Journal of Forest Economics 19 (2013) 350–360

Contents lists available at ScienceDirect

Journal of Forest Economics

journal homepage: www.elsevier.com/locate/jfe

A review of recent developments and applications of partial equilibrium models of the forest sector

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ARTICLE INFO

Article history:
Received 15 September 2012
Accepted 24 June 2013

JEL classification:
C61
L73
Q23
Q28

Keywords:
Partial equilibrium
Forest sector modeling
Economic analysis

ABSTRACT

Recent history has seen an increase in the utilization of partial equilibrium based forest sector models to identify potential impacts of various policies or timber market shocks. These models are particularly useful in that they employ economic theory to capture the interaction of supply and demand in a framework where commodity prices are endogenous to the policy or shock simulated. We present recent developments and linkages between models and review applications of these models to forest policy questions over the previous decade. We conclude with a discussion of potential future directions for such research.

Introduction

Policy makers and forest managers have a need for effective means of not only estimating potential future forest market conditions, but also possible outcomes due to changes in the current market and policy framework. As interactions and impacts cross between the forestry and forest industry subsectors, framework integrating these two parts may provide more consistent analyses than those only

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1104-6899/$ – see front matter
http://dx.doi.org/10.1016/j.jfe.2013.06.006

focusing solely on one subsector. A forest sector model, "a model (numerical or strictly analytical) which takes into account both forestry and forest industries and the interaction between these two activities" (Solberg, 1986, p. 420) is in this context a framework which may provide useful information for industry and policy-makers. A subset of forest sector models, partial equilibrium (PE) models, have been employed extensively in research since the end of the 1980s. These models are based on Samuelson (1952) spatial equilibrium problem maximizing the sum of consumers' and producers' surplus making not only the quantities of demand or supply endogenous, but also price. In addition to this market equilibrium condition, a key feature of these models is the simulation of forest sector agents maximizing both profit and utility as price-takers; thus their behavior is strongly tied to the economic theory of rational agents. However, despite their common theoretical ground, the models in use today vary considerably in geographical scope, degree of detail, assumptions regarding agent information and their usefulness in the study of different research questions. Buongiorno (1996) recounts the historical development of some forest sector PE models in the 1980s and Toppinen and Kuuluvainen (2010) provide a review of such models' applications in Europe in the period 1998–2007. Since Buongiorno's (1996) efforts, several new models have emerged, but they have not been complemented with a synthesis of the status quo of the forest sector PE model family. Actually, no less than three new models have emerged in Europe alone since the review of Toppinen and Kuuluvainen (2010). The objective of this paper is to provide an up-to-date overview of forest sector PE models from all regions around the globe, including national, regional and global models either in use today or that formed the basis for those models. We emphasize how the models relate to each other and their features and while we do present a range of policy issues recently studied, we do not intend to provide an exhaustive review of model applications. Acknowledging that other types of models of the forest sector exist, we limit our review to forest sector PE models, abbreviated FSM in the paper.

The remainder of the paper focuses on model development beginning with the four models which provided the basis for the models in use today, beginning with recursive dynamic models followed by intertemporal optimization models The following section explores the types of policies and issues researchers have analyzed. We conclude with a look to the future, both in terms of the types of policies researchers and policymakers need to be ready to evaluate, as well as the modeling tools most appropriate.

Historic model development

As described in Buongiorno (1996), there are four models developed in the 1980s that form the basis for the FSM models of today: (1) TAMM – the Timber Assessment Market Model (Adams and Haynes, 1980) covering North American solid wood products markets; (2) PAPYRUS (Gilless and Buongiorno, 1987) covering the North American pulp and paper markets; (3) IIASA GTM – the International Institute for Applied Systems Analysis Global Trade Model (Kallio et al., 1987) covering global forest products and trade; and (4) TSM – The Timber Supply Model (Lyon and Sedjo, 1983). Of those, only TSM remains in use today, albeit heavily modified, but most of the models in use today have some sort of direct connection to them as shown in Fig. 1. The models that do not have direct links to these efforts do have indirect links through the methodology pioneered by them.

The four models that laid the groundwork for the forest sector models of today differ dramatically in their solution technique and optimization assumptions. While TAMM, PAPYRUS, and IIASA GTM are based on a recursive dynamic framework solving the net social surplus optimization one time period at a time, TSM maximizes surplus in all time periods simultaneously through intertemporal optimization.

This means that in an intertemporal optimization model, such as TSM, the discount rate by which future time period surpluses are weighted becomes of crucial importance. These mathematical problems are also typically much larger as information for all time periods is needed for the solution. This includes not just demand curve locations, costs and elasticities, but also growth and yield information for the forest resource that defines supply which is typically much more detailed for the intertemporal-optimization models.