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THE U.S. PULP AND PAPER MODEL

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ABSTRACT

The U.S. Pulp and Paper Model is an economic model of the pulp and paper sector. It simulates the adoption of new pulp and paper manufacturing processes and simultaneously projects the prices and quantities of pulpwood and wastepaper consumed in the United States and Canada. The model encompasses production and trade of the United States and Canada with respect to each principal grade of pulp, paper, and paperboard, hardwood and softwood pulpwood, and several grades of recycled wastepaper. This report describes the context in which the U.S. Pulp and Paper Model is being developed, and provides a general description of methods and research that are being incorporated in the model.

INTRODUCTION

The U.S. Pulp and Paper Model is being developed by the USDA Forest Service to assess long-range supply and demand for pulpwood in the United States in relation to economic growth, trade, and likely technological changes, such as increased use of wastepaper for recycling. The Forest Service is required by congressional legislation to provide periodic assessments of forest resources in the United States, including analysis of the supply and demand for timber.² The most recent assessment was completed in 1989 and the next assessment is scheduled for completion in 1993.

Research in support of the most recent assessment included development of an economic model of the U.S. and Canadian pulp and paper sector, previously referred to as the Forest Products Laboratory (FPL) Pulpwood Model. In this paper, the improved version of the FPL Pulpwood Model is referred to as the U.S. Pulp and Paper Model because it is designed specifically for use in the 1993 resource assessment. The model provides 50-year projections of technological change in the pulp and paper sector, and projections of future pulpwood consumption

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² See Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (P.L. 93-378, 88 Stat. 476, 16 U.S.C. 1600-1614).

and prices in the United States (see Ince and others 1987, Howard and others 1988). We used the model to examine various scenarios for future technology, including one that assumes an accelerated use of wastepaper in North America (Howard and others 1989). In comparison with many other timber market scenarios that we examined for the 1989 assessment, we found that accelerated wastepaper use could have a very significant impact on future timber prices and consumption patterns in the United States.

Wastepaper recycling has become a major social and political issue in the United States because of mounting concerns about disposal of municipal solid waste, shortfalls of permitted landfill capacity, and rising landfill costs. A comprehensive report on the municipal solid-waste problem in the United States was recently prepared by the United States Congressional Office of Technology Assessment (OTA 1989). Findings of this and other studies point logically to a future in which strong pressures will accelerate the use of wastepaper for papermaking in the United States.

How will the use of wastepaper accelerate in the United States and what are the likely consequences for domestic timber markets? These are the kind of questions that require an analytical tool such as the U.S. Pulp and Paper Model. This economic model is the means by which we will specify detailed assumptions regarding technology change and recycling, and by which we will project the economic consequences in domestic timber markets for the 1993 resource assessment. The model may be used for other purposes as well, such as analysis of joint U.S. and Canadian issues or separate analysis of the Canadian pulp and paper sector.

METHODS

The U.S. Pulp and Paper Model is a spatial equilibrium model, as conceptualized in general by Samuelson (1952). The modeling framework is based on the Price Endogenous Linear Programming System (PELPS) developed originally by Gillies and Buongiorno (1985). As such, the model contains a linear programming formulation of the spatial equilibrium problem (see Duloy and Norton 1975), and it uses "recursive programming" (Day 1973) to find year-to-year solutions for the market equilibria. In this system, it is assumed that the optimizing behavior of the free market can be simulated as the maximization of consumer and producer surplus among all markets and regions in the model.

On the demand side of the model, demand functions represent North American and overseas demands (such as Europe and Asia) for each of the principal grades of paper and paperboard products produced in the United States and Canada. Demand functions include elasticity with respect to North American price and with respect to change in demand determinants, such as projected population and gross national product (GNP). On the supply side, regional U.S. and Canadian supply functions represent pulpwood supply for hardwood and softwood, and wastepaper supply for several principal grades of wastepaper. Supply functions include elasticity with respect to price and with respect to projected regional timber inventories or projected recovery volumes of wastepaper raw material.

In addition, the model includes an endogenous representation of regional U.S. and Canadian production capacity and supply for all principal grades of pulp, paper, and paperboard. Furthermore, regional production capacity for each product is divided among one or more competing processes. These include current processes and processes that will become available for production at assumed future dates. Product supply functions consist of the production capacity existing each year among the various processes and the production costs of each process for the various regions. Capacity growth is allocated to the most economically efficient processes and regions each year, with exogenous constraints on capacity growth. The interaction of the

exogenous demand functions and the endogenous supply functions determines the equilibrium solution for product markets in the projection period. The model also includes an endogenous solution of the regional supply and demand equilibrium for pulpwood and wastepaper, with regional demand determined by raw material requirements of production processes and the simultaneous equilibrium solution for paper and paperboard production.

As fiber raw material markets change during the projection period and as new production technologies are introduced in the model, the regions and processes that experience the most capacity growth can change as well. Thus, as technology for utilizing wastepaper and the supply of wastepaper are projected to change over time, the model will simulate the economic allocation of wastepaper recycling capacity in the pulp and paper sector. It will also simultaneously estimate the future supply and demand equilibrium for pulpwood and wastepaper in the United States (and Canada).

RESEARCH

Several preliminary studies are needed to address some key questions related to the future of wastepaper supply and recycling technology. We encourage others interested in collaborating or supporting this research to contact us directly.

Wastepaper and Recycling Research

Modeling future wastepaper supply is one area that needs additional research. Much research has already been done on institutional aspects of wastepaper supply, including estimates of the volumes of wastepaper generated in the U.S. economy, limitations on waste disposal capacity, infrastructure capabilities, and alternative technologies for disposal of wastepaper (see OTA 1989). Development of precise wastepaper supply functions for each principal grade of wastepaper will involve further research on more detailed questions related to availability of wastepaper for recycling:

In what time frame will specific regions lack landfill availability so that alternatives to landfilling will become mandatory or inevitable?

What precise quantities of wastepaper, by principal grade of wastepaper, go to regional landfills?

How much wastepaper is recoverable for recycling in each region? What costs are associated with recovery and transportation of wastepaper furnish from one region to another?

To what extent will current mandatory source separation laws and other legislative initiatives increase regional supplies of wastepaper (by principal grade of wastepaper)?

Research in this area will examine the volumes of wastepaper generated in various regions by principal grade of wastepaper, infrastructure capabilities, costs of recovery and transportation, alternative disposal technologies, and legal developments likely to influence wastepaper supply functions. We will then develop appropriate supply functions for wastepaper in the U.S. Pulp and Paper Model.

Modeling current and future production processes is another research area that needs to be addressed. Current technological constraints and future developments will determine the pro-

duction processes represented in the U.S. Pulp and Paper Model. Developing accurate process assumptions involves answering various questions related to wastepaper recycling technology:

How will technological developments increase the proportions of recycled wastepaper that can be accommodated in each principal grade of paper and paperboard?

How will production costs be affected in each grade?

When will improved production processes become available in the model?

What legislative mandates will affect papermaking technology (such as mandates on consumer purchase of recycled products or minimum recycled fiber content)?

How will these mandates affect production costs?

Research in this area will involve an extensive review of the technical literature on likely technological, legal, and institutional developments that may affect the future of wastepaper utilization technology. We will then develop specific assumptions about current and future input requirements and production costs for the various production processes incorporated in the U.S. Pulp and Paper Model.

Model-Related Research Topics

Additional research is underway to improve the general structure and capabilities of the U.S. Pulp and Paper Model. Research areas include study of overseas trade (to and from North America) in the principal grades of pulp, paper, paperboard, and wastepaper. The model will include overseas supply and demand functions to represent exogenous trade flows. One question is to what extent will the overseas demand for wastepaper change in the future? Of particular interest is the growing importance of wastepaper export from the United States. Our research will include estimation of overseas demand functions for wastepaper exported from North America. Important questions concern the sensitivity of the overseas demand for wastepaper with respect to domestic prices and exchange rates. Demand functions in the model relate to North American prices and can be adjusted to simulate projected changes in the exchange rates.

Other areas of research that will improve the U.S. Pulp and Paper Model include additional research on North American demand functions for paper and paperboard products, improved mechanisms for dealing with intertemporal constraints on capacity expansion, and development of computerized process models to investigate the effects of technological changes on production processes.

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