice between domestically produced and imported forest biomass can be treated as weakly separable from all other input choices, Armington elasticities can be