Working Paper

Medium-Term Scenarios for the Finnish Pulp and Paper Industry

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Abstract

This report analyzes the competitiveness of the pulp and paper industry in Finland as well as potential future changes in its structure in response to changes in factors affecting the business environment. Examples of such factors include development of market demand, availability of raw materials, and production capacity growth in competing countries. Feasibility of alternative capacity projects is studied using a spatial partial equilibrium model that accommodates firm level and regional details of the Finnish forest sector. Alternative competition hypotheses, perfect competition and Cournot oligopoly, are applied to assess the sensitivity of the results to the choice of market hypothesis. Also, a set of hypothetical mergers is explored as potential future developments. The model structure, the data used, and the results of the alternative scenarios are reported. In addition to the scenario outcomes, we derive the following results that we consider useful in future research.

First, our results suggest that, with the current structure of the European paper industry, it is relatively safe to adhere to the perfect competition hypothesis when modeling the use of existing capacity. To model capacity expansion, further empirical work elucidating an accurate behavioral form is required, because the competition pattern significantly contributes to the investment behavior of the leading firms and hence to overall developments in the industry.

Second, an interesting finding was that when firms realize the price effect of their output but do not consider their influence on their rivals' behavior the industry that is initially composed of several heterogenous firms converges toward a more homogenous size distribution when the same technology is available to all the firms in the market. This is explained by the fact that if the industry lacks the ability to coordinate investments, the large firms have less incentive to expand their capacity, because the potential decrease in product prices hurts them more than it would hurt a small firm with little initial capacity. Mergers are a safe way for large firms to expand or maintain significant market share without harming market prices. However, our result repeats earlier presented conclusions: in homogenous product markets, mergers do not necessarily provide the merged firms private gain other than the potential savings in fixed cost. Instead, an exogenous change in industrial structure can cause losses for the merged firms if they try to dominate the industry in order to restrict output. However, mergers increase concentration, which facilitates coordinating investments. This provides public good to the entire industry.

Keywords: Pulp and paper industry, forest resources, capacity expansion, Cournot oligopoly, horizontal mergers, partial equilibrium model.

Contents

1 Introduction

The aim of this research is to analyze the competitiveness of the pulp and paper industry in Finland as well as potential future changes in its structure. By competitiveness, we mean the ability to produce and sell at a market price without making loss. Thus, competitiveness is affected by prices and production costs, both of which depend on several factors and are in a constant state of change. Typically, main factor affecting the market price is the relation between demand and supply. In times of over supply prices tend to decrease and only firms with low enough costs are able to supply the markets while remaining profitable. In times of excess demand, producers are able to raise prices and supply those customers most willing to pay. The demand is affected by changes in income and consumer preferences as well as by changes in the population. The supply side, in turn, is determined by the existing capacities and production costs of the firms in the industry together with the degree of competition in the industry.

To meet our objective, we must examine the development of the entire forest sector (forestry and forest industry[1]) in Finland, the behavior of competing foreign firms, as well as changes occurring in the markets. Therefore, our analysis is based on scenarios created with a model of the Finnish forest sector, SF-GTM. The SF-GTM is a static multi-periodic partial equilibrium model that originates from a global trade model of the forest sector products (GTM) developed at the International Institute for Applied Systems Analysis (IIASA) during 1980's [23]. The main difference between the SF-GTM and former models depicting the Finnish forest sector is the high level of disaggregation of the SF-GTM. The model accommodates plant-level details of the Finnish forest industry companies, as well as regional details of the forest resources in Finland. To recognize differences in the competitiveness of individual firms, a separate production technology with specific data on furnishes, production costs, and location is defined for each production line of each pulp and paper mill. In addition to the domestic regions, a region "Rest of Europe" (ROFE) has been defined, the characteristics of which are presented in less detail. The consumption of the final forest industry products, the production capacity of the (European) rivals of the Finnish forest industry, as well as a part of the production capacity of the Finnish producers that is located in Western Europe have been placed in that region. For Finnish-owned mills, separate technologies have been defined in ROFE; the aggregation level for the capacities of the other foreign mills varies.

In previous forest sector models, for instance in the original GTM-model, it has been commonly assumed that pulp and paper markets are competitive. However, some considerations suggest that this assumption may not hold. For example, the high level of capital intensiveness of the pulp and paper industry is likely to deter new firms from entering the markets. Also, it is not easy to eliminate potential excess capacity once it has been created, and complete exit from the industry is possible mainly through selling the production facilities to the competitors. Ongoing growth of the companies via mergers and acquisitions, as well as increase of the plant sizes resulting from the pursuit of scale economies are the reality in the pulp and paper industry. Considering these aspects, caution should be paid in the selection of a competition hypothesis for the different products in the model. In this study, we experiment with a hypothesis

[1]Here, the forest sector is defined narrowly to include forestry and forest industry. However, particularly in a country like Finland where the forestry and forest industry are of major importance to the whole economy, the concept could also cover other related entities, for instance, industries supplying investment goods for forestry and the forest industry.

of Cournot-type oligopolistic competition [11] alongside the standard perfect competition assumption to assess the sensitivity of the results to the choice of competition hypothesis.

The existing capacity and technologies used by the incumbent firms form the basis on which the development scenarios are built. The base year levels of the production, consumption, and prices of forestry and forest industry products are input to the model, and the model calculates the equilibrium values of these variables for the subsequent periods, taking into account the constraints, for instance, availability of raw materials, demand growth, and development of consumer preferences. New capacity may be implemented in accordance with the planned capacity investment projects of the forest industry firms in Europe. Feasibility of these projects is endogenously determined by the model.

The results from several experiments with perfect and imperfect competition combined with different assumptions made on the parameters affecting the business environment are compared to screen the feasible capacity investment alternatives and to portray potential directions for changes in the structure of the forest industry in Finland.

Under the imperfect competition hypothesis, we also explore the possibilities for creating mergers between the forest industry companies that would give the companies involved a clear competitive advantage (i.e., power to act as a price setter). Whether the investment policies of the companies involved would change after a merger is also considered.

This report is organized as follows. In Section 2 we review forest sector modeling and earlier studies related to the field. In Section 3 we present the SF-GTM model, and in Section 4, the data for the model are dokumented. The results of the base scenario created with the perfect competition hypothesis are described in Section 5, and sensitivity analyses to the base scenario are reported in Section 6. The alternative scenario created using the Cournot hypothesis is discussed in Section 7, and the impacts of hypothetical mergers are discussed in Section 8. Section 9 summarizes the scenario results and discusses the options for future research.

2 Relation to Earlier Forest Sector Modeling

Forest sector modeling became popular in the late 1970s when numerous models and modeling approaches were developed. The first models were set at the national level (See e.g., Seppälä, Kuuluvainen, and Seppälä [42]). Thereafter global models were constructed. A substantial share of the past and present modeling effortssa concentrate on forestry dynamics alone with purely exogenous treatment of the markets for forest products. This is because these models are designed to analyze the long-run impacts of alternative forestry management policies or environmental changes on the development of forest resources. Our interest lies in the class of models focusing on the economic system connecting forestry, forest industry, and the forest product market.

An economy-wide model that closely resembles the SF-GTM in terms of disaggregation by region and by product, and characterization of forestry and the forest industry, is the Swedish version of the structural model of the World Bank (IBRD) [48]. The model was tailored by Nilsson [33] during 1978-1979 to provide support for discussions concerning medium-term structural changes necessary in the Swedish forest sector.

It was later also applied to the Norwegian forest sector by Gundersen and Solberg [21][22]. The Swedish IBRD was a multi-periodic but static linear programming model consisting of 18 regions: 16 domestic, and 2 import regions. The products modeled included 7 timber categories, 10 pulp grades, 9 paper and board grades, and 5 mechanical forest industry products. The production technologies were defined in the form of input-output matrices taking into account the use of wood fiber raw materials, energy, and chemicals, as well as the aggregate of other costs. The forest industry mills, with their alternative production technologies and respective capacity limits, were located in the regional centers: intra- regional transportation was subject to linear transportation costs. Capital costs for the existing technologies were considered sunk, while yet provided to new mills. The prices for the forest industry products were exogenously defined assuming the Swedish forest industry to be the price taker. The model calculated the optimal harvests and production levels to maximize exports income less the production costs of forestry and the forest industry.

The timber assessment market model (TAMM) by Adams and Haynes [1] was among the first forest sector models deriving from the work of Samuelson. Samuelson [40] demonstrated that the process for finding spatial partial equilibrium for individual trading regions can be viewed as a maximization process where the maximand is the sum of consumers' and producers' surpluses over all the regions less the total costs of interregional transportation. The TAMM model was developed to assist the US Department of Agriculture Forest Service in long-range (50 years) planning and policy analysis in the US forest products sector. The model examines regional production and consumption of roundwood and mechanical wood products in the U.S.A. The product supply functions are estimated econometrically using statistical analysis of production and cost data. The problem is cast in a linear programming model, where the supply, consumption and prices of roundwood, lumber, and plywood are endogenous. The prices for the inputs coming from the other sectors as well as roundwood demand by other sectors are exogenous.

Buongiorno [6] presents a competitive equilibrium model of Samuelson type, now used for international trade in pulp and paper. The modeled products contain four timber categories, two types of pulp, and three paper and board products. Unlike TAMM, this model is of a global scope, with eight supply regions and six demand regions. The five- period model is made dynamic by adding time subscripts for all variables and discounting all costs and benefits. The objective function has been linearized using step functions to approximate the nonlinear production and demand functions.

The base work for global modeling was done during 1980-1985 at IIASA, where the GTM was created. The IIASA forest sector model, which was designed to simulate the long-run economic behavior of forest products markets and the economic system linking forest resources around the world, is also a spatial partial equilibrium economic model. See [23] for the documentation, and [7] or [8] for the evaluation of the behavior and performance of the GTM. There have not been many changes from the original GTM to the SF-GTM. Therefore, the discussion in Section 3 not only applies to the original model to a large extent, but also derives from its documentation.

The SF-GTM is very similar to the Scandinavian versions of IBRD in the way it depicts a national forest sector. The key difference between these models and the competitive market version of the SF-GTM is that the SF-GTM, like TAMM and the original GTM, applies the Samuelsonian concept allowing endogenously determined prices. In addition, the SF-GTM is not a purely national model. Considering the aim of this study, we felt it to be vital to make the international rivalry to the domestic pulp and paper industry endogenous.

Like the models above, the forest sector models have traditionally been based on the perfect competition hypothesis and we argue that this approach has been justified in the past: only 10 years ago there were still so many firms in the pulp and paper industries that with our present experience we may confidently say that, at that time, changing from a competitive to a noncompetitive hypothesis would have had little impact. However, the concentration process in the pulp and paper industries has been extremely intense during the last decade.

Some empirical studies on competition pattern in the forest industy exist. For instance, Booth et al. [5] estimated a dynamic model for demand, price, and regional capacity equations for the North American newsprint industry and found that neither the adjusted full-cost pricing hypothesis or the mark-up over marginal cost pricing hypothesis could be rejected. They also found that the deviations from the marginal costs were dependent on the capacity utilization. On the other hand, Bernstein [4] performed an econometric test hypothesizing noncompetitive behavior in the Canadian pulp and paper industry but rejected the hypothesis: the deviations of product price from marginal costs or factor price from its marginal product revenue were explained by the fact that, due to adjustment costs of capital stock, the markets were in a short-run competitive equilibrium adjusting toward a long-run equilibrium.

3 SF-GTM Model

In this section we describe the structure of the SF-GTM more closely. As much of the details have not changed since the original GTM model, the subsequent description is, to some extent, adopted from Chapters 19 to 25 of [23] containing the documentation of the GTM. Especially when presenting the general structure for partial equilibrium models in general and the SF-GTM in particular (Sections 3.1 and 3.2), we freely capitalize on the framework by Salo and Kallio [39].

Like the original GTM model, the SF-GTM is a partial equilibrium model, because it includes forestry and the forest industry, but the existence of the other sectors in the economy are only accounted for indirectly, via demand functions, if they are considered at all. It is intertemporal but static: it seeks an equilibrium solution for several succeeding periods so that the solution of a particular period is used for updating the data on which the solution of the subsequent period is based. Still, when searching for a solution to any period, the impact of the solution on the outcomes of the subsequent periods is not among the search criteria.

The model consists of two competing economies, Finland and the rest of the world, that are willing to trade commodities whenever gains from trade exist, that is, whenever the trade increases economic welfare in the regions. The rest of the world region is an aggregate of the countries trading forestry and forest industry products with Finland. Because the main market area for the Finnish forest industry products is Europe, and because also the most important competitors for the Finnish forest industry firms are in Europe, we defined the rest of the world region so that it can loosely be interpreted as being Europe excluding Finland and the former Soviet Union. We call that region Rest of Europe (ROFE). Because we are also interested in the regional features of the forest sector in Finland, Finland is further divided into 17 subregions.

For each of the 18 regions we define supply functions for capital, waste paper, and timber, as well as a set of technologies for producing intermediate (pulp, chips) and

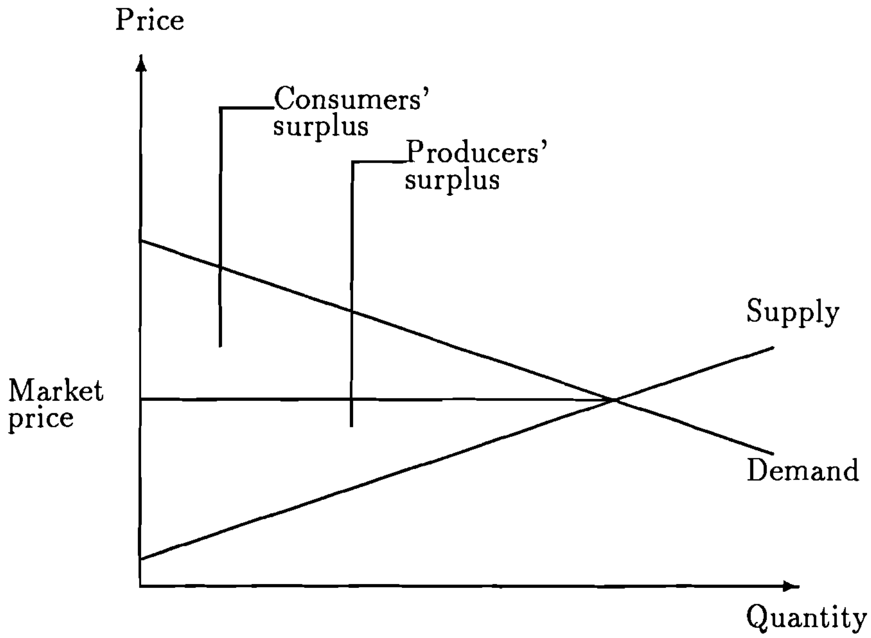


Figure 3.1: Consumers' and producers' surplus

final products (mechanical forest industry products, paper and paperboard). Because consumed quantities in Finland are marginal in comparison to those in Europe and because 90% of the paper and market pulp produced in Finland is exported, demand functions for the final products were only defined for ROFE.

Given an exogenous price vector, each region prepares information on the quantities of the commodities it is willing to produce, consume, import, and export. This information is consolidated and used to calculate regional price vectors equilibrating all the markets. When selecting production levels in the forest industry, a prespecified competition hypothesis is applied. The original GTM employs a perfect competition hypothesis. We also assume competitive markets in our base scenario runs. Thereafter, the competition hypothesis is modified to perform analysis of noncompetitive markets with Cournot-type quantity setting behavior of the firms.

3.1 Structure of a Model with Perfect Competition

The model, in its original competitive markets form, is cast into a mathematical programming problem with a clear economic interpretation. Each region maximizes its social welfare function, which is the sum of consumer and producer surpluses less the transportation costs resulting from trade with the other regions. The outcome of this maximization is restricted by resources, capacity and budget constraints, as well as by possible barriers of trade. Due to these constraints, some economic agents may be able to a make profit (or carry a loss) in the short run despite a competitive economy. For instance, when capacity constraints are binding, firms may be able to sell at a price that exceeds the marginal production costs.

Although the model is formulated into a single mathematical programming problem following the idea of Samuelson, we shall clarify the model structure by considering several levels of hierarchy. At the lowest level, the behavior of the sectoral agents - producers, consumers, and trade agents - is modeled assuming these agents maximize their welfare under specific constraints. Together they form the second hierarchical level, a regional module that may be a sub-module of a larger regional module. In the regional module the objectives and the constraints of the individual agents are aggregated and a further constraint is added: in each region the material balance equation must hold for all the products. This means that the sum of consumption in the region and exports from the region to other regions must equal the sum of production in the region and imports to the region from the other regions. The top level of the hierarchy, the global module, links the regional modules together. Because the individual regions operate independently and are only connected to the other regions via the exports and imports of the interregionally traded products, we can readily aggregate the regional modules to construct the global module. Let us now briefly look into problems at each hierarchical level and their linkage to each other. For notational convenience, we sometimes suppress the superscripts i referring to a region.

Sectoral agents

Consumers

We assume that consumers attempt to maximize their welfare, which depends on the consumption of the final products. With the separable demand functions applied in this study, this welfare is greatest when consumers' surplus, defined as the area below the demand curve and above the equilibrium price, as illustrated in Figure 3.1, is maximized for each product.

The consuming sector is assumed to consist of numerous agents with no bargaining power over prices. In a given region i, let $q = (q_k)$ be a vector of the consumed quantities, and $P_k(q_k)$ be the inverse demand function for product k. Assume that $P_k(q_k)$ is differentiable and nonincreasing. Let $\pi = (\pi_k)$ be a vector of product prices, and let Q denote the consumption possibility set, which is assumed to be closed, convex, and non- empty. Then the consuming sector's problem is given as follows:

$$\max_{q \in Q} \sum_k \int_0^{q_k} P_k(q_k) \mathrm{d}q_k - \pi q \ . \tag{3.1}$$

Producers

Producers (e.g., timber growers and forest industry firms) of a given region i maximize their profits, defined as producer's surplus. Let $z = (z_k)$ be a vector of net output volumes for products k, let $C_k(z_k)$ be the marginal cost function for product k, and let V be a closed, convex, and non-empty production possibility set. Under competitive markets, the vector of product prices $\pi = (\pi_k)$ is not perceived as being dependent on net output volumes by any individual producer. Then the producers' problem is the following:

$$\max_{z \in V} \ \pi z - \sum_k \int_0^{z_k} C_k(z_k) \mathrm{d}z_k \ . \tag{3.2}$$

Trade agents

Trade agents also attempt to maximize their welfare. To do this exporters buy goods at the domestic price, pay for the transportation, and sell at the price of the importing region. Similarly, importers buy at import prices and aim to make profits by selling at the domestic prices. The problem faced by a trade agent operating in region i is the following:

$$\max_{e_{ijk}, e_{jik}} \sum_{jk} [(\pi_k^j - \pi_k^i - D_{ijk}) e_{ijk} + (\pi_k^i - \pi_k^j - D_{jik}) e_{jik}] \ , \tag{3.3}$$

where π_k^i is the price for product k in domestic region i; π_k^j is the price for product k in region j; e_{ijk} are exports for product k from region i to j; e_{jik} are imports from region j to i; and D_{ijk} is the transportation cost for a unit of product k from region i to j. Exports and imports may be restricted exogenously.

Regional models

The objective function for region i is specified by adding up the agents' objective functions (3.1), (3.2), and (3.3), while the feasible set for the regional problem consists of the constraints of the agents and the material balance equations:

$$q_k + \sum_j e_{ijk} = z_k + \sum_j e_{jik} \qquad \forall\, k\ . \tag{3.4}$$

As equations (3.4) hold in equilibrium, the regional objective function can be reduced to (3.5), where the vector π^i of domestic prices no longer appears. The entire problem will then be

$$\max \sum_k \int_0^{q_k} P_k(q_k)\mathrm{d}q_k - \sum_k \int_0^{z_k} C_k(z_k)\mathrm{d}z_k + \sum_{jk}[(\pi_k^j - D_{ijk})e_{ijk} - (\pi_k^j + D_{jik})e_{jik}] \tag{3.5}$$

s.t.

$$q_k + \sum_j e_{ijk} = z_k + \sum_j e_{jik} \qquad \forall\, k \tag{3.6}$$

$$q \in Q \tag{3.7}$$

$$z \in V. \tag{3.8}$$

The global model

The global model aggregates the constraints (3.6) to (3.8) and the objective functions (3.5) of all the regions. As the imports of product k to region i from region j equal the respective exports from j to i, the import variables e_{jik} match the export variables e_{jik}. The global problem is now stated as follows:

$$\max \quad [\sum_{ik} \int_0^{q_k^i} P_k^i(q_k)\mathrm{d}q_k - \sum_{ik} \int_0^{z_k^i} C_k(z_k)\mathrm{d}z_k - \sum_{ijk} D_{ijk}e_{ijk}] \tag{3.9}$$

s.t.

$$q_k^i + \sum_j e_{ijk} = z_k^i + \sum_j e_{jik} \qquad \forall\, k, i \tag{3.10}$$

$$q^i \in Q^i \qquad \forall\, i \tag{3.11}$$

$$z^i \in V^i \qquad \forall\, i\ . \tag{3.12}$$

Following Samuelson [40], the optimality conditions for the problem above equal the equilibrium conditions for global competitive market.

3.2 The SF-GTM: Competitive Model

Let us now turn to a more detailed specification of the competitive markets version of the SF-GTM. The model uses activity analysis framework for production, i.e., there are various separable activities l ($l = 1, 2, .., m^i$) for producing commodities k ($k = 1, 2, ., n$). These activities relate to supply of capital, roundwood, fuelwood, waste paper, mechanical forest industry products, and pulp and paper. The marginal cost functions related to activities l are constant for forest industry products, fuelwood, and waste paper; for roundwood and capital they are increasing. Production possibility set is limited by the capacities (upper bounds) for these activities. For timber imports to Finland, upper and lower bounds have been set to maintain some inertia in trade. For capital, exports refer to foreign investments.

Let $y^i = (y_l^i)$ be the vector of the activity levels in region i; let K_l^i be the available capacity; and let $A^i = (a_{kl})$ be an $n \times m^i$ matrix of input-output coefficients of products k in activities l in region i. Let U_{ijk} and L_{ijk} denote the upper and lower bounds for trade flows, and let $e_{ij} = (e_{ijk})$ denote the vector of exports from region i to j. Further, let $q^i = (q_k^i)$ be the vector of consumed quantities in region i, and let $P_k^i(q_k)$ be the inverse demand for final products. Again, D_{ijk} are the transportation costs per unit of product k from region i to j. A modification of the problem (3.9) to (3.12) to adapt these details yields

$$\max_{q^i, y^i, e_{ij}} \; [\sum_{ik} \int_0^{q_k^i} P_k^i(q_k) \mathrm{d}q_k \; - \; \sum_{il} \int_0^{y_l^i} C_l^i(y_l) \mathrm{d}y_l - \sum_{ijk} D_{ijk} e_{ijk}] \tag{3.13}$$

$s.t.$

$$q^i \; - \; A^i y^i \; + \; \sum_j (e_{ij} - e_{ji}) \; = \; 0 \qquad \forall\, i \tag{3.14}$$

$$0 \leq \; y_l^i \; \leq \; K_l^i \qquad \forall\, l,\, i \tag{3.15}$$

$$L_{ijk} \; \leq \; e_{ijk} \; \leq \; U_{ijk}\, . \qquad \forall\, i,\, j,\, k \tag{3.16}$$

Note that the inverse demand functions $P_k^i(q_k)$ are only defined for final products. Hence q_k^i only refers to the final consumption (mechanical forest industry products, market pulp and paper), and the factor demand is taken into account inherently via the matrix A^i.

The equations (3.13) to (3.16) define a convex optimization problem. Therefore, any solution satisfying the Karush-Kuhn-Tucker conditions of the problem is optimal. Denoting the Lagrangian multipliers for the constraints (3.14) to (3.16) by π^i, μ_l^i, δ_{ijk}, and η_{ijk} respectively, the optimality conditions are then given as follows:

$$
\begin{array}{rlll}
\text{i} & q^i,\, y^i, \text{ and } e_{ij} \text{ satisfy (3.14) to (3.16)} & \forall & i,j \\
\text{ii} & P_k^i(q_k^i) - \pi_k^i = 0 & \forall & i,k \\
\text{iii} & \pi^i A_l^i - C_l^i(y_l^i) - \mu_l^i \leq 0 & \forall & i,l \\
\text{iv} & (\pi^i A_l^i - C_l^i(y_l^i) - \mu_l^i) y_l^i = 0 & \forall & i,l \\
\text{v} & -D_{ijk} - \pi_k^i + \pi_k^j - \delta_{ijk} - \eta_{ijk} \leq 0 & \forall & i,j,k \\
\text{vi} & (-D_{ijk} - \pi_k^i + \pi_k^j - \delta_{ijk} - \eta_{ijk}) e_{ijk} = 0 & \forall & i,j,k \\
\text{vii} & \mu_l^i (K_l^i - y_l^i) = 0 & \forall & i,l \\
\text{viii} & \delta_{ijk}(U_{ijk} - e_{ijk}) = 0 & \forall & i,j,k \\
\text{ix} & \eta_{ijk}(e_{ijk} - L_{ijk}) = 0 & \forall & i,j,k \\
\text{x} & \mu_l^i \geq 0 & \forall & i,l \\
\text{xi} & \delta_{ijk} \geq 0 & \forall & i,j,k \\
\text{xii} & \eta_{ijk} \leq 0 & \forall & i,j,k
\end{array}
$$

It is tedious, but straightforward, to verify that the conditions (**i**) - (**xii**) are in fact equivalent to the conditions of regional equilibrium.

3.3 The SF-GTM: Cournot Hypothesis

In this study we experiment with a hypothesis of Cournot-Nash type oligopolistic competition on the side of the standard perfect competition assumption. When turning from a competitive markets hypothesis to oligopolistic competition, the behavior of the producers is altered. In a Cournot oligopoly, firms choose their production quantities recognizing that their choice has an impact on the price level. When selecting their production quantity they do not, however, consider the effect of their choice on the production decisions of the competing firms. The Cournot equilibrium of the industry is a standard Nash equilibrium for this game.

In this study we will apply the Cournot hypothesis for paper and paperboard only; other products and factor markets are assumed to be competitive. Any firm may produce several products, but as the production and demand functions are assumed separable and the firms are assumed to take factor prices as given. However, for notational convenience, consider a Cournot firm f that only produces one product p with technologies r using intermediate products k acquired from the competitive markets of inputs. Note that, although we here suppress regional indices, the production activities of the firm may locate in any region; however, the consumption of the Cournot products is assumed to take place in ROFE only.

Let z_{pf} be a total quantity of p supplied by firm f, and let Z_p be the total market supply for the product. Let $P_p(Z_p)$ denote the inverse demand function for product p, and let π_k denote a price for input k. Let a_{kr} be the factor coefficient for forest sector input k in technology r, and let c_r denote the unit production costs other than the costs of forest sector inputs. As before, K_r is the productive capacity and y_r is the activity level for technology r. Then the problem of a Cournot firm is

$$
\max \quad P_p(Z_p) z_{pf} - \sum_r c_r y_r - \sum_r \sum_{k \neq p} \pi_k a_{kr} y_r \tag{3.17}
$$

s.t.

$$
z_{pf} = \sum_r y_r
$$

$$
0 \leq y_r \leq K_r \qquad \forall\, r\, . \tag{3.18}
$$

For simplification, we let the Cournot producers handle their trade themselves. Hence, besides non-forest sector inputs, c_r also includes the unit costs of transportation of product p from the region where the particular production activity r is located to the region Rest of Europe.

With linear inverse demand and constant marginal costs, the problem (3.17) - (3.18) is convex, implying that any solution satisfying its Karush-Kuhn-Tucker conditions is globally optimal. Also as the profit functions of all the firms are concave, there exists a unique Cournot-Nash equilibrium for a given vector of input prices.

Let us substitute z_{pf} by $\sum_r y_r$ in (3.17) and form a Lagrangian with multipliers μ_r for the capacity constraints (3.18). Denoting the slope of the demand curve for product p by P'_p, we receive the following optimality conditions for the firm's choice[1]:

$$P_p(Z_p) + P'_p \sum_{r'} y_{r'} - c_r - \sum_{rk} \pi_k a_{kr} - \mu_r \leq 0 \qquad \forall\ r \tag{3.19}$$

$$[P_p(Z_p) + P'_p \sum_{r'} y_{r'} - c_r - \sum_{rk} \pi_k a_{kr} - \mu_r] y_r = 0 \qquad \forall\ r \tag{3.20}$$

$$K_r - y_r \geq 0 \qquad \forall\ r \tag{3.21}$$

$$\mu_r \geq 0 \qquad \forall\ r \tag{3.22}$$

$$\mu_r (K_r - y_r) = 0 \qquad \forall\ r\ . \tag{3.23}$$

Condition (3.23) implies that the shadow price μ_r for capacity constraint (3.18) (the marginal revenue of capital) is zero when the constraint is not binding. On the other hand, condition (3.20) implies that when $y_r = K_r$, μ_r equals the marginal profit for activity l:

$$\mu_r = P_p(Z_p) + P'_p \sum_{r} y_r - c_r - \sum_{rk} \pi_k a_{kr}\ . \tag{3.24}$$

As the slope of the demand curve is assumed to be negative, a marginal increase in production by a firm lowers the price for all the units produced. The marginal profit for the technology is positive when a price less the production costs for a marginal additional unit exceeds the decrease in the initial revenue resulting from the drop in price. The firm tries to choose production levels that equalize the marginal profits for all of its production technologies to zero. Due to the capacity constraints (or too high marginal production costs of a particular technology) this is not always possible.

When all sectors considered in a partial equilibrium problem were competitive, a convex mathematical programming problem resulted, as the problem for the economy was formed by aggregating the objectives and constraints of producers, trade agents, and consumers. However, accommodating the producer behavior described above makes it infeasible to reconstruct the original Samuelson- type model. Here, the problem of restoring the mathematical optimization problem is circumvented by using a heuristic tatônnement algorithm for solving the model.

[1]Note that for homogenous products it applies that $P'_p(Z_p) = \frac{\mathrm{d}P}{\mathrm{d}z_{fp}}$, and here also $\frac{\mathrm{d}P}{\mathrm{d}z_{fp}} = \frac{\mathrm{d}P}{\mathrm{d}y_r}$.

3.4 Solution Algorithm

The solution algorithm of the SF-GTM is based on a tatônnement procedure for linearly constrained convex optimization by Kallio and Salo [24]. One of the benefits of the procedure is that it allows us to solve the model accommodating the Cournot hypothesis with a marginal modification.

Our problem of maximizing the total surplus $U(y,q)$ of the consumers and producers in the competitive economy stated by equations (3.13) - (3.16) is the following:

$$\max_{y,q} \quad U(y,q) = -\int_{y_0}^{y} C(y)\mathrm{d}y \ + \int_{q_0}^{q} P(q)\mathrm{d}q \tag{3.25}$$

s.t.

$$Ay = q \tag{3.26}$$

$$\underline{y} \leq y \leq \overline{y}\ , \tag{3.27}$$

where $\underline{y}$ and $\overline{y}$ denote the lower and upper bounds for the activity levels y that here also include the interreginal trade flows. The tatônnement algorithm solves the problem (3.25) - (3.27) iteratively by adjusting the activity level $y = (y_l)$ and the price vector $\pi = P(q)$ subject to $q = Ay$ until the marginal profit

$$\Pi_l(y,\pi) = -C_l(y_l) + \pi A_l \tag{3.28}$$

satisfies the following equilibrium conditions with respect to tolerance $\delta_l > 0$ for all l:

$$\begin{array}{rll} \text{(i)} & -\delta_l \leq \Pi_l(y,\pi) \leq \delta_l, & \text{if } \underline{y}_l < y_l < \overline{y}_l \\ \text{(ii)} & \Pi_l(y,\pi) \leq 0, & \text{if } y_l = \underline{y}_l \\ \text{(iii)} & \Pi_l(y,\pi) \geq 0, & \text{if } y_l = \overline{y}_l\ . \end{array}$$

Such adjustments of y_l are proportional to the marginal profit of activity l.

In [24] the problem is proved to converge to an equilibrium within tolerances δ_l in a finite number of iterations, provided that the marginal cost functions $C(y)$ and the price functions $P(q)$ are differentiable, and the Jacobians $\partial C/\partial y$ and $-\partial P/\partial q$ are symmetric, positive semi-definite, and bounded over compact domains $\{y \mid \underline{y} \leq y \leq \overline{y}\}$ and $\{q \mid q = Ay,\ \underline{y} \leq y \leq \overline{y}\}$. These conditions are satisfied in this study under perfect competition.

Solving the model under the Cournot hypothesis requires a minor modification of the algorithm. Recall that the production and demand functions are separable. For an activity r related to the production of a Cournot product p, the equilibrium conditions are modified to account for the conditions (3.19) - (3.23) by changing the marginal profit expression 3.28 to:

$$\Pi_l(y,\pi) = -C_l(y_l) + \pi A_l + \partial P_p/\partial q\ z_f\ , \tag{3.29}$$

where the price impact of the total supply z_f of firm f is now taken into account. With this definition the equilibrium conditions (i) - (iii) remain unchanged. This approach is heuristics in the sense that it lacks a convergence proof. As this study is of an empirical nature, we are satisfied with the fact that an equilibrium was always found in our particular exercises.

3.5 Regionalization

Domestic regions

Finland is currently divided into 20 forestry board districts (Figure 3.2). Diverse statistical data about the forest resources and their use are collected annually from these regions, which makes a considerable amount of data readily available. In the model, the domestic regions have been defined maintaining the forestry board districts with three exceptions:

- District 0 (Ahvenanmaa) was left out because there is no significant wood processing industry there.
- Forest resources and sawmills situated in District 1 (Helsinki) were allocated to Districts 4 (Uusimaa-Häme) and 6 (Itä-Häme). There is no pulp and paper industry in District 1.
- Forest resources and the production capacity of the sawmills in District 15 (Keski-Pohjanmaa) were shared by Districts 14 (Pohjanmaa) and 17 (Pohjois-Pohjanmaa). There is no pulp and paper industry in District 15.

Rest of Europe

The region Rest of Europe can be interpreted as being Europe excluding Finland and the regions of the former Soviet Union, with following exceptions.

First, instead of defining trade between Europe and other parts of the world, we have assumed that all the European production is consumed in Europe. Thus, for the products for which Europe is a net exporter, the demand specified in the model is greater than the actual demand in Europe, while the reverse holds for net imports. Market pulp is an exception to the rule. European surplus or deficit of pulp is sold to or bought from the non-European countries.

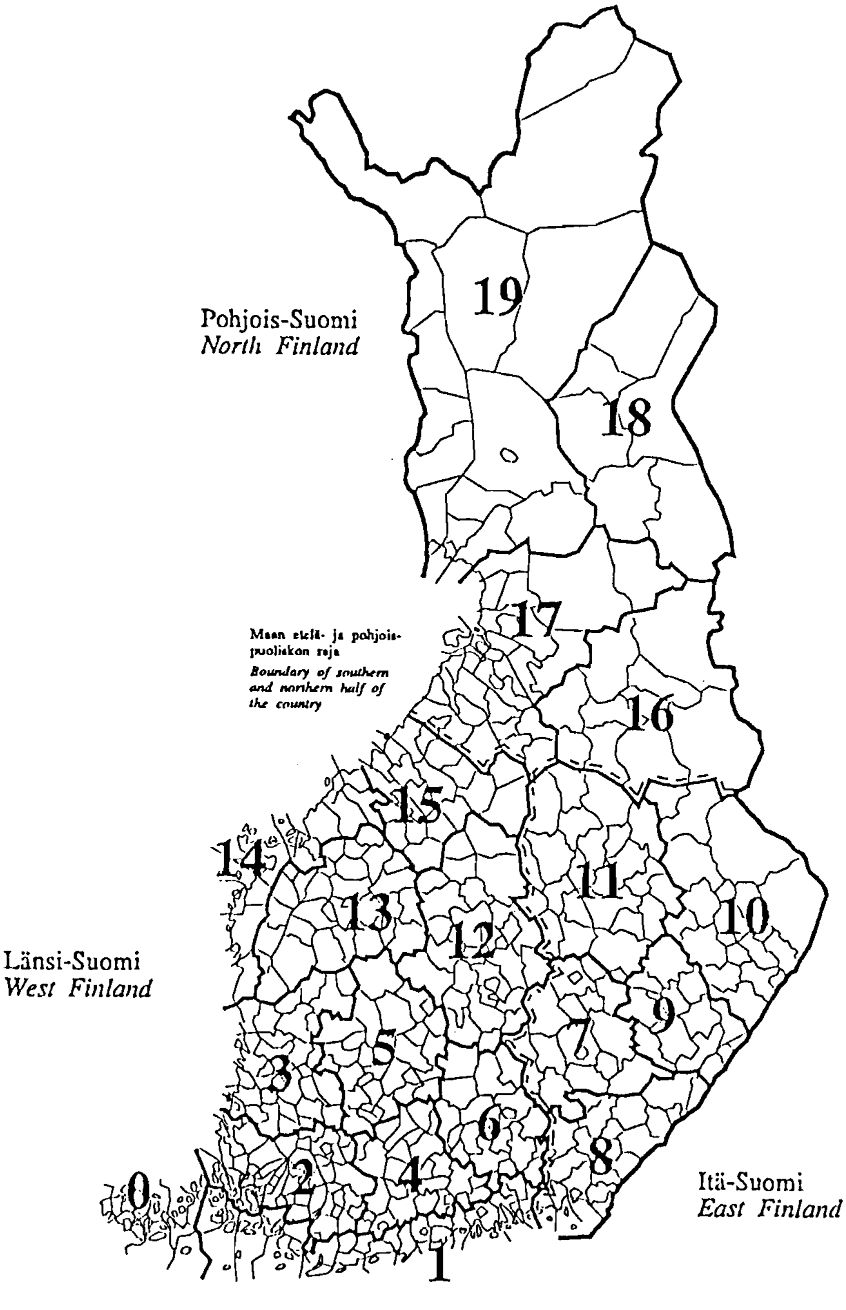
Second, although in reality a major part of the timber imported to Finland originates in Russia, which is not included in ROFE in the model, we still defined Finnish timber imports as coming from ROFE. This was done by aggregating the Finnish base year timber imports to the base year timber consumption in ROFE.

3.6 Product Disaggregation

There are six timber categories in the model. These include two categories for softwood saw logs (pine and spruce), a category for hardwood saw logs (in Finland mainly birch) and three types of pulpwood. Saw logs can be used for veneer plywood and sawnwood production, or it can be chipped for pulpwood or fuelwood. Pulpwood can be chipped to produce mechanical or chemical pulp, veneer plywood, or fuelwood.

Forest industry products are classified into 22 categories including 4 pulp grades, 13 paper and board grades and 5 types of mechanical forest products. In addition, there are categories for recycled paper, and fuelwood. By recycled paper we mean waste paper or paperboard that has yet not been processed in any way. Semi-chemical and mechanical pulps, as well as secondary pulp made of waste paper, are not included as independent product categories in the model, because their production is generally integrated into the production of paper or paperboard. Their production processes are here regarded as being a part of paper and board manufacturing.

Although the emphasis of the study is on the pulp and paper industry, incorporating the mechanical forest industry products into the model was necessary for proper



0.	Ahvenanmaa		10.	Pohjois-Karjala	PKAR
1.	Helsinki		11.	Pohjois-Savo	PSAV
2.	Lounais-Suomi	LOSU	12.	Keski-Suomi	KESU
3.	Satakunta	SATK	13.	Etelä-Pohjanmaa	EPOH
4.	Uusimaa-Häme	UUMH	14.	Pohjanmaa	POHM
5.	Pirkka-Häme	PIRH	15.	Keski-Pohjanmaa	
6.	Itä-Häme	IHAM	16.	Kainuu	KAIN
7.	Etelä-Savo	ESAV	17.	Pohjois-Pohjanmaa	PPOH
8.	Etelä-Karjala	EKAR	18.	Koillis-Suomi	KOSU
9.	Itä-Savo	ISAV	19.	Lappi	LAPI

Figure 3.2: Forestry Board Districts in Finland. The abbreviations refer to the SF-GTM regions. Source: the Finnish Forest Research Institute [51]

representation of the forest sector dynamics. The mechanical forest industry not only competes for timber resources with the pulp and paper industry, but it also acts as a supplier of raw material for pulp production. In 1989 the Finnish pulp industry consumed around 7 mill. m^3 of wood residues from the domestic plywood and sawmill industry, approximately 18% of the total consumption of wood fiber in the pulp industry [50].

The products are classified as primary, intermediate, and final products, of which primary and intermediate products are used within the forest sector as inputs in manufacturing final products. Pulp is here considered to be both an intermediary and a final product. Only the final products are demanded by the consumer sector. The products and their abbreviations used in this study are presented in Table 3.1. All products belonging to the same category are assumed to be homogenous and perfect substitutes in the consumers' utility functions or producers' input demand functions. Potential quality differences between the goods belonging to the same group have in some cases been accounted for when defining the production costs.

All units of measurement are based on the metric system. Volumes of roundwood and mechanical forest industry products are expressed in cubic meters. For roundwood we always refer to over bark volume. For pulp and paper, metric tons are used as a measure of volume.

3.7 Forestry

The interface between forestry and the forest industry consist of a commodity flow from forestry to the forest industry and the information flow between the two sectors. The information that forestry obtains from the forest industry is converted to actions such as harvest decisions and decisions concerning the level of the silvicultural effort that have impact on the future levels of the growing stocks. Similarly the signals from forestry concerning the market behavior of the forest owners and the future development of the timber resources affect the capacity decisions of the forest industry.

As the emphasis of this study is on the medium-term (15 years) behavior of the forest industry, the forestry sector has been overly simplified in the model version employed and many aspects important to the long run dynamics of its development have been omitted, among them the impact of silvicultural activities on the timber supply and the development of the forest area. Forests are regarded primarily as timber inventories, and the amount of wood resources is conceived as a constraint for the decision alternatives of the forest industry. Thus, the model depicts the forest state at the most aggregated level, employing average values for the parameters characterizing the regional forest areas. The development of the regional forest resources is described through the data on the growing stock levels and on the average growth of the forests by tree species. In addition to these data, exogenous upper bounds may be used for the annual harvests of each timber category to ensure that the forest is harvested on a sustainable basis. Because the sustainable harvesting possibilities have not been fully utilized in Finland in the 1980's, the forest growth cannot be directly employed as an upper limit for harvests.

Hence, the information flow between forestry and the forest industry is limited to the periodical timber trade. The model calculates the harvest volumes and timber prices for each period and updates the growing stock data according to the forest growth and the harvest levels received as a model outcome.

Forestry products:		
PLOG	Pine sawlogs	P
SLOG	Spruce sawlogs	P
NLOG	Birch sawlogs	P
PPWD	Pine pulpwood	P
SPWD	Spruce pulpwood	P
NPWD	Birch pulpwood	P
Mechanical forest industry products:		
PSAW	Pine sawnwood	F
SSAW	Spruce sawnwood	F
NSAW	Birch sawnwood	F
VEPY	Veneer plywood	F
PART	Particle board and fiber board	F
Pulp and paper products:		
CWIP	Bleached softwood sulphate pulp	I/F
NWIP	Bleached hardwood sulphate pulp	I/F
CUBP	Unbleached sulphate pulp	I/F
CSIP	Sulphite pulp	I/F
NEWS	Newsprint	F
PRWU	Wood-containing printing and writing papers, uncoated	F
PRWC	Wood-containing printing and writing papers, coated	F
PRFU	Wood-free printing and writing papers, uncoated	F
PRFC	Wood-free printing and writing papers, coated	F
LNER	Linerboard	F
FLUT	Fluting medium	F
FBBO	Folding boxboard	F
SACK	Sack kraft	F
LQPC	Liquid packaging boards	F
CORE	Coreboard	F
SOFT	Household and sanitary papers	F
OPBO	Other paper and paperboard	F
Other:		
RCYC	Waste paper and paperboard	P
FWOD	Fuelwood	F

Table 3.1: SF-GTM -product groups and their abbreviations, P = primary product, I = intermediate product, F = final product

Through the study, we assume that timber markets are perfectly competitive and that timber growers maximize their income for each period separately. Whenever the price is sufficiently high to cover marginal costs, forest owners are expected to be willing to sell timber. Marginal costs are assumed to be an increasing function of the harvested volume, implying the timber supply to be an increasing function of the timber price. The increasing marginal cost function may be explained by a number of reasons. For instance, we may regard that higher timber prices decrease the value of non-timber benefits relative to timber.[2] Also, higher timber prices make the harvesting of timber from the less accessible forests plausible. The fact that the timber producing regions are mature and have a well-developed infrastructure for timber production in Finland makes the latter argument less significant.

When defining the regional timber supply functions, our starting point was the reference values for harvests $\hat{h}_k^i$ for different timber categories k, reference timber prices $\hat{\pi}_k^i$, and econometrically estimated values for supply elasticities of timber price E_k^i.

The actual supply function for timber belonging to category k in region i is presented in its inverse form as

$$\pi_k^i = c_k^i + \alpha_k^i {h_k^i}^{\beta_k^i} \ . \tag{3.30}$$

where π_k^i is a timber price in Finnish *markka* per cubic meter (FIM/m^3), c_k^i is the minimum marginal cost for harvesting (FIM/m^3), h_k^i is a harvest level (mill. m^3/a), and α_k^i and β_k^i are estimated parameters. The value of β_k^i is defined as

$$\beta_k^i = \frac{E_k^i \hat{\pi}_k^i}{\hat{\pi}_k^i + c_k^i},$$

Hence, at the reference harvest level, timber price equals the reference price, and the elasticity of timber price with respect to the harvest volume equals E_k^i.

The value of α_k^i is calculated for the first period by substituting the reference values for harvests, $\hat{h}_k^i$, and price, $\hat{\pi}_k^i$ in (3.30):

$$\alpha_k^i = \frac{\hat{\pi}_k^i - c_k^i}{{\hat{h}_k^i}^{\beta_k^i}} \ .$$

The level of the growing stock affects the supply tightness via parameter α_k^i. Assuming unitary inventory elasticity for timber supply, α_k^i is thereafter updated in each period t, setting

$$\alpha_{k,t}^i = \frac{\alpha_{k,t-1}^i}{(\ G_{k,t}^i / G_{k,t-1}^i\ )^{\beta_k^i}},$$

where $G_{k,t}^i$ is the growing stock level (mill. m^3) in period t.

Separate supply functions are defined for pulpwood and logs, but their growing stock volumes are aggregated, and updated in each period employing the specification

$$G_{k,t}^i = (1 + g_k^i) G_{k,t-1}^i - H_{k,t-1}^i,$$

where g_k^i is the growth rate of the growing stock and $H_{k,t-1}^i$ is the aggregated harvest of pulpwood and logs in period $t-1$.

[2] Although the market behavior of the different owner groups may vary due to, for instance, differences in the valuation of the non-timber uses of the forests, we do not differentiate the timber supply by ownership, but assume that the same supply function applies to all timber within the same timber category. (Private persons own 63% of the forests in Finland [51])

It follows from the equilibrium conditions (**iv**), (**vii**) and (**x**) in Section 3.2 that the timber price may exceed the price suggested by function (3.30) if the desired harvest level is above the exogenously specified upper bound. The price is then determined as the sum of harvesting costs and the shadow price of the harvest constraint that is derived from the ability of the forest industry producers to pay for extra units of timber.

We recognize that the assumption of perfectly competitive timber markets is controversial. The existence of transportation costs may render some spatial monopsony power to forest industry companies, and the forest industry has indeed been accused by the forest owners of behaving collusively when buying timber. Also, traditionally the recommendations for timber prices have been determined in the centralized negotiations between the forest owners and the forest industry, where the forest owners have been represented by the Union of Agricultural Producers and the industry by the Industrial Wood Association. In 1991 timber price negotiations failed and no agreement over prices was achieved. The price of wood has dropped since then by 10 to 30% depending on the grade [52]. Not until 1994 was a new one-year contract concerning the prices and quantities accomplished by the two parties. However, in the present situation the return to centralized price setting seems unlikely, because the kind of contracts that transpired in the past has been condemned by the Finnish competition agency as being in conflict with the Finnish legislation of competition and with the contract upon European Economic Space. The issue was also under investigation by the Efta Surveillance Authority (ESA), which accepted the negotiation over prices but only at the regional level. A recently proposed solution to settle the issue of timber trade was to establish a commodity exchange for timber [25], which would help to ensure the existence of competitive timber markets.

3.8 Forest Industry

For each forest industry product a set of Leontief-type, constant returns to scale production functions is defined. These technologies determine the production factor coefficients, i.e., the amounts of the inputs required and the byproducts received when one unit of the product is produced. For the use of each technology an upper limit is defined.

For the pulp and paper mills in Finland the production factors considered include wood fiber raw materials, capital, labor, energy, and an aggregate of other factors. For mills located in Rest of Europe, we have only segregated costs of wood-fiber raw materials and capital from the other production costs.

The amount of technologies specified in the model varies according to product. The paper and board industry in Finland is the most disaggregated: a specific production technology is defined for each machine for each firm. For the Finnish pulp industry, technologies are defined at the mill level; for the mechanical forest industry technologies are defined at the mill or regional level, depending on data availability. In Rest of Europe the aggregation level of the productive capacity varies considerably, depending on the data that have been available.

Individual Leontief technologies do not allow substitution between factors, whereas some substitution takes place at the industry level via the choice of the new technologies and via production and closure decisions concerning the incumbent technologies. Also, although the firms collectively determine the factor prices via their total input demand, is assumed that no individual firm realizes its effect on factor prices. It follows that each activity has a linear production cost function

$$\Gamma(y_l) = (c_l - \sum_{k \neq p} \pi_k a_{kl}) y_l,$$

where y_l is an output of main product p with technology l (the activity level of the technology); π_k is an endogenously determined price for input or by-product k; a_{kl} is the production factor coefficient for the SF-GTM product categories ($a_{kl} \leq 0$ for inputs and $a_{kl} \geq 0$ for byproducts); and c_l is the aggregated cost for other inputs required to produce one unit of product p.[3] These inputs come from the exogenous sectors.

The issue of capacity adjustment is crucial in this study. Here, we specify the alternative investment plans for new technologies for the model, which determines the feasibility of these plans endogenously. For an investment plan to be feasible, the post-investment market clearing price of the product must cover the per unit variable production costs and the capital costs. The capital costs resulting from an investment in the new capacity are considered only in the period when the installation takes place; thereafter they are regarded as being sunk and as such are assumed to have no impact on the production decisions in the post-investment periods. Existing capacity may be left idle or may be divested whenever production with it is unprofitable.

A specific investment project may also be forced to take place in the model even if it is considered unprofitable. We will exploit this feature only with the ongoing installations of the new capacity to ensure that they are taken into account.

The capital expenditure in any region may be constrained to not exceed the ability to acquire capital.

3.9 Consumer Sector

Consumers of the final products are represented via demand functions assumed to originate from utility maximizing behavior. Due to a lack of data, specific end-user sectors are not identified, but for each product only one aggregated Cobb-Douglas demand function has been defined:

$$\frac{q_k}{\hat{q}_k} = \left(\frac{\pi_k}{\hat{\pi}_k}\right)^{\gamma_k} \tag{3.31}$$

where q_k is a quantity of product k demanded at a price π_k, $\hat{q}_k$ and $\hat{\pi}_k$ denote a reference consumption and price, and γ_k is the price elasticity of the demand. The model solution algorithm uses the following linear approximation of (3.31):

$$\frac{q_k}{\hat{q}_k} = (1 - \gamma_k) + \gamma_k\left(\frac{\pi_k}{\hat{\pi}_k}\right) . \tag{3.32}$$

The price elasticity given by equation (3.32) increases when the price level increases and equals γ_k at the reference price.

The reference demand is updated in each period $\hat{q}_k$ to account for the exogenously given forecasts of the annual demand growth. Thus, there are periodical shifts in the demand function.

As seen from the above equations, the demand for any product is assumed to depend on its own price only, i.e., cross-substitution effects have been omitted. This is due to

[3]Note that constant c_l refers to the marginal cost function $C_l(y_l)$ in the problem specification (3.13) to (3.16). Technically, the SF-GTM allows us to choose between linear and nonlinear cost functions, but we adhere to linear production cost functions for forest industry products in this study.

inadequate data for a joint demand function estimation. This sometimes contradicts empirical evidence. For instance, substitution between PRWU and PRWC exists. Substitution also takes place between forest sector and non-forest sector products. This applies particularly to the mechanical forest industry products used as construction materials, but also to packaging paper and paperboard with plastics, metal, and glass as substitutes. We consider potential consequences of cross-substitution while discussing the results.

3.10 Interregional Trade

Modeling the transportation is a complex matter because transportation costs depend both on the selected transportation range and the volumes and distances transported. It is practically infeasible to specify the most economical means of transportation for each product and each pair of regions. Finding data on the actual costs would be especially difficult. Furthermore, the fact that the model is built to calculate aggregated annual commodity flows renders that approach unappealing because the selection of the transportation range also depends on the transported lot sizes. For these reasons, a simplified method for treating transportation has been chosen: for each product, variable cost of transporting one unit for one distance unit has been defined. The interregional distance matrix is used to compute the total variable transportation costs as a product of distances and unit variable costs. In addition to variable costs, a certain fixed transportation cost is defined for each product and region. The fixed part of the transportation costs is directly added to the production costs of the particular product.

In the absence of trade constraints, the price of a product in an exporting region equals the price of that product in an importing region net of the transportation costs. But if the trade flows are limited by upper or lower bounds and these constraints become active, the above statement about regional prices differing by the cost of intraregional transportation may no longer hold. Then the trade agents may be able to make profits (or carry loss), while the price of the commodity is determined by the importers' willingness to pay for extra units of the commodity. This follows from the optimality conditions (**vi**),(**viii**)(**ix**), (**xi**) and (**xii**) in Section 3.2.

We introduced trade inertia conditions for timber trade only. These conditions state by what percentage the volume of Finland's timber import from Rest of Europe is allowed to decrease or increase periodically.

4 SF-GTM Data Base

The SF-GTM model requires a considerable amount of data on forestry, and the forest industry and various sources were employed to construct the data base. Among the most important data sources were the Finnish Forest Resource Institute (hereafter Metla), Jaakko Pöyry Oy (hereafter also JP), publications of Food and Agriculture Organization of the United Nations (FAO), *Paper European Databook* 1992 [47](hereafter also PED), and numerous magazine articles and company annual reports. Despite all the attempts to make the data as accurate as possible, we do not claim that all the data are indisputable. Presumably, the data on prices of the forest industry products and the data on the raw material furnishes of the non-Finnish paper producers are the most ambiguous part in the data base.

The data reported in this section are used in all the scenarios unless otherwise stated in a scenario presentation. In the scenarios done for sensitivity analysis, the modified data are presented at the beginning of the particular scenario documentation.

In Section 4.1 we will first present the forestry data used by the model for calculating the prices and the supply for timber. In Section 4.2 we discuss the choices made for the treatment of the secondary pulp supply. Section 4.3 describes the data determining the pulp and paper supply in the model: production capacities, potential investment projects, and production technologies. In Cournot scenarios the segregation of the production capacity of paper and paperboard between the individual firms is required. The choices for the firm division are addressed in Section 4.4. As we are especially interested in the printing and writing paper industries, where the Finnish firms are most important, some background information of the industry structure and the main producers will prove useful. Although it is not input data for the model itself, this background information is also discussed in Section 4.4. Section 4.5 describes the capacity and technology data used to model the mechanical forest industry. In Section 4.6 we proceed to the market demand data characterizing consumer behavior in the model. In Section 4.7 the parameters applied to specify the transportation cost are discussed.

All units of money refer to the 1991 Finnish *markka* (FIM) before devaluation, unless stated otherwise. The wholesale price index was used for the conversion of the money from different years.

4.1 Timber Supply

Most forestry data for Finland, for instance the data on timber supply and forest resources, are based on the statistics collected by Metla and published mainly in the annual issues of Yearbook of Forest Statistics ([49]-[52]).

Data on the forest resources in Rest of Europe are primarily from PED [47]. Note that we did not introduce the forestry sector to ROFE to depict the development of the harvest levels in Europe, but merely to define import supply of roundwood to Finland and to establish a connection between the production costs of the competing European producers with their demand for pulpwood and chips. To achieve these objectives we have not scrutinized the details of the forestry development in Europe, but instead have chosen rather coarse estimates to characterize the roundwood supply in ROFE. Note also that we are only interested in pulpwood supply in Rest of Europe, because we introduced no mechanical forest industry there, and because the volume of log imports to Finland is marginal.

	Volume of Growing Stock			Annual Growth Rate of Growing Stock		
Region	Pine	Spruce	Birch	Pine	Spruce	Birch
LOSU	33	30	7	.039	.044	.056
SATK	34	35	11	.043	.043	.056
UUMH	34	64	14	.038	.043	.050
PIRH	32	54	12	.041	.044	.056
IHAM	28	51	12	.038	.045	.047
ESAV	44	42	18	.044	.047	.045
EKAR	35	34	10	.049	.046	.055
ISAV	27	26	11	.040	.048	.043
PKAR	62	43	19	.052	.040	.043
PSAV	45	71	22	.050	.043	.050
KESU	55	63	18	.046	.043	.049
EPOH	46	25	12	.045	.040	.053
POHM	31	28	16	.045	.037	.048
KAIN	68	30	17	.036	.030	.046
PPOH	78	27	31	.046	.038	.056
KOSU	40	21	9	.031	.022	.023
LAPI	95	28	27	.031	.029	.037
Finland	787	672	266	.042	.040	.048
ROFE	4728	4728	5529	.014	.014	.017

Table 4.1: Volumes $G^i_{k,1}$ (mill.m^3) and relative annual growth rates g^i_k of growing stock by tree species in 1989-1990 in the SF-GTM regions. Sources: Metla, PED, with modifications by the author.

All measures of pulpwood and logs are for unbarked timber. Therefore, they are not directly comparable to the figures presented in some other sources, for instance in the documentation of the original GTM.

The volumes and the growth rates of the growing stock

Data on the volumes of growing stock in Finland are based on the computationally updated total volume estimates by tree species on forest and scrubland for January 1990 obtained from Metla; the data on forest growth are based on Metla statistics of the forest growth by tree species during the years from 1985 to 1989. As the growth rate is not only dependent on the forest type but also on the weather conditions of the particular year, averages of the growth volumes from the five years were used.

The statistics for the coniferous growing stock in ROFE, except in Scandinavian countries, generally do not differentiate spruce and pine. Therefore, to meet data input requirements of the SF-GTM, we made this division artificially by splitting the growing stock figures of [47], assigning equal shares for pine and spruce. This division was maintained when defining the softwood pulpwood input for pulp and paper industry in ROFE.

The growth rate of the growing stock applied to ROFE is smaller than the actual growth rate in Europe (around 2.9% pa. in 1990), because it was modified to make the relative increment in the growing stock [(growth - harvests)/growing stock] in the

Region	PLOG	SLOG	NLOG	PPWD	SPWD	NPWD
LOSU	.311	.427	.021	.336	.308	.083
SATK	.457	.639	.033	.398	.405	.193
UUMH	.386	1.062	.094	.481	.705	.253
PIRH	.488	.998	.094	.421	.646	.214
IHAM	.480	.850	.210	.356	.551	.334
ESAV	.758	.627	.233	.554	.527	.480
EKAR	.568	.555	.086	.452	.442	.218
ISAV	.519	.405	.173	.389	.386	.313
PKAR	1.006	.743	.198	.766	.825	.497
PSAV	.616	1.314	.182	.572	1.109	.562
KESU	.843	1.116	.190	.653	.844	.440
EPOH	.534	.458	.022	.603	.469	.339
POHM	.294	.357	.031	.454	.559	.526
KAIN	.646	.342	.007	.587	.598	.303
PPOH	.493	.249	.012	1.012	.475	.503
KOSU	.309	.107	0	.554	.285	.172
LAPI	.521	.097	.003	.971	.506	.562
Finland	9.229	10.346	1.589	9.559	9.640	5.992
ROFE	.190	.130	.040	41.400	41.200	32.200

Table 4.2: Reference timber harvests $\hat{h}$ (mill.m^3) in 1989 for the SF-GTM regions. Sources: Metla, for ROFE; author estimates.

absence of log harvests in the model equal to the actual one in the base year. In the absence of the log harvests, the procedure of increasing the growing stock annually with respect to its total growth and shifting the supply curve accordingly would otherwise give a too generous increase in the pulpwood supply and quickly cause unrealistically low timber price levels in ROFE.

The data on the volumes and the annual growth rates of the growing stock in Finland and ROFE are presented in Table 4.1.

Base year timber supply

The reference timber supply volumes for Finland and ROFE used in the model are shown in Table 4.2. For Finland the reference timber supply volumes employed correspond to the commercial roundwood fellings in 1989 published in [49]. For Rest of Europe we first derived our own estimate for the demand of pulpwood and chips based on the 1989 pulp and paper production in Europe, and then added the Finnish timber imports to that.

These figures cannot be interpreted as harvest volumes in Rest of Europe, because they include pulpwood residuals from the mechanical forest industry and timber exports from North-western Russia to Finland,

For Finland we used the 1989 delivery prices (price of logs delivered to roadside) as a basis for establishing reference prices for timber. These prices provided by [50] include costs of harvesting but not costs of transportation to the mill. The regional reference prices shown in Table 4.3 were defined adding a fixed cost of transportation (20 FIM/m^3) to these delivery prices. (Section 4.7 illustrates how the transportation costs were derived.) Timber prices have dropped dramatically since the chosen base

Region	PLOG	SLOG	NLOG	PPWD	SPWD	NPWD
LOSU	297	247	286	199	224	178
SATK	304	250	280	199	223	181
UUMH	297	245	301	197	225	185
PIRH	302	246	300	199	224	184
IHAM	302	243	329	200	225	188
ESAV	301	234	317	200	224	187
EKAR	301	240	309	203	227	190
ISAV	293	229	313	200	224	186
PKAR	286	227	297	198	222	186
PSAV	288	229	304	197	221	184
KESU	293	237	302	199	222	186
EPOH	292	238	271	199	222	183
POHM	283	235	264	198	222	184
KAIN	281	228	234	201	226	186
PPOH	276	224	246	207	206	187
KOSU	267	213	220	209	205	191
LAPI	262	219	220	201	209	189
Finland	291	239	301	201	223	185
Import	265	211	336	143	200	163

Table 4.3: Reference prices $\hat{\pi}$ (FIM/m^3) for timber for the SF-GTM regions in 1989. Source: Metla.

year (1989) following both the economic recession and the discontinuation of the centralized timber price negotiations. Also the harvest levels have dropped, indicating that a lower price level will not necessarily apply to larger quantities of timber. We chose not to convert these prices to 1991 money to create some (roughly 3.5%) discount to timber prices.

Timber prices in Rest of Europe are far from being uniform and they change constantly. As an example, the mill prices for pulpwood were roughly 10% higher in Sweden and Germany than in Finland in 1989, while in Austria pulpwood cost less than in Finland. In 1990, producers in Finland and Sweden paid approximately the same price for pulpwood, while German and Austrian producers paid roughly 8% less [32]. Fluctuations in the exchange rates are an important factor behind the changes of the relative price levels. The question arises of how to define timber prices for ROFE, which comprises several countries for which no compatible price data are available. Because no approach was found to be more justifiable than another, we chose to use the Finnish import prices from 1989 shown in Table 4.3 as reference prices of timber in Europe. In this way, at least the prices for timber imports comply with the actual base year data. The import prices for spruce pulpwood and hardwood pulpwood equaled the average delivery prices in Finland in 1989; for pine pulpwood the average import price was below the delivery price. We added no extra costs for internal transportation to these prices; hence, we started from the assumption that pulpwood prices in ROFE are lower than in Finland. Note, that because softwood pulpwood input in the pulp and paper production in ROFE is equally divided between pine and spruce, the price of softwood pulpwood perceived by ROFE producers in the model is the average of the prices for spruce and pine, approximately 170 FIM/t in the base year.

The difference between the delivery and stumpage prices in Finland has been used

Region	PLOG	SLOG	NLOG	PPWD	SPWD	NPWD
LOSU-POHM	40	50	40	90	90	90
KAIN-LAPI	50	60	55	100	95	100
ROFE	60	70	60	110	110	110

Table 4.4: Minimum costs for timber harvests and transportation to mill, c_k^i (FIM/m^3). Source: Our own estimates based on the difference between the delivery and stumpage prices for timber in Finland

as an approximation of the minimum harvesting costs (FIM/m^3) in Finland and in ROFE. Fixed transportation cost (20 FIM/m^3 for Finland and 40 FIM/t for ROFE), have been added to these figures and the totals displayed in Table 4.4 have been employed as lower bounds for timber prices.

To our knowledge, no conclusive research on timber price elasticity in Finland has been done. Some experts suggest that 0.5 would be reasonable estimate for timber price elasticity E_k in Finland, and we used that for all the timber categories in the domestic regions. For ROFE pulpwood categories we chose a slightly higher figure (0.7) than that used for Finland, based on the original GTM.

Exogenous limits for harvests

The model permits specification of upper limits for regional harvests to eliminate the possibility of unsustainable harvest levels. These limits do not affect the timber supply curve if the harvested quantities remain below them. Still, they may have great influence on prices via the shadow price effect should a desired harvest level exceed the limit.

To have some data available for comparison, and to be used if the harvests suggested by the model would reduce the growing stock levels, we modified the target harvest levels of the Forest 2000 Program[1] [18][32] to comply with such a need. However, because the growing stock levels predominantly increased in all the scenarios and. because the harvests did not considerably deviate from the modified harvest targets, we chose not to restrict the harvest levels at all in our scenarios.

4.2 Waste Paper Supply

According to PED the consumption of waste paper and paperboard in Europe totalled 25.3 mill.t in 1990, which was 6.4% higher than in 1989. At the same time the consumption of all primary pulp grades except mechanical pulp decreased. The average waste paper recovery rate in 1990 was 37.3% in Europe, and waste paper imports roughly balanced exports [47]. FAO [14] provides a lower figure (21 mill.t) than PED for waste paper consumption in Europe in 1989, and it forecasts that the total European waste paper consumption will more than double to total 53 mill.t in 2010.

The detailed analysis of the supply and the price of recycled paper is beyond the scope of this study and we proceeded with a rather simple approach. We assumed waste paper to be in abundant supply in proportion to the European demand in the coming decade, and because the waste paper use was directly accounted for in the raw

[1] A long-term program for forestry and the forest industries that was organized by the Finnish Ministry of Forestry and Agriculture and carried out between 1983 and 1985 and further updated between 1990 and 1992.

	Import Volumes				Average unit price			
	1989	1990	1991	1992	1989	1990	1991	1992
Finland	86	57	63	127	851	1024	614	599
Sweden	218	275	307		545	475	407	

Table 4.5: Import volumes (1000 t) and unit values (FIM/t) for waste paper in Sweden for 1989 - 1991, and in Finland for 1989 - 1992. Source: Official Statistics of Sweden, Metla.

material inputs of the technologies, the question of how the secondary pulp markets will be arranged in the future was not addressed. In European countries, waste paper has typically been processed to secondary pulp in the on-site plants of the consuming paper mills, whereas in North America secondary pulp has been produced as market pulp to a great extent. Some experts believe the latter trend will also become more common in Europe in the future. Basically, our approach supports integrated secondary pulp production; but when the lack of accurate price data is considered, the transportation costs for the secondary pulp from the separate suppliers to the customers could also be included in the costs currently defined in the model. The maximum demand for waste paper defined in the model via the raw material inputs in the current and future technologies is around 35 mill.t in 2004. Based only on the European paper consumption in 1990, this amount would be collected if the European waste paper recovery rate increased to 50%, that is, to the level it was in 1990 in the Netherlands, Austria, Switzerland, and some other European countries.

Different types of waste paper and paperboard with varying recovery costs are used for different end uses, making the concept of an average waste paper price nonexistent. The price can be negative for grades mixed with other materials like plastic or metal and thus difficult to reuse (e.g., LQPC). On the other hand, it can be close to the price of virgin pulp if the recyclable material is relatively pure and easy to repulp (e.g., fine paper office waste)[2]. We applied one price, 500 FIM/t in Finland and 400 FIM/t in ROFE for all waste paper and paperboard. Some data on waste paper import prices for Finland and Sweden are provided for comparison in Table 4.5 [52][44].

The amount of secondary pulp received in waste paper pulping depends on the purpose for which the fiber is used and varies from 70 to 80% (household or sanitary paper) to 85 to 90% (newsprint) of the amount of waste paper. These differences have been accounted for when defining waste paper inputs for paper and paperboard, granting some variance in the costs of secondary pulp for different grades.[3]

4.3 Pulp and Paper Industry Production

A substantial share of the data on the pulp and paper industry in Finland was acquired from JP. Some of the JP data were ready for application as such, but in most cases further refinement relying on our subjective view was required. In addition to JP, various other data sources were employed, among them the Official Statistics of Finland, FAO, and the Central Association of Finnish Forest Industry (hereafter CAFFI). Also, numerous articles published in periodicals were reviewed. Regarding

[2]Secondary pulp prices even higher than primary pulp prices have been reported in North America. This is explained by the good will value of waste paper.

[3]Due to the fiber degrading, the secondary fiber yield of waste paper is likely to decline in the future. Even a downfall to 50% has been suggested by some sources [34].

		1990	1994	1998	2002
CWIP	Finland	2.7	2.9	3.6	3.9
	ROFE	4.4	4.9	5.0	5.0
	Total	7.1	7.8	8.6	8.9
CWIP	Finland	2.3	2.3	2.8	3.4
	ROFE	5.1	6.1	6.1	6.1
	Total	7.4	8.4	8.9	9.5

Table 4.6: Suggested capacities (mill.t/a) for bleached softwood and hardwood sulphate pulp in Europe used in the SF-GTM.

the data for ROFE, among the most important sources were PED, FAO, and issues of *Pulp and Paper International*. Contradictory data on the volume of European production and consumption appear frequently when different sources are compared. These contradictions result, for instance, from inaccuracies in product categorization. Due to this and the fact that the available data did not always readily fall into the SF-GTM product categories, a great deal of consideration was required to integrate the European data for the model.

Base year supply and capacity development

The base year capacities for pulp and paper mills in Finland were obtained from JP. The data on the capacity projects are based on an FAO investment inquiry from 1991 [17] and on public announcements from the forest industry companies collected from newspaper and magazine articles. Other investment alternatives may have been considered according to our personal judgement.

When specifying the capacity and capacity growth in ROFE, we leaned on FAO capacity surveys [15] [16] and PED. Diverse magazine articles shed further light on the capacity plans of European producers. Particularly, the information provided by the most recent volumes of *Pulp and Paper International* proved useful in completing the European capacity and production data.

The suggested capacity development for paper and paperboard that was applied in the SF-GTM can be seen in Tables 4.18 to 4.29 in Section 4.4. The proposed capacity development for bleached sulphate pulp is presented in Table 4.6. Capacity of chemical pulp other than bleached sulphate pulp has not been projected to expand.

Jaakko Pöyry Oy provided investment expenditure estimates for new machines/mills producing standard grades of pulp, paper, and paperboard. For the rest of the products the respective figures either have been taken from magazine articles covering the capacity investments of the forest industry firms (mechanical forest industry products, CORE) or are based on our own judgment (CUBP, CSIP, OPBO). The investment costs were divided by the associated production capacities to attain the investment costs per unit of production (see Table 4.7). We used the same figures for all European producers.

The data on the base year production volumes are used to define market supply, which is assumed to equal market demand in the base year. These data are presented together with the demand data in Section 4.6. The base year production volumes of the pulp and paper mills in Finland were attained from CAFFI. For respective data on ROFE we mainly employed information provided by PED [47], complemented by FAO capacity statistics [15][16], as product categories in PED are more aggregated than

	Investment Expenditure	Capacity
Chemical Pulp		
CWIP	7800	450
NWIP	7200	450
CUBP	5850	-
CSIP	8100	-
Paper and Paperboard		
NEWS[a]	7425	250
PRWU	7200	300
PRWC	8550	300
PRFU	6300	300
PRFC	12150	250
LNER[b]	8100	400
FLUT	5875	185
FBBO[c]	11250	280
SACK[d]	13500	140
LQPC	12150	300
CORE[e]	2000	80
SOFT[f]	9000	50
OPBO[a]	13500	-

Table 4.7: Typical capacities of new pulp mills and paper machines (1000 t) and investment expenditures by unit of capacity (FIM/t). [a)] Furnish 100% TMP. [b)] Kraftliner. [c)] Includes mechanical pulp. [d)] Sack kraft, includes CUBP. [e)] Example case: UPM, Pori, FIM 1.55 mill. for 80 000 t/a board machine + NSSC pulp line. [f)] Includes de-inked pulp.

are the SF-GTM input data. For instance, for many countries, linerboard and fluting production were aggregated under the category "corrugated boards". We redivided them following the liner and fluting capacities in the respective countries given by FAO.

The list of alternative furnishes and examples of their respective use of factors other than wood fiber production factors in the manufacturing of standard paper and paperboard grades were obtained from JP. Employing these example technologies, each domestic paper machine was assigned to its assumed furnish group at the analyst's discretion. The data on capacities, base year production volumes, and the integration level of the mechanical and chemical pulp plants on the site of the paper and paperboard mills were used as an aid in the classification. Demand of energy and all the other factors except labor were assumed to be similar among the machines that were assigned to the same furnish group. In addition, energy costs for different machines were assumed to increase with machine/mill age and to be less in integrated mills than in nonintegrated ones. Labor input was assumed to be dependent on machine size only. Because a certain minimum amount of personnel is required to staff a paper or paperboard machine regardless of its capacity, required man hours per production unit were assumed to be a decreasing function of the machine capacity.

Generally, we used Finnish averages when specifying costs other than wood fiber production costs in ROFE and did not segregate labor and energy costs from these costs. To define the raw material furnishes for the technologies in ROFE we used

	Finland		ROFE	
	Softwood	Hardwood	Softwood	Hardwood
CWIP	5.5 - 6.3	-	5.8	-
NWIP	-	4.1 - 4.6	-	4.2
CUBP	4.3 - 5.5	4.2	4.3	4.2
CSIP	4.7 - 6.5	-	4.8	4.7

Table 4.8: Ranges for softwood and hardwood pulpwood inputs (m^3/t) in chemical pulp production as currently used in the SF-GTM.

Finnish examples combined with the production and furnish structures of the individual European countries presented in PED. We also referred to the documentation of the data in the original GTM.

Pulp

We disaggregated factor use in the Finnish pulp mills to timber, energy, labor, and other factor costs. For the pulp industry in Rest of Europe, only pulpwood input was segregated from the total factor use and the Finnish averages were employed in specifying the costs incurred from use of other factors. For the new pulp capacity we applied the same cost and pulpwood input in Finland and Rest of Europe.

Use of pulpwood (m^3/t, over bark) in the Finnish pulp mills was set to follow the pulpwood input levels in the base year attained from CAFFI. For bleached pulp produced in Rest of Europe, we selected input levels below the Finnish averages following what was suggested in the documentation of the original GTM for Sweden and Western Europe. The specified pulpwood inputs were within the ranges listed in Table 4.8.

The energy consumption in the pulp mills was specified using mill examples as a reference and applying the following rule: the more modern the mill, the more energy efficient it is. The net energy consumption of a modern pulp mill is negative, because it produces a surplus of energy as a by-product of pulp manufacturing. Mills with a high technical age are dependent on purchased energy. The most energy efficient mill in Finland purchases on the average 1.8 GJ of heat energy and produces a surplus of 0.2 MWh of electricity per ton of pulp. Conversely, the mill that is most dependent on purchased energy must buy 0.7 MWh/t of electricity and 2.8 GJ/t of heat and from outside. As these figures refer to mills and not to pulp grades, we segregated them further to attain separate reference points for CWIP and NWIP. NWIP production is more energy intensive than CWIP production, and the average difference in the energy balances of these grades is 0.7 GJ/t for heat and 0.33 MWh/t for electricity. Although these figures are averages and vary depending on the mill, we used them as a standard for all the mills due to a lack of better data. Presuming energy consumption to increase linearly with the technical age of the mill, we estimated the energy consumption for these two extreme cases. Our estimates are shown in Table 4.9. Using these estimates and denoting the technical age of the mill in years with x, we derived heat consumption (GJ/t) to be .07x + 1.23 in CWIP production and 0.07x + 1.93 in NWIP production; the respective formulas for electricity demand (MWh/t) being .053x - .473 for CWIP and 0.05x - 0.14 for NWIP.

The labor input requirement (h/t) for pulp was assumed to be a decreasing function of the mill capacity and to be roughly the same for NWIP, CWIP and CSIP. For CUBP, a 25% lower level of labor input was employed as no personnel for bleaching is required.

		CWIP		NWIP	
	Age (years)	Heat (GJ/t)	Electricity (MWh/t)	Heat (GJ/t)	Electricity (MWh/t)
Mill A	1	1.3	-.42	2.0	-.09
Mill B	21	2.7	.64	3.4	.97

Table 4.9: Energy consumption in sulphate pulp mills by pulp grade. Author estimates.

	CWIP			NWIP	
	Capacity (t/a)	Costs (FIM/t)		Capacity (t/a)	Costs (FIM/t)
Mill A	200 000	557	Mill B	385 000	464
Mill C	430 000	478	Mill C	430 000	437

Table 4.10: Costs of inputs other than those of wood fiber, energy, or labor in representative sulphate pulp mills by pulp grade.

Mill examples were used as a reference in calculations. The lowest labor requirement, 1.35 h/t, was given to new 400 000 t/a mills, while the maximum labor input, 3.0 h/t, was assigned for old mills with inefficient size. The figures are based on 1650 annual working hours per employee.

The costs of other factors (chemicals, operating materials, packaging, etc.) were set at 444 FIM/t for CWIP and 407 FIM/t for NWIP for the new pulp mills. The cost difference of the two grades is due to lower chemical costs in NWIP manufacturing. We extrapolated to attain the respective figures for old, existing mills, employing the assumption of the economies of scale together with the mill examples presented in Table 4.10.

When pulp and paper production are integrated, savings occur due to omission of drying, packaging, and transportation. These savings, influencing labor, energy, and other costs in pulp production, were assumed to be 330 FIM/t for all chemical pulp. This amount was accounted for when defining the other costs of paper or paperboard manufacturing. For instance, in the case of a paper machine consuming 0.4 t/t pulp coming from the on-site pulp mill, 130 FIM/t was discounted from the paper manufacturing costs. In addition, some further savings are made in the paper mill due to the fact that no storage or preparation of dried pulp is needed.

Newsprint

There are several alternative furnishes for producing newsprint. Its furnish can, for instance, be mixture of TMP (thermo-mechanical pulp) and secondary pulp, their shares varying from 0% to 100%, but other types of mechanical and chemical pulp are also commonly used. In 1991, the typical structure of the variable production costs for newsprint in Finland was 53% fiber, 23% energy, 17% labor, and 7% other. The variable costs other than fiber costs were some 790 FIM/t independent of furnish. We used the Finnish average for all the producers in Rest of Europe except for those using 100% secondary pulp furnish and having lower energy costs. The allocation of the newsprint capacity between the furnish groups used in the model is shown in Table 4.11.

I		**III**	
Furnish:		**Furnish:**	
RCYC	9-25%	RCYC	80 - 100%
Mechanical pulp	57-75%	**Other costs**	770 FIM/t
Chemical pulp	15-20%	**Existing capacity:**	
Other costs:	790 FIM/t	ROFE F	270 000 t/a
Existing capacity:		ROFE S	760 000 t/a
ROFE S	525 000 t/a	ROFE NF	1 240 000 t/a
ROFE NF	610 000 t/a	**Projected capacity:**	
		ROFE F	280 000 t/a
		ROFE NF	1210 000 t/a
II		**IV**	
Furnish:		**Furnish:**	
RCYC	40-60%	RCYC	0-8%
Mechanical pulp	40-40%	Mechanical pulp	70-100%
Chemical pulp	0- 4%	Chemical pulp	0-15%
Other costs:	790 FIM/t	**Other costs:**	790 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	230 000 t/a	Finland	1 415 000 t/a
ROFE F	570 000 t/a	ROFE F	445 000 t/a
ROFE S	740 000 t/a	ROFE S	1 540 000 t/a
ROFE NF	1 970 000 t/a		
Projected capacity:		**Projected capacity:**	
ROFE F	270 000 t/a		
ROFE S	500 000 t/a	ROFE S	560 000 t/a
ROFE NF	260 000 t/a	ROFE NF	280 000 t/a

Table 4.11: Assumed allocation of existing (1994) and projected European newsprint capacity into furnish groups I to IV and average variable costs other than wood fiber costs. ROFE F = capacity owned by Finnish companies but located in Rest of Europe; ROFE S = capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

I		**II**	
Furnish:		**Furnish:**	
Mechanical pulp	49-52%	RCYC	35 - 50%
Chemical pulp	20-25%	Mechanical	
Other costs:	1120 FIM/t	or Chemical pulp	25 - 40%
Existing capacity:		**Other costs:**	1050 FIM/t
Finland	1 060 000 t/a	**Existing capacity:**	
ROFE F	200 000 t/a	ROFE NF	680 000 t/a
ROFE S	1 290 000 t/a	**Projected capacity:**	
ROFE NF	2 770 000 t/a	Finland	300 000 t/a
Projected capacity:		ROFE F	250 000 t/a
ROFE S	270 000 t/a	ROFE NF	760 000 t/a
ROFE NF	250 000 t/a		

III	
Furnish:	
Mechanical pulp	60%
Chemical pulp	15%
Other costs:	1120 FIM/t
Existing capacity:	
Finland	730 000 t/a

Table 4.12: Assumed allocation of existing (1994) and projected European capacity for uncoated wood-containing printing and writing papers into furnish groups I to III and average variable costs other than wood fiber costs. ROFE F = capacity owned by Finnish companies but located in Rest of Europe; ROFE S= capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

Uncoated, wood-containing printing and writing papers

The most common PRWU grade is SC (supercalendered) paper, the furnish of which typically contains 20 to 25% chemical pulp, 50% mechanical groundwood pulp, and 25% fillers, or alternatively 15% chemical pulp, 60% thermo-mechanical pulp, and 25% fillers. With increasing frequency, secondary pulp is also used as a raw material. Then at most 50% of the furnish may contain secondary pulp [13], although a recycled fiber content of 20 to 30% is currently more common.

In 1991, the production factors had the following shares of the average variable production costs in Finland: 45 to 50% fiber, 13 to 20% energy, 14 to 17% labor, and 20 to 24% fillers, chemical and other. The average variable costs other than fiber costs were roughly 1120 FIM/t. This figure was used for all foreign firms except those producing recycled fiber-based PRWU.

The allocation of the PRWU capacity between the furnish groups that was used in the model is shown in Table 4.12.

Coated, wood-containing printing and writing papers

The furnish of coated wood-containing printing and writing papers typically contains about 30% CWIP and 30% mechanical pulp. The rest is fillers and coaters. In 1991, the average variable production costs for PRWU in Finland were shared by the production factors as follows: 40% fiber, 11% energy, 15% labor, and 34% other variable costs.

I		II	
Furnish:		**Furnish:**	
RCYC	18 - 34%	RCYC	0%
Mechanical pulp	18 - 34%	Mechanical pulp	40%
Chemical pulp	0 - 25%	Chemical pulp	24%
Other costs:	1700 FIM/t	**Other costs:**	1770 FIM/t
Existing capacity:		**Existing capacity:**	
ROFE NF	260 000 t/a	Finland	1 090 000 t/a
Projected capacity:		ROFE F	250 000 t/a
Finland	830 000 t/a	ROFE S	420 000 t/a
ROFE F	280 000 t/a	ROFE NF	400 000 t/a
ROFE S	300 000 t/a		
ROFE NF	880 000 t/a		

III	
Furnish:	
RCYC	0%
Mechanical pulp	30-34%
Chemical pulp	30-34%
Other costs:	1670 FIM/t
Existing capacity:	
Finland	1 450 000 t/a
ROFE F	370 000 t/a
ROFE NF	3 600 000 t/a

Table 4.13: Assumed allocation of existing (1994) and projected European capacity for coated wood-containing printing and writing papers into furnish groups I to III and average variable costs other than wood fiber costs. ROFE F= capacity owned by Finnish companies but located in Rest of Europe; ROFE S= capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

I		**II**	
Furnish:		**Furnish:**	
CWIP	21%	CWIP	33 - 40%
NWIP	57%	NWIP	40 - 49%
Other costs:	495-1015 FIM/t	**Other costs:**	495-1015 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	340 000 t/a	Finland	1 000 000 t/a
ROFE F	510 000 t/a	ROFE S	800 000 t/a
ROFE NF	3 600 000 t/a	ROFE NF	520 000 t/a
Projected capacity:		**Projected capacity:**	
Finland	200 000 t/a	Finland	55 000 t/a
ROFE NF	100 000 t/a		
III		**IV**	
Furnish:		**Furnish:**	
CWIP or CSIP	78%	RCYC	48% - 70%
		CWIP	10% - 30%
Other costs:	495-1015 FIM/t	**Other costs:**	700-1015 FIM/t
Existing capacity:		**Existing capacity:**	
ROFE F	260 000 t/a	ROFE NF	2 000 000 t/a
ROFE NF	600 000 t/a	**Projected capacity:**	
		ROFE F	230 000 t/a
		ROFE NF	470 000 t/a

Table 4.14: Assumed allocation of existing (1994) and projected European capacity for uncoated wood-free printing and writing papers into furnish groups I to IV and average variable costs other than wood fiber costs in a nonintegrated mill. ROFE F= capacity owned by Finnish companies but located in Rest of Europe; ROFE S= capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

The variable costs without labor and wood fiber raw material costs totalled roughly 1350 FIM/t for furnish II and 1250 FIM/t for furnish III (see Table 4.13 for the furnish compositions), the discrepancy being mainly due to the differing energy requirements. Some 350 to 490 FIM/t for labor costs is to be added to these figures (depending on the machine size and varying from 140 000 to 215 000 t/a respectively.) For Rest of Europe we applied 350 FIM/t labor cost for new machines and 420 FIM/t for older machines.

Uncoated, wood-free printing and writing paper

The typical furnish for uncoated fine paper with older machines in Finland contains 38% CWIP and 46% NWIP. In the more modern mills NWIP, is used to replace CWIP. Also recycled paper can be mixed into the furnish.

The mill with older technology integrated into pulp production had the following average variable cost structure in 1991: 43% fiber, 10% energy, 33% labor, and 16% other variable factors. When specifying costs other than furnish costs for existing PRFU machines, we used 1015 FIM/t (includes 385 FIM/t labor cost related to a machine size of 115 000 t/a) for a nonintegrated mill in Finland. When data were lacking on the integration levels of paper mills outside Nordic countries, we assumed

I		**II**	
Furnish:		**Furnish:**	
CWIP	22%	RCYC	50%
NWIP	26%		
Other costs:	1640-2000 FIM/t	**Other costs:**	1640-2000 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	630 000 t/a	ROFE S	340 000 t/a
ROFE NF	3 600 000 t/a	ROFE NF	1 130 000 t/a
Projected capacity:		**Projected capacity:**	
Finland	470 000 t/a	ROFE F	250 000 t/a
ROFE NF	470 000 t/a	ROFE NF	400 000 t/a
III		**IV**	
Furnish:		**Furnish:**	
CWIP	50%	CWIP	31%
		NWIP	19%
Other costs:	1640-2000 FIM/t	**Other costs:**	1640-2000
Existing capacity:		**Existing capacity:**	
ROFE F	150 000 t/a	Finland	190 000 t/a
ROFE NF	300 000 t/a	ROFE S	310 000 t/a
		ROFE NF	180 000 t/a

Table 4.15: Assumed allocation of existing (1994) and projected European capacity for coated wood-free printing and writing papers into furnish groups I to IV and average variable costs other than wood fiber costs in a nonintegrated mill. ROFE F= capacity owned by Finnish companies but located in Rest of Europe; ROFE S= capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

the mills to be nonintegrated. Further, we assumed all the capacity installed after the base year to be integrated into chemical pulp production unless it seemed otherwise apparent, and used 495 FIM/t for new integrated PRFU mills.

Coated, wood-free printing and writing paper

The furnish of coated fine papers typically contains 22 to 33% CWIP and 19 to 26% NWIP; the rest is fillers and coaters. PRFC may also be produced from recycled fiber. In an integrated Finnish mill, the average production costs of the coated virgin pulp-based fine papers are shared between the production factors roughly as follows: 24% fiber, 28% energy, 17% labor, and 51% other. We assumed the costs other than wood fiber production costs for an old nonintegrated PRFC mill to be roughly 2000 FIM/t, with the main factor causing the variation in the costs being the machine size contributing to labor input requirement. We assumed the integration into pulp production to reduce the costs by 330 FIM per ton of chemical pulp used. The new machines were assumed to have labor input of about 2.0 h/t and when lacking data on the integration, all the new machines using chemical pulp were assumed to be integrated.

Other paper and paperboard

Tables 4.16 and 4.17 present the principle furnish categories for the rest of the paper and paperboard products and the allocation of the production capacity in the model to these furnish groups. The tables also show the average costs other than wood fiber variable production costs for these products in Finland, applied for the technologies in ROFE.

4.4 Firm Level Division of Paper Capacity

In the following we discuss the choices made in dividing the existing and projected productive capacity of paper and paperboard between the individual firms. When studying the imperfect competition, our interests are in the products that are most important for the Finnish forest industry, namely, printing and writing papers. For these products more effort was paid to make the capacity allocation as realistic as possible; for the rest of the products the chosen capacity division is of an explorative nature.

Newsprint

Newsprint is a relatively homogenous product with standardized quality requirements and a relatively simple production process. Therefore, as there is little room for product differentiation, it may be considered a bulk product. Newsprint has practically no substitutes. As it is almost solely used for newspapers, the size of the newspaper circulation and the amount of advertising dictates its demand, which therefore in the short- and medium-term depends on the level of economic activity. Occasional media events may have great impact on the newspaper industry, rendering uncertainty to already cyclical demand [26][5].

In 1985 roughly 6% of the total newsprint capacity in the world (31.7 mill.t/a) was located in Finland. However, during the last decade, not only this share, but also the absolute capacity has declined, because some capacity has been divested and some has been converted to produce other mechanical papers. High recycling pressure faced by the industry is an important factor behind this development: instead of producing in Finland, it is more economical to place the production facilities near the raw material and the markets. Apparently, the bulky character of newsprint has also made investments to its domestic production less attractive for Finnish companies. Due to the relatively high domestic cost level, Finnish forest industry has been looking for its competitive edge from products with higher quality requirements.

The latest newsprint machine in Finland started production in 1989 in the Kaipola mill of United Paper Mills Ltd (UPM). United Paper Mills is one of the biggest newsprint producers in Europe, with a capacity of about 1.4 mill.t/a. The new machine has a capacity of 230 000 t/a. The two other machines in the mill are relatively old and have not been rebuilt recently. United Paper Mills also has a newsprint mill in Kajaani, Finland, with two recently rebuilt machines with average capacities of 190 000 t/a. Some of the newsprint machines in the Kajaani and Kaipolas mill are also used for producing MF -magazine paper, which is allocated under PRWC in our study. United Paper Mills' newsprint capacity abroad is located in Stracel, France, and Shotton, UK. The construction of the Stracel mill was only finished in 1990, and installation of another machine in the mill is expected. The two-machine newsprint mill in Shotton started one year before the mill in Stracel.

LNER

I		II	
Furnish:		**Furnish:**	
CWIP	0 - 11%	RCYC	100%
NWIP	0 - 11%		
CUBP	72%		
RCYC	7 - 30%		
Other costs:	250 FIM/t	**Other costs:**	250 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	490 000 t/a	ROFE S	100 000 t/a
ROFE S	1 640 000 t/a	ROFE NF	5 750 000 t/a
ROFE NF	1 670 000 t/a	**Projected capacity:**	
		ROFE NF	970 000 t/a

FLUT

I		II	
Furnish:		**Furnish:**	
NPWD (NSSC)	90 - 100%	RCYC	100%
RCYC	0 - 10%		
Other costs:	720 FIM/t	**Other costs:**	720 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	460 000 t/a	ROFE NF	5 430 000 t/a
ROFE S	430 000 t/a	**Projected capacity:**	
ROFE NF	1 040 000 t/a	ROFE NF	720 000 t/a
Projected capacity:			
ROFE NF	100 000 t/a		

FBBO

I		II	
Furnish:		**Furnish:**	
Chemical pulp	35 - 44%	RCYC	50%
Mechanical pulp	0 - 11%	Chemical pulp	40%
RCYC	0 - 17%		
Other costs:	1720 FIM/t	**Other costs:**	1720 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	625 000 t/a	ROFE NF	3 460 000 t/a
ROFE S	620 000 t/a	**Projected capacity:**	
ROFE NF	860 000 t/a	Finland	115 000 t/a
Projected capacity:		ROFE NF	330 000 t/a
ROFE S	420 000 t/a		

Table 4.16: Assumed allocation of existing (1994) and projected capacity for linerboard, fluting and folding boxboard into furnish groups I to II and average variable costs other than wood fiber costs. ROFE F= capacity owned by Finnish companies but located in Rest of Europe; ROFE S= capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

SACK			
I			
Furnish:			
Chemical pulp	80 - 100%		
RCYC	0 - 20%		
Other costs:	70 FIM/t		
Existing capacity:			
Finland	300 000 t/a		
ROFE S	810 000 t/a		
ROFE NF	810 000 t/a		

LQPC			
I		**II**	
Furnish:		**Furnish:**	
CWIP	40%	CWIP and NWIP	27%
NWIP	60%	CUBP	63%
Other costs:	700 FIM/t	**Other costs:**	750 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	390 000 t/a	Finland	140 000 t/a
Projected capacity:		ROFE S	840 000 t/a
Finland	470 000 t/a	**Projected capacity:**	
ROFE S	300 000 t/a	Finland	80 000 t/a
		ROFE S	110 000 t/a

CORE			
I		**II**	
Furnish:		**Furnish:**	
NSSC pulp	100%	RCYC	97%
		Chemical pulp	3%
Other costs:	1250 FIM/t	**Other costs:**	1250 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	140 000 t/a	Finland	115 000 t/a
		ROFE F	65 000 t/a
		ROFE NF	500 000 t/a

SOFT			
I		**II**	
Furnish:		**Furnish:**	
Chemical pulp	40 -100%	RCYC	60 - 100%
RCYC	0 - 60%		
Other costs:	1725 FIM/t	**Other costs:**	1725 FIM/t
Existing capacity:		**Existing capacity:**	
Finland	90 000 t/a	Finland	90 000 t/a
ROFE F	130 000 t/a	ROFE NF	710 000 t/a
ROFE S	220 000 t/a	**Projected capacity:**	
ROFE NF	3 200 000 t/a	ROFE NF	900 000 t/a

Table 4.17: Assumed allocation of existing (1994) and projected capacity for sack kraft, liquid packaging board, coreboard, and tissue paper I to II into furnish groups and average variable costs other than wood fiber costs. ROFE F= capacity owned by Finnish companies but located in Rest of Europe; ROFE S= capacity located in Sweden or Norway; ROFE NF= rest of European capacity.

Enso-Gutzeit (hereafter also EG), with an annual capacity of about 800 000 t, is another important newsprint producer, not only in Finland but also at the European level. In EG's Summa Mill there are currently three machines with capacities ranging between 100 000 t/a and 180 000 t/a. The latest rebuild of a machine in the mill took place in 1989. In Varkaus, EG produces lightweight and other special newsprint. In 1993, Tampella, with its two newsprint machines in the Anjala Paper mill, was acquired by EG . The bigger machine has a capacity of 225 000 t/a and was rebuilt in 1990 for production of special grades. The smaller machine is used to produce MF magazine. In the autumn of 1994, EG started a new mill in Germany (Sachsen Papier) that uses secondary pulp as a raw material.

In addition to UPM and Enso-Gutzeit, the Kymmene Group (hereafter also KG) and Myllykoski also have some newsprint capacity. KG produces roughly 50 000 t/a standard and 110 000 special newsprint grades in Finland. It also has a capacity of 350 000 t/a newsprint in France. The Grand Couronne newsprint mill in France, which produces waste paper-based newsprint and office papers, has belonged to KG since 1990. Myllykoski only produces newsprint in a mill in Germany.

The most important foreign newsprint producers in Europe are the Swedish Stora Group, Svenska Cellulosa Ab (SCA) and the MoDo Group, the Norwegian Norske Skogindustrier (hereafter NSI), and Haindl of Germany.

Stora produces some 1.4 mill. t/a newsprint in Europe, mostly in Sweden. It also owns a newsprint mill in Nova Scotia, Canada. However, this was not considered in this study. A potential future project for Stora is to construct a new machine either at Langerbrugge, Belgium, or at its Swedish Kvarnsveden mill.

In 1989 NSI's newsprint production in its six newsprint mills (five in Norway and one in UK) totalled 1 mill. t, which accounted for 20% of the Nordic newsprint capacity. Since then, NSI has built a new mill in France (Papeteries Golbey S.A.), with a capacity of 220 000 t per year. It has plans for building a second machine in its French mill at the end of the 1990s [47]. Another project that has been postponed so far is to build a new machine in Norway.

Before the autumn 1993, SCA owned 30% of MoDo; its current ownership is about 12%. Together, the two firms have about 1.3 mill. t/a newsprint capacity. SCA is building a new machine in UK with a capacity of 280 000 t/a. The expected startup of the recycled-fiber based UK machine is in the summer 1995. SCA also has had plans to construct a new mill in France at the end of the 1990s. Furthermore, it has also considered converting one of its old newsprint machines in Sweden to the production of LWC paper (lightweight coated). MoDo is going to start a new newsprint machine in its Braviken mill in Sweden in 1996.

Haindl is the biggest producer of secondary pulp-based newsprint in Europe with a capacity of some 760 000 t/a. Adding to that the capacity of Parenco in Holland and Steyrermühl in Austria, of which Haindl owns a considerable part, the total newsprint capacity at least partly controlled by Haindl rises to some 1.6 mill. t/a. This figure includes the Schwedt mill in eastern Germany, which started production in 1993. Haindl has had some plans of building a newsprint mill in Spain with a Spanish collaborator (a plan originally considered by Enso-Gutzeit), but this plan is currently on hold if it has not been totally abandoned. However, we included a new mill to Haind into proposed capacity projects.

Other, less significant names to be considered in the European newsprint industry include Holzmann, KNP, Bridgewater Paper and Papierfabrik Palm. European newsprint producers also risk competition from the North American firms if the Eu-

NEWS	1990	1992	1994	1996	1998	2000	2002	2004
UPM	1445	1380	1380	1650	1650	1650	1650	1650
Stora	1400	1400	1400	1400	1680	1680	1680	1680
Haindl+Steyrerm.	1380	1380	1610	1610	1610	1610	1890	1890
Norske Skog	1060	1280	1280	1280	1280	1280	1780	1780
Enso-Gutzeit	800	810	1090	1090	1090	1090	1090	1090
MoDo	740	740	740	740	1020	1020	1020	1020
SCA	560	560	560	560	840	840	1120	1120
Holzmann	350	350	350	630	630	630	630	630
Kymmene	400	400	400	400	400	400	400	400
KNP	300	300	300	300	300	300	300	300
Myllykoski	270	270	270	270	270	270	270	270
Bridgewater Paper	270	270	270	270	270	270	270	270
Papierfabrik Palm	80	80	80	280	280	280	280	280
North British N.	0	0	0	0	0	0	230	230
2 Firms	100	100	200	200	200	200	200	200
2 Firms	120	120	120	120	120	120	120	120
6 Firms	60	60	60	60	60	60	60	60
Total	9855	10020	10730	11480	12320	12320	13610	13610

Table 4.18: Assumed allocation of European newsprint capacity (1000 t/a) into the individual firms employed in the Cournot scenarios.

ropean price level gets too high, for instance, due to an alteration of the exchange rate of US dollar against European currencies, or if there are unfavorable shocks in American demand. The same applies to other printing and writing papers. Due to the transportation costs the two markets are, however, somewhat separated.

Table 4.18 shows the division of the existing and projected capacity between the individual firms we used in the Cournot scenarios.

Uncoated, wood-containing printing and writing papers

Uncoated, wood-containing printing and writing papers are used for magazines, telephone books, paperbacks, and publications. Coated grades, for instance LWC paper, are used as a substitute for PRWU, if the price difference of the two grades gets too narrow. The average price gap between SC and LWC has typically been around 20%. The main determinant of the PRWU demand, together with the price of PRWC, is the amount of economic activity in general affecting the amount of advertising and other publishing. In the future, the amount of secondary pulp in the furnish may be an increasingly important factor in determining the market shares among competing PRWU grades.

With the annual production of some 1 mill. t, UPM is the biggest SC producer in the world. Before raising the 230 000 t/a SC capacity in its Jämsänkoski mill to 530 000 t/a by installing the world's biggest SC paper machine in 1992, it already had 6% of the world's PRWU capacity [29]. In addition to Jämsänkoski it has two other mills producing SC paper in Finland. In Kajaani, UPM has one recently rebuilt, 130 000 t/a SC machine. In its Rauma mill, which has belonged to UPM since the merger between Rauma Repola and UPM in the early 1990s there are two SC machines, one of which was completely modernized in 1990, raising the capacity of the machine to

230 000 t/a. The other machine was converted from newsprint to SC -paper production in 1989. A new paper machine in the mill is expected after the completion of the Rauma pulp mill in 1996, and in that case, the possibility of a new SC machine can not be disregarded.

SC paper is Myllykoski Oy's main product. In 1991 Myllykoski was the second largest SC producer in the world with 4% of the world's production capacity [29]. In Finland, Myllykoski has three SC machines, the sizes of which vary from 70 000 t/a to 150 000 t/a. The smallest machine has not been rebuilt since 1980, and with its lower quality, it is the first machine to be stopped if there is a lack of orders. The second-biggest machine is currently being rebuilt. Myllykoski also has production capacity in Germany, where it has planned to build a new SC machine with an annual capacity of 250 000 t, and in the USA, which is not considered in this study.

Other Finnish PRWU producers are small in scale. Kymmene has some PRWU production in its Voikkaa mill. Kymmene has also announced some plans for building a new SC machine in the mill. Due to severe over capacity in SC markets and the fact that KG is already an important LWC producer, we proposed a new LWC machine for the mill instead. The Metsä-Serla Group (MS) had a PRWU machine in Kirkniemi, but conversion of that machine to Film Coated Offset paper (PRWC) took place in 1993, and a new machine started in January 1994. Finally, Enso-Gutzeit produces improved newsprint and other uncoated magazine grades in its Anjala paper mill.

The main competitors to the Finnish PRWU producers in European markets are Scandinavian: Stora, SCA, MoDo, and NSI. Stora has currently about 500 000 t/a of SC capacity in Sweden, Germany, and Belgium [2], and it plans to build a new machine in Belgium or Sweden [47]. MoDo and SCA together have over 0.5 mill. t/a SC capacity, of which SCA's 330 000 t/a SC capacity is provided by its Austrian subsidiary Laarkirchen, which intends to invest in additional capacity of 270 000 t/a in the 1990s [2]. Norske Skog Industrier has an SC-capacity of 500 000 t/a, half of which was installed only in 1993.

There are several less important firms producing PRWU in Europe. Among the most significant are the German companies Holzmann and Haindl, both of which intend to increase their PRWU capacity in the late 1990s.

Table 4.19 shows the firm division of the European PRWU capacity applied in the Cournot scenarios with the suggested periodical development.

Coated, wood-containing printing and writing papers

Coated wood-containing printing and writing papers, of which LWC paper is the most common, are used for magazines, books, catalogues, and advertising.

Markets for coated magazine paper are relatively concentrated: 71% of the European production capacity was controlled by five producers in 1993. These producers were Kymmene and Cartiere Burgo, both having 18% of the European capacity, Stora (15 %), MoDo-MD Papier (11%), and KNP (9%) [36].[4] These companies are the world leaders in PRWC supply [29]. 20% of the 3 mill. t/a PRWC production capacity owned by the Finnish companies located in Western Europe in 1993. After KG, UPM is the second biggest Finnish producer of PRWC, having 560 000 t/a LWC capacity in addition to some MF-paper capacity. Enso-Gutzeit and Veitsiluoto together have over 700 000 t/a PRWC productive capacity. A potential merger would double their

[4] The concentration ratio of [36] is based on the total capacity of 6.3 mill. t/a, whereas we have defined it to be over 7 mill. t/a.

PRWU	1990	1992	1994	1996	1998	2000	2002	2004
UPM	780	1100	1100	1100	1400	1400	1400	1400
Stora	540	540	540	810	810	810	810	810
Norske Skog	250	250	500	500	500	500	500	500
Myllykoski	520	520	540	540	790	790	790	790
SCA	330	330	330	330	600	600	600	600
Burgo	300	300	300	300	300	300	300	300
Haindl	320	320	320	430	430	430	430	430
Holzmann	290	290	290	290	440	440	440	440
MoDo	250	250	250	250	250	250	250	250
Metsä-Serla	190	190	0	0	0	0	0	0
Kymmene	100	100	100	100	100	100	100	100
Enso-Gutzeit	60	60	60	60	60	60	60	60
30 Firms	70	70	80	80	90	90	90	90
Total	6030	6350	6730	7110	8380	8380	8380	8380

Table 4.19: Assumed allocation of European uncoated wood-containing printing and paper capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

individual PRWC capacities. In addition to the above mentioned foreign firms, SCA has some 400 000 t/a of LWC capacity and plans to further expand its LWC production by converting one of its newsprint machines in Ortviken, Sweden, to LWC production. SCA has been negotiating for the acquisition of MD Papier, of which MoDo owns 25% [2]. If that acquisition were to take place, there would be four major LWC producers in Europe: Kymmene, Stora-Feldmuhle, Cartiere-Burgo and SCA-MoDo-MD Papier.

In Finland we forced a Metsä-Serla PRWU machine to be converted to coated grades and proposed new PRWC machines to Rauma (UPM) and Voikkaa (KG). In ROFE, the projected capacity expansion from 1994 to 2004 exceeds 2 mill. t, including a new machine for Myllykoski, which we proposed. See Table 4.20 for the firm-level capacity allocation employed in the Cournot scenarios.

Uncoated, wood-free printing and writing paper

Uncoated fine papers are typically used for books and office paper, copy paper, and computer printouts. However, the division of fine paper capacities into uncoated and coated grades is inevitably ambiguous, because uncoated grades also serve as base for coating, which is often completed in a separate coating machine. In the base year, PRFU capacity of the Finnish companies was 1.7 mill. t/a, of which 0.5 mill. t/a were located in Central Europe. Kymmene, with its over 1 mill. t/a production capacity, is the biggest European producer of uncoated fine papers. In 1991 its 3% share of the world market was outnumbered only by three North American firms: International Paper (IP, 7% of the world PRFU markets), Georgia Pacific (5%) and Champion International (4%). The next six firms each supplied 2% of the world total [29].

The most important PRFU producers in Europe after KG are Arjo Wiggins Appleton (AWA), which is the largest producer of carbonless copy papers, with a capacity of some 0.7 mill. t/a including its Portuguese subsidiary Soporcel; MoDo, with almost 0.8 mill t/a of productive capacity; Papierwerke Waldhof Aschaffenburg AG (PWA, 0.6 mill. t/a); and Stora (0.5 mill. t/a). A merger between Enso-Gutzeit and Veitsiluoto

PRWC	1990	1992	1994	1996	1998	2000	2002	2004
Kymmene	1300	1300	1300	1300	1600	1600	1600	1600
Burgo	1040	1270	1270	1270	1270	1570	1570	1570
Stora	950	950	950	1180	1180	1180	1180	1180
Enso+Veitsiluoto	720	720	720	720	720	720	720	720
MoDo+MD papier	670	670	670	670	670	670	970	970
UPM	670	670	670	670	970	970	970	970
KNP	570	570	570	570	570	570	570	570
Haindl	500	500	500	500	500	500	500	500
SCA	0	420	420	420	720	720	720	720
Myllykoski	300	300	300	300	580	580	580	580
Metsä-Serla	160	160	160	390	390	390	390	390
4 Firms	70	70	80	80	80	80	80	80
Total	7160	7810	7850	8310	9490	9790	10090	10090

Table 4.20: Assumed allocation of European capacity for coated wood- containing printing and writing papers (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

would elevate the new firm to the group of the most important fine paper producers in Europe. Table 4.21 shows the firm division employed. For Finnish firms, we proposed new PRFU machines to UPM (EKAR) and to Kymmene (ROFE).

Coated, wood-free printing and writing paper

Coated fine papers are used for publications requiring high-quality printing: artbooks, companies' annual reports and print advertisements. European KNP-Leykam and North American S.D. Warren/Scott were the leading producers of coated fine papers in the world in 1991, each having 6% of the world total. They were followed by Stora-Feldmuhle, with a 5% share and some 0.6 mill. t/a productive capacity. The next seven firms had a 20% share of the world markets [29]. Among PRFC producers in the European markets, Torraspapel and PWA are currently as important as Stora-Feldmuhle.

In 1993 the PRFC capacity of the Finnish companies was roughly 1.3 mill. t/a, of which some 150 000 t/a was located in Western Europe. No Finnish company was particularly important in an international context. The company with the most PRFC capacity in Finland was Veitsiluoto, which only started to produce PRFC with a 270 000 t/a machine in 1992. The second biggest Finnish PRFU producer is Kymmene producing coated fine papers both in Finland and abroad. Enso-Gutzeit and Metsä-Serla each have roughly 180 000 t/a of PRFU capacity. For Finnish firms, we proposed new PRFC machines to MS (UUMH), Veitsiluoto (PPOH), and KG (ROFE). The capacity allocation for individual firms is given in Table 4.22.

Household and sanitary paper

Markets for household and sanitary paper have become increasingly concentrated during the 1990s as a result of the entrance to the markets of a couple of American firms and the expansion of their market share either via acquisitions (e.g., James River) or via investments in new productive capacity (e.g., Kimberley Clark). According to a survey made by *Pulp and Paper International* [36], 61% of the European 4000 t/a capacity for tissue and towel was owned by the five largest firms in the industry in

PRFU	1990	1992	1994	1996	1998	2000	2002	2004
Kymmene	860	1120	1120	1120	1120	1120	1120	1120
Enso+Veitsiluoto	800	800	800	800	1030	1030	1030	1030
MoDo	540	770	770	770	770	770	770	770
AWA+Soporcell	440	690	690	690	690	690	690	690
PWA	350	350	600	600	600	600	600	600
Stora	500	500	500	500	500	500	500	500
IP	320	320	320	520	520	520	520	520
Frantschach	260	260	260	530	530	530	530	530
Fletcher Chall.	300	300	300	300	300	300	300	300
UPM	60	60	60	60	260	260	260	260
Metsä-Serla	115	115	115	170	170	170	170	170
5 Firms	165	165	165	165	165	165	165	165
4 Firms	75	100	100	100	100	100	100	100
35 Firms	80	80	80	80	80	80	80	80
Total	8470	9310	9560	10085	10515	10515	10515	10515

Table 4.21: Assumed allocation of the European capacity of uncoated fine papers (1000 t/a) into the individual firms for 1989 - 2004 employed in Cournot the scenarios.

PRFC	1990	1992	1994	1996	1998	2000	2002	2004
KNP	900	900	900	900	900	900	900	900
Stora	520	520	520	720	720	720	990	990
PWA	540	540	540	540	540	540	540	540
Torraspapel	380	380	580	580	580	580	580	580
Enso+Veitsiluoto	180	450	450	450	720	720	720	720
AWA+Soporcell	350	350	350	550	550	550	550	550
Kymmene	270	270	270	270	520	520	520	520
The Marchi Group	300	300	340	340	340	540	540	540
IP	230	230	400	400	400	400	400	400
Sappi	220	400	400	400	400	400	400	400
Metsä-Serla	180	180	180	180	380	380	380	380
Cellulose du Pin	220	360	360	360	360	360	360	360
Cartiere Burgo	230	230	230	230	230	230	230	230
Scheufelen	180	180	180	180	180	180	180	180
Fletcher Chall.	170	170	170	170	170	170	170	170
Biberist	0	0	150	150	150	150	150	150
MoDo	120	120	120	120	120	120	120	120
Ahlström	40	40	40	40	40	40	40	40
UPM	40	40	40	40	40	40	40	40
10 Firms	60	60	60	60	60	60	60	60
Total	5670	6260	6820	7220	7940	8140	8410	8410

Table 4.22: Assumed allocation of the European capacity of coated fine papers (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

SOFT	1990	1992	1994	1996	1998	2000	2002	2004
Scott Paper	750	750	750	750	850	850	950	950
PWA	510	590	650	650	750	750	850	850
James River	550	550	550	550	650	650	750	750
Kimberley Clark	240	320	320	420	520	520	620	620
SCA	220	220	220	220	220	220	220	220
Metsä-Serla	220	220	220	220	220	220	220	220
5 Firms	100	100	150	150	150	150	150	150
15 Firms	60	60	60	60	60	60	60	60
Total	3890	4050	4360	4460	4860	4860	5260	5260

Table 4.23: Assumed allocation of the European household and sanitary paper capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

SACK	1990	1992	1994	1996	1998	2000	2002	2004
Cellulose du Pin	300	300	300	300	300	300	300	300
Frantschach	250	250	250	250	250	250	250	250
Korsnäs	200	200	200	200	200	200	200	200
NCB	200	200	200	200	200	200	200	200
Stora	200	200	200	200	200	200	200	200
MoDo	150	150	150	150	150	150	150	150
Kymmene	135	135	135	135	135	135	135	135
UPM	190	95	95	95	95	95	95	95
5 Firms	60	60	60	60	60	60	60	60
Total	1925	1830	1830	1830	1830	1830	1830	1830

Table 4.24: Assumed allocation of the European sack kraft capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

1992, these firms being Scott Paper (19%), PWA (15%), James River (14%), Kimberley Clark (8%), and Metsä-Serla or SCA (both 5%). After allocating the capacities for the six most important firms, we allocated the remaining capacity to fringe firms as presented in Table 4.23. The projected capacity increment was allocated to these firms assuming that the four biggest firms would grow the most.

Sack paper

According to [36], the major European producers of sack paper in 1992 were Cellulose du Pin, Frantschach, Stora, Korsnäs, NCB, MoDo, UPM and Kymmene, with capacities ranging from 150 000 t/a to 300 000 t/a and with none of them being considerably more important than the others. The capacities of these sack producers were allocated accordingly and the remaining capacity was divided between hypothetical fringe firms (See Table 4.24).

Corrugated boards

The most important corrugated board manufacturers in Europe are SCA, KNP, Jefferson Smurfit, Cellulose du Pin, and PWA. These firms control over 50% of the European capacity. At the time of writing, we lack data on the allocation of the capacities of these firms between linerboard and fluting, and the firm division for LNER and FLUT shown

LNER	1990	1992	1994	1996	1998	2000	2002	2004
SCA	1290	1290	1390	1390	1390	1390	1490	1490
Rec. Paper Europe	600	830	830	830	830	830	830	830
Jefferson Smurfit	780	780	780	780	900	900	900	900
KNP	780	780	780	780	780	780	780	780
Cellulose du Pin	780	780	780	780	780	780	780	780
Assi	600	600	600	600	600	600	600	600
Leydier	400	400	600	600	600	600	600	600
IP	400	400	400	400	400	400	400	400
Saica	230	230	380	380	380	380	380	380
Metsä-Serla	300	330	330	330	330	330	330	330
PWA	300	300	300	300	300	300	300	300
Prinzhorn	180	180	180	180	180	180	480	480
Nettingsdorfer	50	50	300	300	300	300	300	300
Enso-Gutzeit	160	160	160	160	160	160	160	160
20 Firms	100	100	100	110	110	110	110	110
Total	8850	9210	9910	10110	10230	10230	10630	10630

Table 4.25: Assumed allocation of the European linerboard capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

in Tables 4.25 and 4.26 is highly preliminary. The tables show capacity assignments to several named firms; however, except for some of these companies, this allocation should be regarded being our best guess.

Folding boxboard

According to [36], the most important European folding boxboard producers in 1992 were Mayr Melnhof Karton, Saffa, Stora and MoDo, and Tampella, which is currently part of Enso-Gutzeit. Accounting for the sizes of these firms, some 2400 t/a of the productive capacity remains unassigned. We have allocated this capacity by us among 20 hypothetical fringe firms, as presented in Table 4.27.

Liquid Packaging Board

There are only a few LQPC producers in Europe all of them Nordic. Enso-Gutzeit is the most important of them, followed by Stora. Both firms have planned heavy capacity expansion, but these projects have not yet been fulfilled. Another Swedish LQPC producer, AssiDomän also recently announced its plan to expand its LQPC capacity. Table 4.28 presents the capacity allocation applied in the Cournot scenarios.

Coreboard

European coreboard consumption is around 800 000 t/a. United Paper Mills and Enso-Gutzeit market their coreboard through a common company, Eurocore Oy Ltd. and together they form the most important coreboard producer in Europe (even alone EG would be the most significant firm in the market). In addition to UPM and EG, important producers are Ahlström of Finland, the French firms L'Homme and La Rochette and Macher of Germany. The world's largest producer is Sonoco of USA. The capacity allocation in Table 4.29 is hypothetical.

FLUT	1990	1992	1994	1996	1998	2000	2002	2004
PWA	290	520	520	520	520	520	520	520
SCA	350	350	350	350	350	350	350	350
Stora	350	350	350	350	350	350	350	350
Saica	300	300	460	460	560	560	560	560
KNP	300	300	300	300	300	300	300	300
Jefferson Smurfit	300	300	300	300	300	300	300	300
Greena Papierf.	150	150	150	300	300	300	300	300
Rec. Paper Europe	220	220	260	260	260	260	260	260
Metsä-Serla	230	230	250	250	250	250	250	250
Enso-Gutzeit	210	210	210	210	210	210	210	210
Belisce Zagnep	200	200	200	200	200	200	200	200
Prinzhorn	180	180	180	180	180	180	180	180
NSI	80	80	80	80	80	80	80	80
25 Firms	150	150	150	150	160	160	170	170
Total	6910	7140	7360	7510	7860	7860	8110	8110

Table 4.26: Assumed allocation of the European fluting capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

FBBO	1990	1992	1994	1996	1998	2000	2002	2004
Mayr Melnhof	950	950	950	950	950	950	950	950
Saffa	730	730	730	730	730	730	730	730
MoDo	450	450	660	660	660	660	660	660
Stora	450	450	660	660	660	660	660	660
Enso-Gutzeit	260	260	260	380	380	380	380	380
Metsä-Serla	240	240	240	240	240	240	240	240
UPM	130	130	130	130	130	130	130	130
Kyrö	65	65	65	65	65	65	65	65
Stromsdahl	45	45	45	45	45	45	45	45
10 firms	110	150	160	180	180	180	180	180
10 firms	90	80	80	80	80	80	80	80
Total	5220	5620	6140	6460	6460	6460	6460	6460

Table 4.27: Assumed allocation of the European folding boxboard capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios

LQPC	1990	1992	1994	1996	1998	2000	2002	2004
Enso-Gutzeit	460	460	460	670	670	670	670	670
Stora	330	330	480	630	630	630	630	630
Korsnäs	270	270	270	270	270	270	270	270
Assi Domän	240	240	240	350	350	350	350	350
Metsä-serla	30	30	30	30	200	200	200	200
UPM	40	40	40	40	210	210	210	210
Total	1370	1370	1520	1990	2330	2330	2330	2330

Table 4.28: Assumed allocation of the European liquid packaging board capacity (1000 t/a) into the individual firms for 1989 - 2004 employed the in Cournot scenarios.

CORE	1990	1992	1994	1996	1998	2000	2002	2004
Enso-Gutzeit + UPM	180	260	260	260	260	260	260	260
Ahlström	60	60	60	60	60	60	60	60
3 Firms	130	130	130	130	130	130	130	130
3 Firms	40	40	40	40	40	40	40	40
Total	750	830	830	830	830	830	830	830

Table 4.29: Assumed allocation of the European coreboard capacity (1000 t/a) into the individual firms for 1989 - 2004 employed in the Cournot scenarios.

4.5 Mechanical Forest Industry Production

Because mechanical forest industry is not central in this study, less effort was made for specification of the production technologies of the domestic mills, and to ROFE we specified no mechanical forest industry at all. Although the capacities of the mills and the quality of their products vary substantially, we assumed identical technologies for all the mills producing the products within the same category. For sawmills it was assumed, as suggested by [45], that to produce 1 m^3 of sawnwood, 2.1 - 2.3 m^3 of logs is consumed, of which 38% is converted to residuals (chips and sawdust) that can be further used for pulping. The part of the rest not lost due to shrinkage is converted to fuelwood. The costs other than timber costs were taken to be 350 FIM/m^3 for PSAW, SSAW, and NSAW to comply with the typical base year operating margins in the sawmilling industry. For veneer plywood we defined log input to be 3.5 m^3/m^3 (for birch veneer) and pulpwood output of around 1.6 m^3/m^3, and nontimber production costs were assumed to be 2500 FIM/m^3 to leave an operating margin of 10 to 20% in the base year. Finally, pulpwood consumption was defined to be, on the average, 1.5 m^3/m^3 in particle board production and 2.5 m^3/m^3 in fiberboard production. The other costs were assumed to be 600 to 1100 FIM/m^3 accounting for the base year price difference between fiber board and particle board.

The capacities of mechanical forest industry plants in Finland were set to correspond to the regional production volumes in 1989 attained from CAFFI. As these statistics only included 80% of the sawnwood production in Finland, CAFFI figures were adjusted to comply with the regional saw log consumption volumes reported in [50]. Whenever possible, information published in the annual reports of the companies and other publications was used to complete these data. This approach lead to the following total productive capacities in the base year in Finland: PSAW 4.0 mill. m^3/a; SSAW 4.0 mill. m^3/a; NSAW .2 mill. m^3/a; VEPY .7 mill. m^3/a; and BOAR .7 m^3/a. Since the base year some of the specified production units have been closed, which has been accounted for in the model.

4.6 Forest Industry Products Demand

The inaccuracies in available data and aggregated product categories make it difficult to specify the European production volumes, not to mention the trade flows of products between Europe and the other continents. This implies that problems are faced in defining apparent consumption data for the model that are as detailed as the SF-GTM data. Therefore we chose to equalize the base year demand for paper and paperboard products with the European production volumes. Hence, we assumed that if Europe was a net exporter of a product in the base year, it would also be able to export the base year quantity at the base year price in the future, and any net export was added to the base year consumption in Europe. If, instead, Europe was a net importer, we assumed that any quantity imported in the base year could continue to be imported in the future without further influencing the demand for European production. European trade in many paper products is balanced so that the imports of a product roughly match the exports, net exports or imports being insignificant. Whether this feature will be enforced via intensified trade between European countries remains to be seen. Ignoring the developments occurring outside Europe can obviously result in an unrealistic outcome, because it is the discrepancies in prices that dictate the level of trade between the continents. Possible effects of this treatment are discussed in the results section.

As pulp is eventually an intermediate product it was treated differently. We defined an export demand function for NWIP (base year net exports as reference demand), and import supply functions for CWIP, CUBP, and CSIP (base year net imports as reference demand), because Europe was a net exporter of NWIP but a net importer of CWIP, CUBP, and CSIP in 1989. Thus the model endogenously accounts for pulp trade between Europe and the rest of the world.

Table 4.31 shows the parameters chosen to specify the demand for final forest industry products. The respective information for pulp is displayed in Table 4.30.

With some exceptions discussed below, the reference prices in ROFE have been specified by adding the sea freight from Finland to Western Europe (220 FIM/t) to the export prices (FOB) of the Finnish customs statistics from 1989. These prices are averages for all the exports of the year.

Liner price is the price for bleached kraftliner, and fluting price is the price for semi-chemical fluting medium. For pulp we used the average of the export prices from the years 1987 to 1991, because the price level for pulp was exceptionally high in year 1989. The export price statistics for 1989 do not follow the product categorization of our model, and the prices for CORE, LQPC, PRFC and OPBO were not given. For LQPC we used the information given by an Enso-Gutzeit annual report stating that the net sales revenue in its food packaging paperboard industry was FIM 1315 mill. in 1989, and the production was 370 000 t/a, which gives an estimate 3555 FIM/t for the unit export value in 1989 money. For CORE we used the same procedure. The net sales revenues for the coreboard industry of Enso-Gutzeit were FIM 167 mill. in 1989, and the production was 90 000 t, which gives a unit value 1855 FIM/t. There were no statistics for PRFC price in 1989. Hence, we specified the price by comparing the average price difference between PRFU and PRFC in 1990 to 1992. The price of PRFU was 80% of the PRFC price in 1990 and 1992 according to [50] and [51]. We assumed that to be true for 1989 as well. For highly heterogenous product group OPBO, there is naturally no standard price. The group is of low importance in our study and we gave an arbitrary value 3300 FIM/t for the price.

The price elasticities for paper and paperboard demand are JP estimates for Western Europe, and annual demand growth figures for paper and paperboard are JP estimates for Western Europe and the USA for 1990 to 2000. For mechanical forest industry products we used Ekono's forecasts for the European community for 1990 to 2010. We assumed no growth in the demand for market pulp, because the use of pulp is determined endogenously via paper and board production growth in Europe.

	Production in ROFE (1000 t)	Production in Finland (1000 t)	Consumption in Europe (1000 t)	Net exports $\hat{q}_k$ (1000 t)	Reference price $\hat{\pi}_k$ (FIM/t)	Demand growth (%/a)	Price elasticity γ_k
CWIP	3870	2380	11250	-5000	3000	0.0	-1.00
NWIP	4650	2100	5380	1370	2780	0.0	-1.00
CUBP	4720	730	5710	-260	2570	-0.2	-1.00
CSIP	3390	320	3540	170	3320	-1.0	-1.00

Table 4.30: Data used to characterize the base year (1989) supply and demand for pulp in Europe. Net exports has been used to specify the reference demand for market pulp.

	Production in ROFE (1000 t)	Production in Finland (1000 t)	Reference demand $\hat{q}_k$ (1000 t)	Reference price in ROFE $\hat{\pi}_k$ (FIM/t,m^3)	Demand growth (%/a)	Price elasticity γ_k
PSAW	-	3630	3630	1330	0.8	-5.00
SSAW	-	3590	3590	1230	0.8	-5.00
NSAW	-	70	70	1610	0.8	-5.00
VEPY	-	580	580	3870	3.3	-5.00
BOAR	-	700	700	1980	3.3	-5.00
NEWS	7130	1240	8370	2780	2.3	-1.00
PRWU	4190	1355	5550	3190	1.9	-0.20
PRWC	4190	1930	6120	3820	3.7	-1.50
PRFU	6460	1020	7480	4040	2.3	-0.10
PRFC	3860	300	4160	5000	4.4	-1.20
LNER	6720	360	7080	3020	2.3	-0.40
FLUT	5700	360	6060	1850	2.3	-0.80
FBBO	4270	500	4770	3960	2.5	-0.30
SACK	1590	290	1880	3190	0.0	-0.50
LQPC	680	410	1090	3910	2.1	-0.50
CORE	510	130	640	2140	1.0	-0.10
SOFT	3220	150	3370	5150	3.3	-0.30
OPBO	8860	640	9500	3560	0.0	-5.00

Table 4.31: Data used to characterize the base year (1989) supply and demand for the mechanical forest industry and the paper and board industry products in Europe in the SF-GTM. Reference demand volumes are set to equal the European total production volumes in the base year.

4.7 Transportation Costs

It is expected that, due to the cargo loading and unloading activities, a certain minimum cost has to be paid for transportation regardless of distance. To define this minimum expenditure, let us first focus on the transportation costs for roundwood. It is reported in [50] in reference to The Finnish Forest Industries Federation that the mean transportation distance for the long-distance transportation of roundwood was 137 km and the mean cost was 38.4 FIM/m^3 in Finland in 1991, resulting in an expenditure of .28 FIM/m^3-km. This figure is the average for all methods of transportation used (truck, railway, water transportation). The same source states that transporting roundwood the mean distance of 32 km by truck to the railway costs 22.8 FIM/m^3 on the average, and transporting roundwood 40 km by truck to a waterway costs 22.3 FIM/m^3. This suggests that the fixed costs of transportation might be around 20 FIM/m^3 for roundwood. The figure "Transportation costs for spruce pulpwood by transportation ranges" in [28] supports this. Regarding what was presented in the two sources, we decided to use the following rule in calculating transportation costs for timber: fixed costs of 20 FIM/m^3 are paid for any transportation with .18 FIM/m^3 paid for each kilometer. We used this rule for all the timber categories and for the mechanical forest industry products.

According to [28] and [32], the transportation costs for logs are lower than those for pulpwood. The cost difference is due to differing weights, volumes, and required loading time, but also due to the fact that logs are generally transported shorter distances than pulpwood, because not only are there fewer pulp mills than sawmills, but also the pulp mills are demanding roundwood in larger quantities and therefore from larger areas. However, [51] presents data on the unit cost of the long-distance transportation of roundwood provided by the Finnish Forest Industries Federation stating that the mean unit transportation costs were .37 FIM/m^3-km for logs, and between .34 and .40 FIM/m^3-km for pulpwood in 1992. This indicates no significant cost difference between the logs and pulpwood.

For implementation of the transportation costs for timber, we added a lump payment of 20 FIM/m^3 to the reference timber prices and to the production costs of the mechanical forest industry products in Finland, and let the variable part of the cost be calculated by the model using the parameters presented in Tables 4.33 and 4.34. As discussed in Section 4.1, we assumed the transportation costs to be already included in the timber prices in ROFE (for which we applied Finnish import prices for timber). If the transportation costs had to be explicitly segregated, 40 FIM/m^3 would be a reasonable estimate to account for the internal transportation in Rest of Europe. That would comply with an assumption of equal average transportation costs in Finland, Sweden, and France made by JP in their comparison of the mill costs of pine pulpwood in these countries, prepared for the Forest 2000 committee [32].

From Table 4.32 [44] one can see that there are no great differences in transportation costs per ton across the forestry and the forest industry products. According to [46], a green weight of wood varies between .750 and 950 t, depending on tree species, timber category, and time of year. Hence, the transportation costs for roundwood per m^3 would be lower than the figures presented in the table.

Jaakko Pöyry Oy employed the figure 40 FIM/t for the average cost of the land transportation of pulp from a mill to a harbor or a neighboring mill. If we assume this figure to include transportation for about 100 km and 20 FIM/t for fixed costs, the following formula results, which we applied to all the pulp and paper products:

	Average haul per ton (km)				Mean freight (SEK/t/km)			
Product	1985	1986	1987	1990	1985	1986	1987	1990
Roundwood	80	83	82	75	0.41	0.44	0.41	0.53
Sawnwood	112	131	135	140	0.34	0.34	0.34	0.42
Pulp and waste paper	106	70	98	93	0.35	0.45	0.45	0.44
Paper and paperboard	124	94	198	149	0.44	0.46	0.42	0.51
Chips	60	67	76	82	0.47	0.53	0.44	0.48

Table 4.32: Average haul per ton and average freight revenue for transports by commodity from forestry or forest industry 1985-1990. (SEK = Swedish Crown, 1 SEK = 0.65 FIM in 1991.) Source: Official Statistics in Sweden.

transportation costs are 20 FIM/t + 0.20 x (distance/km/t). For sea freight for pulp and paper products from the Finnish harbors to ROFE we used 220 FIM/t.

The fixed cost 20 FIM/t was added directly to the production costs of the pulp and paper mills in Finland and the distance units from the Finnish regions to ROFE were specified so that the resulting transportation costs cover the whole transportation range (land and sea), the total freight from coastal regions to Rest of Europe being 260 FIM/t. For the mills in ROFE, except for those in Norway and Sweden, we added 40 FIM/t to the production costs for interregional transportation. For the mills in Norway and Sweden, a transportation cost of 260 FIM/t was assigned, because the two countries face roughly the same transportation costs as Finnish producers when exporting most of their production.

Table 4.33 shows the applied transportation cost parameters, and Table 4.34 shows the distance units between the regions. The eventual transportation cost is the product of these two terms added to the fixed costs (20 FIM/t in Finland, 40 FIM/t or 260 FIM/t in ROFE). So, for instance, the transportation of one ton of newsprint from KOSU to ROFE costs roughly 300 FIM. Note that distances between the places are not symmetric, because the place that is considered the center of the region may vary depending on whether the region is importing or exporting. The distances from the domestic regions to ROFE are defined regarding the paper and pulp exports to Western Europe. The distances from ROFE to Finland are defined regarding the imports of secondary pulp, waste paper, and timber. The distance from ROFE to Finnish regions is defined to be one unit, because using the import prices for timber in Finland for ROFE we did not want to add any further transportation costs for the timber coming from Europe but still wanted to specify transportation costs for waste paper from ROFE to Finland. The cost for transporting waste paper from ROFE to Finland was assumed to be 100 FIM/t. This is less than the cost of pulp transportation from Finland to Europe because, at least theoretically, waste paper or secondary pulp can be shipped to Finland at lower costs by taking advantage of the fact the ships carrying pulp and paper products to Western Europe typically return empty.

Timber	.180
Mech. forest products	.180
Pulp	.200
Paper and paperboard	.200

Table 4.33: The variable transportation costs (FIM/m^3/dist.unit, FIM/t/dist.unit).

To / From	LOSU	SATK	UUMH	PIRH	IHAM	ESAV	EKAR	ISAV	PKAR
LOSU	0	138	120	155	247	343	361	446	632
SATK	138	0	215	114	273	369	389	473	597
UUMH	120	215	0	181	165	262	210	364	563
PIRH	155	114	181	0	161	257	190	355	477
IHAM	247	273	165	161	0	96	30	199	399
ESAV	343	369	262	257	96	0	105	157	239
EKAR	361	389	210	190	30	105	0	155	268
ISAV	446	473	364	355	199	157	155	0	176
PKAR	632	597	563	477	399	239	268	176	0
PSAV	430	396	347	275	183	163	267	161	168
KESU	304	269	301	148	135	162	268	254	325
EPOH	294	188	364	179	339	379	484	422	493
POHM	414	290	477	300	388	396	501	448	526
KAIN	622	558	585	466	419	334	439	333	237
PPOH	633	509	641	487	473	448	551	446	425
KOSU	944	819	945	797	783	673	824	718	622
LAPI	741	617	742	595	985	556	659	554	533

To / From	PSAV	KESU	EPOH	POHM	KAIN	PPOH	KOSU	LAPI	ROFE
LOSU	430	304	294	414	622	633	944	741	1200
SATK	396	269	188	290	558	509	819	617	1200
UUMH	347	301	364	477	585	641	945	742	1200
PIRH	275	148	179	300	466	487	797	595	1312
IHAM	183	135	339	388	419	473	783	985	1312
ESAV	163	162	379	396	334	448	673	556	1347
EKAR	267	268	484	501	439	551	824	659	1200
ISAV	161	254	422	448	333	446	718	554	1436
PKAR	168	325	493	526	237	425	622	533	1554
PSAV	0	144	300	377	172	286	558	394	1510
KESU	144	0	216	282	318	291	600	399	1446
EPOH	300	216	0	77	290	338	628	446	1298
POHM	377	282	77	0	367	318	628	426	1200
KAIN	172	318	290	367	0	181	385	289	1376
PPOH	286	291	338	318	181	0	310	108	1200
KOSU	558	600	628	628	385	310	0	201	1398
LAPI	394	399	446	426	289	108	201	0	1200

Table 4.34: Distances between the SF-GTM regions. Between the Finnish regions kilometers are used as a unit of distance. Between Finland and Rest of Europe distance units are purely technical.

5 Base Scenario with Perfect Competition

5.1 Scenario Assumptions

In our base scenario (BASE) we cast the development of the Finnish forest sector for eight 2-year periods covering the years from 1989 to 2004 assuming competitive markets for all the forest sector products. In the base year, 1989, the Finnish forest industry was operating with a high capacity utilization rate (85% for sawmill industry, 97% for market pulp, and 94% for paper and board [50]). Because boosting pulp and paper markets were accompanied by an exceptionally high market pulp price level, we used the five-year (1987-1991) average pulp prices as reference prices for pulp instead of the 1989 prices. Although the domestic timber prices have come down from the 1989 level, we still employed harvests and prices from 1989 when defining the reference values for timber supply functions. This is because the harvest levels have also dropped since 1989, indicating that the low timber prices were not reflecting the timber growers' willingness to supply at the lowered prices. Rather, they were at least partly the result of a weakened ability of the industry to pay for timber due to the economic recession and over supply in European markets that burdened the forest industry during 1991-1993. For ROFE we used the Finnish import prices in 1989 as reference timber prices. Hence, the price for softwood pulpwood in ROFE was assumed to be about 80% of the respective average Finnish price, while the price for hardwood pulpwood was assumed to be 12% lower than in Finland. We introduced trade inertia conditions for timber, requiring that import from ROFE to the domestic regions that consumed imported timber in the base year could not be increased by more than 20% or decreased by more than 25% in a given period.

We assumed an abundant supply of secondary pulp at a steady price: 500 FIM/t in Finland and 400 FIM/t in ROFE. Wages and energy costs in Finland were defined to preserve their nominal base year values in all the periods: 144 FIM/MWh for electricity, 15 FIM/GJ for heat, and 120 FIM/h for labor. For pulp and paper producers in ROFE the average Finnish cost level was applied for the variable production costs other than furnish costs.

For annual demand growth we employed the figures presented in Section 4.6: 0% for market pulp, and from 0% (SACK) to 4.4% (PRFC) for paper and board products.

The Finnish *markka* was devaluated by roughly 13% in the autumn of 1991 and a year later it was left to float. Since then, its value has been determined by the market. In our model we accounted for the changes in the Finnish *markka* as follows: in the second period (1991-92) we devaluated the *markka* by 6% against foreign currencies, and in the third period (1993-94) we devaluated it by 30% to reflect changes that had occurred. Thereafter we left *markka* to recover its second period level and maintain it for the rest of the periods.

To gain a better understanding of the overall developments, we will start by discussing the main results of BASE in Section 5.2. Thereafter, we discuss the developments in the different sectors in more detail, starting with the projections of the Finnish timber markets and pulpwood consumption in Europe in Section 5.3. Section 5.4 describes the developments in pulp production and consumption in Europe, and Section 5.5 addresses the developments in the paper and paperboard industries.

5.2 Main Results

The results of BASE suggest that the Finnish pulp and paper industry will remain competitive and will expand despite its European competitors having better access to secondary fiber in the era of enforced recycling.

A great amount of new capacity entered the markets in Western Europe at the start of an economic recession at the beginning of the 1990s. As a result, many forest industry products suffered from excess supply, and there was a dramatic drop in prices. With most grades, the recovery process started in 1994. Our BASE scenario reproduces this phenomenon, but forecasts less extensive price cuts after the base year, because the demand-lowering impact of the recession was neglected.

All the planned capacity that was based on the use of relatively cheap (in this scenario) secondary pulp entered the markets in Europe, which brought the waste paper consumption to a total of 34 mill. t in 2004. In most industries the new capacity did not force the incumbent capacity to exit the markets; rather it hurt the profitability of the industry. The capacity grew more than the reference demand with NEWS (a discrepancy of 0.8 mill. t in 2004), PRWU (0.1 mill. t), PRFC (0.2 mill. t), and LNER (0.2 mill. t). The reference demand for 2004 exceeded the supply for PRWC (by 1.1 mill. t), PRFU (0.3 mill. t), FBBO (0.7 mill. t), FLUT (1.0 mill. t), and SOFT (0.2 mill. t). The levels of reference demand in the year 2004 employed above were calculated by combining the base year reference demand with the estimated annual demand growth. It should be noted that the consumption growth figures employed were for Western Europe and USA, but the reference demand also included the consumption in Eastern Europe and net exports from Europe to regions for which these demand growth estimates may not be applicable. Also, as we adhered to a great extent to the known capacity expansion plans in our projection, actual competition may become more fierce than suggested by BASE, provided that the markets are competitive. On the other hand, for many firms several alternative projects were suggested, although it may be unrealistic to assume that the smaller firms will undertake more than one or two projects during the period under study.

Parallel to the increased waste paper consumption, new production capacity for bleached sulphate pulp and mechanical pulp was built in Europe. The projected capacity plans roughly matched the growth in consumption. European net exports of NWIP remained at the base year level in 2004, and CWIP net imports from non-European countries increased by 13% causing a respective price increase.

All the capacity projects for bleached softwood sulphate pulp proposed for Finland materialized in BASE. Also, the hardwood pulp production expanded, but less than suggested. In 2004, production of bleached softwood sulphate pulp was 3.7 mill.t (compared with 2.4 mill.t in 1989) and production of bleached hardwood sulphate pulp was 2.8 mill.t (2.1 mill.t in 1989). Production increase of NWIP was mostly supplied to the domestic markets, where the annual consumption grew by 0.6 mill. t, whereas annual CWIP exports increased by 0.5 mill. t. The growth in domestic pulp production relied to a great extent on increased pulpwood imports.

In 2004, the most profitable forest industry products in Finland as measured by the revenue after variable production costs and fixed capital costs were, on the average, CWIP, uncoated fine papers, folding boxboard, and tissue paper. Production of magazine papers was also profitable in the mills with modern machines of efficient scale.

In 2004, the wood consumption of Finnish pulp and paper industry in Finland was close to 52 mill. m^3 including sawnwood residuals (7.7 mill. m^3). The total wood consumption in the Finnish forest industry was 72 mill. m^3. As no significant growth in sawnwood industry was assumed, the almost 13 mill. m^3 increase in pulpwood demand from the base year was mainly supplied by domestic fellings and imports. Imports of pine pulpwood increased from 1.5 mill. m^3 in 1989 to 5.1 mill. m^3 in 2004, and imports for hardwood pulpwood increased from 3.7 mill. m^3 to 5.2 mill. m^3. The domestic harvests totalled 53.5 mill. m^3 in 2004.

5.3 Wood Consumption

5.3.1 Timber markets in Finland

Pine logs and pulpwood

As can be observed from Table 5.1, the increased consumption of pine pulpwood (6.6 mill. m^3, 42%) in the sulphate pulp industry could not be satisfied at competitive prices by domestic wood supply. Harvests of pine pulpwood increased by 2 mill. m^3 (19%) in Finland, whereas PPWD imports grew by 3.6 mill. m^3 (240%). Also, sawlogs were increasingly harvested for pulpwood. Harvests of pine logs grew in all the domestic regions, and the total PLOG harvests increased by 1.2 mill. m^3 (14%) from the base year to 2004. Pine sawlog consumption in sawmills grew by about 6%. Little capacity growth was assumed in the sawnwood industry and the observed increase was due to intensified use of existing capacity. Despite the increased harvests and imports, growing stock levels for pine overshot the base year level in 2004 in all the regions, as is evident in Table 5.7. Note that spruce pulpwood can be used as a substitute for pine to some degree, which may soften the increase in pine pulpwood consumption.

Domestic prices for pine logs and pulpwood (Table 5.2) first decreased, due to a reduction in sulphite pulp and unbleached sulphate pulp production. Thereafter the demand increased, driving up the prices; but as the growing stock increased, more pine timber was supplied to the market, depressing the prices again. The difference between PLOG and PPWD prices narrowed and in the last period the prices were equal in all but two domestic regions (UUMH and PKAR). Our assumption of zero growth in sawmill industry contributes to this phenomena. Above-average prices for pine pulpwood were paid in western and southwestern Finland.

	1990	1992	1994	1996	1998	2000	2002	2004
PLOG								
Harvest	8.8	8.9	9.1	9.0	9.6	9.8	9.9	10.0
Imports	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Conversion	-0.3	-0.1	-0.4	-0.1	-0.7	-0.9	-1.0	-1.1
Consumption	8.7	9.0	8.9	9.1	9.1	9.1	9.1	9.1
PPWD								
Harvest	10.4	9.4	10.9	10.4	11.7	12.0	12.2	12.4
Conversion	0.3	0.1	0.4	0.1	0.7	0.9	1.0	1.1
Imports	1.5	1.8	2.2	2.6	3.1	3.7	4.4	5.1
Residuals	3.3	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Consumption	15.5	14.7	16.9	16.5	18.9	20.0	21.0	22.0

Table 5.1: Harvests, imports, pulpwood conversion, and demand of pine logs (PLOG) and pine pulpwood (PPWD) in Finland in BASE (mill. m^3/a).

	1990	1992	1994	1996	1998	2000	2002	2004
Domestic:								
PLOG, FIM/m^3	263	252	247	226	234	229	216	208
PPWD, FIM/m^3	242	186	231	195	228	224	213	204
Import/ROFE:								
PLOG, FIM/m^3	263	239	251	218	236	233	219	212
PPWD, FIM/m^3	143	169	233	182	190	195	201	212
PLOG, USD/m^3	65	56	45	51	55	55	51	50
PPWD, USD/m^3	35	40	42	43	44	46	47	50

Table 5.2: Average domestic prices and import prices for pine logs (PLOG) and pulpwood (PPWD) in BASE (FIM/m^3, USD/m^3). Domestic prices are averages of regional prices weighted by regional harvest volumes.

Spruce logs and pulpwood

Demand for spruce pulpwood increased by 3 mill. m^3 (23%) by 2004. Less than two-thirds of the increased demand was covered by the domestic SPWD harvests, which grew by 1.8 mill.m^3 (20%). The rest was satisfied by the means of spruce log conversion, which caused SLOG harvests to grow by roughly 1.8 mill. m^3 (19%). No imports for spruce timber were required in 2004 (See Table 5.3 for the supply-demand development).

The price of spruce pulpwood equaled the price of logs in all but the western and southwestern parts of the country, where the SLOG prices were above average. As can be seen from Table 5.4, the prices for the two timber categories were relatively steady, with the difference between the highest and lowest prices being around 10%.

Hardwood logs and pulpwood

Domestic harvests for hardwood pulpwood increased by 1.6 mill. m^3 (27%) and imports increased by 1.5 mill.m^3 (40%). That corresponds to a pulpwood demand increase in the sulphate pulp industry. The harvests of hardwood logs were 1.6 mill. m^3 in 2004 (Table 5.5). Above-average pulpwood prices were paid in the eastern and southeastern

	1990	1992	1994	1996	1998	2000	2002	2004
SLOG								
Harvest	9.7	10.3	10.5	10.8	11.1	11.2	11.4	11.5
Imports	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Conversion	-0.5	-0.7	-1.0	-1.0	-1.3	-1.4	-1.6	-1.7
Consumption	9.3	9.7	9.6	9.9	9.8	9.8	9.8	9.8
SPWD								
Harvest	8.6	9.3	9.5	9.7	10.1	10.3	10.4	10.4
Conversion	0.5	0.7	1.0	1.0	1.3	1.4	1.6	1.7
Imports	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Residuals	3.5	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Consumption	12.8	13.9	14.3	14.5	15.2	15.5	15.7	15.8

Table 5.3: Harvests, imports, pulpwood conversion, and demand of spruce logs (SLOG) and spruce pulpwood (SPWD) in Finland in BASE (mill.m^3/a).

parts of the country. Domestic prices for NPWD remained at the base year level, and import prices increased. Prices for NLOG decreased after initial growth. Table 5.6 presents the price developments.

	1990	1992	1994	1996	1998	2000	2002	2004
Domestic:								
SLOG, FIM/m^3	211	223	221	221	220	215	208	201
SPWD, FIM/m^3	183	197	197	197	201	199	193	187
Import/ROFE:								
SLOG, FIM/m^3	203	233	313	239	243	241	239	242
SPWD, FIM/m^3	200	233	313	239	242	240	239	242
SLOG, USD/m^3	50	55	56	56	57	56	56	57
SPWD, USD/m^3	50	55	56	56	57	56	56	57

Table 5.4: Average domestic prices and import prices for spruce logs (SLOG) and pulpwood (SPWD) in BASE (FIM/m^3, USD/m^3). Domestic prices are averages of regional prices weighted by regional harvest volumes.

	1990	1992	1994	1996	1998	2000	2002	2004
NLOG								
Harvest	1.4	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Imports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conversion	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Consumption	1.3	1.6	1.6	1.6	1.6	1.6	1.6	1.6
NPWD								
Harvest	6.0	6.1	7.3	6.8	6.9	7.1	7.4	7.6
Conversion	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Imports	3.7	3.7	3.0	3.4	3.3	3.7	4.4	5.2
Residuals	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Consumption	10.3	10.4	10.9	10.8	10.8	11.4	12.4	13.4

Table 5.5: Harvests, imports, pulpwood conversion and demand of hardwood logs (NLOG) and pulpwood (NPWD) in Finland in BASE (mill. m^3/a).

	1990	1992	1994	1996	1998	2000	2002	2004
Domestic								
NLOG FIM/m^3	240	283	292	276	262	249	240	227
NPWD FIM/m^3	186	180	249	198	188	185	188	185
Import/ROFE:								
NLOG FIM/m^3	279	290	313	281	284	271	264	251
NPWD FIM/m^3	163	184	265	202	196	192	191	190
NLOG USD/m^3	69	68	56	66	66	63	62	59
NPWD USD/m^3	40	43	48	47	46	45	45	44

Table 5.6: Average domestic prices and import prices for hardwood logs (NLOG) and pulpwood (NPWD) in Finland and in ROFE in BASE (FIM/m^3,USD/m^3). Domestic prices are averages of regional prices weighted by regional harvest volumes.

Changes in growing stock

The domestic growing stock volumes significantly increased in the most regions, as Table 5.7 indicates. Among the exceptions were KAIN, where the growing stock of spruce remained at the base year level, and ISAV and IHAM, where the growing stock levels for birch only grew by 1% and 3% respectively.

	Pine		Spruce		Birch	
	1998	2004	1998	2004	1998	2004
LOSU	18	32	18	34	39	78
SATK	15	28	11	21	32	64
UUMH	11	19	14	27	23	44
PIRH	11	20	12	23	27	54
IHAM	7	14	16	29	1	3
ESAV	13	25	18	34	5	10
EKAR	17	33	15	27	21	40
ISAV	7	13	17	31	-0	1
PKAR	22	42	7	12	5	10
PSAV	22	43	10	17	13	24
KESU	17	32	11	20	11	21
EPOH	17	32	4	8	17	34
POHM	17	31	5	9	8	15
KAIN	17	31	0	0	25	47
PPOH	24	46	11	20	37	73
KOSU	9	16	5	9	4	6
LAPI	12	23	7	12	13	24

Table 5.7: Percentage changes in growing stock levels from 1989 to 1998, and from 1989 to 2004 in the domestic regions in BASE.

5.3.2 Pulpwood consumption in ROFE

In Rest of Europe the consumption of softwood pulpwood and chips in pulping increased from the base year by close to 14 mill. m^3 to some 90 mill.m^3 in 2004. Roughly half of the increase was used as input in mechanical pulping. The price for softwood pulpwood applied to ROFE was determined as an average of spruce pulpwood and pine pulpwood prices (Tables 5.2 and 5.4). This average grew from 43 USD/m^3 in the base year to 54 USD/t in 2004 (26%). Part of this price increase was a result of the growth of Finnish import demand for PPWD.

The use of hardwood pulpwood in ROFE increased by 6 mill. m^3 to around 39 mill. m^3 by 2004. Eighty percent of the increase resulted from a rise in bleached sulphate pulp production. The rest was converted to semi-chemical pulp.

5.4 Markets for Pulp

Bleached sulphate pulp

As shown in Table 5.8 the annual production of bleached softwood sulphate pulp increased by over 1.3 mill.t from the base year to 2004 in Finland, an amount that is equivalent to the output of three pulp mills. All the suggested capacity projects were fulfilled, and new mills or production lines for CWIP were constructed in KAIN (period 6), EKAR (periods 7-8), and POHM (8), in addition to a new mill in Rauma. Furthermore, a considerable increase was attained via an improved capacity utilization rate in the existing mills. Two-thirds of the increase was consumed in Finland.

	1990	1992	1994	1996	1998	2000	2002	2004
Finland								
Production	2.38	2.57	2.77	2.77	3.24	3.39	3.58	3.73
Exports	0.60	0.68	0.61	0.52	0.91	0.90	1.00	1.11
Consumption	1.78	1.90	2.16	2.25	2.34	2.50	2.58	2.62
ROFE								
Production	3.86	4.25	4.69	4.71	4.85	4.85	4.85	4.85
Imports, Finland	0.60	0.68	0.61	0.52	0.91	0.90	1.00	1.11
Imports, Other	5.00	5.69	5.36	5.47	5.17	5.38	5.49	5.66
Consumption	9.46	10.62	10.66	10.70	10.93	11.13	11.34	11.62

Table 5.8: Supply and demand of bleached softwood sulphate pulp in Europe in BASE (mill. t/a).

In ROFE, all the suggested new CWIP capacity was implemented on the proposed schedule, rendering a 1 mill.t (25%) increase in the base year production. The consumption of CWIP in Europe grew more than its supply, which caused the average price level to rise, as is evident in Table 5.9.

In Finland the production of bleached hardwood sulphate pulp totalled 2.8 mill.t in 2004, showing a one-third increase from the base year. The rise was due to a growth in domestic consumption. Exports first decreased as the production of NWIP increased in ROFE and, Finnish firms, instead of taking advantage of the devaluation via pulp exports, increased paper production. Production capacity was increased first in IHAM and EKAR. The pulp mill project in KAIN faced delays from the suggested period of entry. In POHM no new NWIP capacity was installed. See Table 5.11 for the summarized development of NWIP supply.

In ROFE, NWIP production grew by 1.2 mill. t/a following the proposed developments. Net exports from Europe remained relatively steady, indicating that no excess capacity was developed. The prices followed the changes in net exports (Table 5.9).

Table 5.10 shows the profits after variable production costs and fixed capital costs assumed to equal 15% of the investment costs per ton of new capacity. We may observe that the average CWIP producer in Finland experienced losses during 1997 to 2000, when new capacity entered the markets replacing the European imports from

	1990	1992	1994	1996	1998	2000	2002	2004
CWIP:								
FIM/t	2996	3620	4350	3416	3251	3371	3487	3565
USD/t	744	848	797	814	769	801	818	842
NWIP:								
FIM/t	2778	3506	3645	2721	2765	2833	2876	2876
USD/t	690	821	656	637	647	663	673	673

Table 5.9: Price developments of bleached softwood sulphate pulp and bleached hardwood sulphate pulp in Rest of Europe in BASE (FIM/t, USD/t)

	1990	1992	1994	1996	1998	2000	2002	2004
CWIP								
Finland (A)	-24	6	18	2	-9	-3	1	6
Finland (H)	-5	22	29	16	7	12	15	19
Finland (L)	-30	-2	14	-5	-15	-10	-7	-1
ROFE (A)	-9	2	-4	-2	-9	-5	-3	-1
NWIP								
Finland (A)	-7	17	10	-12	-8	-4	-3	-2
Finland (H)	3	27	14	-6	-3	3	4	4
Finland (L)	-16	10	3	-21	-20	-17	-15	-15
ROFE (A)	-3	12	-10	-13	-10	-7	-5	-5

Table 5.10: Base scenario highest (H), lowest (L), and average (A) profit margins after variable production costs and fixed capital costs (% of price) for bleached softwood sulphate pulp and bleached hardwood sulphate pulp in Finland and in Rest of Europe.

	1990	1992	1994	1996	1998	2000	2002	2004
Finland								
Production	2.10	2.08	2.19	2.19	2.19	2.34	2.57	2.80
Exports	1.04	0.95	0.84	0.81	0.79	0.81	0.95	1.13
Consumption	1.06	1.13	1.35	1.39	1.41	1.53	1.62	1.67
ROFE								
Production	4.65	4.98	5.73	5.80	5.84	5.84	5.84	5.84
Imports, Finland	1.04	0.95	0.84	0.81	0.79	0.81	0.95	1.13
Exports	1.37	1.11	1.44	1.48	1.46	1.42	1.40	1.40
Consumption	4.31	4.82	5.13	5.13	5.17	5.22	5.38	5.56

Table 5.11: Supply and demand of bleached hardwood sulphate pulp in Finland and Rest of Europe in BASE (mill. t/a)

non-European countries. The period of unprofitable operation was longer for Finnish NWIP producers.

However, there are some aspects that must be noted when considering the figures in Table 5.10. First, the capital costs employed in the calculations may not, in reality, be applicable to older, low-debt capacity. Second, it should be remembered that we used the five-year average pulp prices as the base year reference prices. Hence, we started from a price level lower than the actual pulp price in the base year. Considering the full utilization of the productive capacity, the price level implying loss to some producers would apparently push the pulp producers to raise the price. The eventual price level would then be affected by the price and costs of pulp imports from non-European countries. The figures in the table indicate that the minimum price for pulp should be 850 USD/t for CWIP and 700 USD/t for NWIP in order for pulp producers to break even with new capacity, or to earn a 15% return on capital with older capacity.

Other primary pulp

According to a capacity survey by FAO [16], mechanical pulp, especially thermomechanical pulp, is the only primary pulp grade in addition to bleached sulphate pulp for which capacity growth is to be expected. In BASE the mechanical pulp production increased by 1 mill.t in Finland and by roughly 2.5 mill.t in ROFE from 1989 to 2004 following the production increase of the mechanical pulp based paper. No capacity addition potential to other pulp grades (CUBP, CSIP) was modeled.

Secondary pulp

Relatively low price for waste paper, and on the average 80 % fiber yield favored waste paper consumption, which increased by almost 12 mill.t to about 34 mill. t/a. in 2004, as all the capacity projects involving secondary pulp were accepted. In some cases, these projects replaced the ones involving virgin fiber only, and often hurt the performance of the existing mills with primary fiber-based technologies.

The growth in waste paper consumption was divided by the different products as indicated in Table 5.12. The most important share of the waste paper was used in the production of linerboard. Newsprint came next, followed by household and sanitary papers. The outcome seems plausible from the practical point of view as well: as disposed after use, household and sanitary papers are good example of the products where the use of recycled paper is suitable. Newsprint is used daily in large volumes and is also subject to disposal, which renders the strength of the paper less crucial.

	Growth 1989-2004	Share of Growth 1989-2004	Consumption 2004
NEWS	2900	25	6030
PRWU	470	4	700
PRWC	360	3	420
PRFU	840	6	1910
PRFC	620	4	1250
LNER	2970	26	7340
FLUT	760	7	5790
FBBO	630	6	2790
SACK	0	0	400
CORE	30	0	680
SOFT	1960	17	4300
OPBO	190	2	2730
Total	11730	100	34340

Table 5.12: Growth (1000 t) and shares of growth (%) of annual waste paper consumption from 1989 to 2004, and total waste paper consumption (1000 t) in 2004 in Europe in BASE.

Fiber furnish in European paper industry

Table 5.13 illustrates the development of the total fiber furnish in European paper and board industry. It can be seen that the share of recycled paper increased by five percentage points, that bleached hardwood sulphate pulp and mechanical pulp roughly maintained their base year shares, and that the share of the other pulp grades diminished.

	1989		2004	
	mill. t	%	mill. t	%
CWIP	11.300	20	14.200	19
NWIP	5.400	10	7.200	10
CUBP	5.700	10	6.100	8
CSIP	3.500	6	3.400	4
Mechanical pulp	11.100	20	14.800	20
Semi-chemical pulp	1.300	2	1.800	2
Secondary pulp	18.100	32	27.500	37
Total	56.400	100	75.000	100

Table 5.13: Wood fiber furnish of paper and board products in Europe in 1989 and 2004 according to BASE. Secondary pulp consumption was here defined to be 80% of the waste paper consumption.

5.5 Markets for Paper

Newsprint

Tables 5.14 and 5.15 summarize the developments in the newsprint sector. No capacity additions for newsprint were suggested for Finland; but, as observed, all the existing capacity remained in use. In ROFE, the annual production increased by 3.6 mill. t (50%) from the base year to year 2004, and 7 out of the 10 proposed newsprint machines materialized after 1994. Price first dropped due to initial excess capacity and then started to recover. Still, it did not reach the base year level as new capacity kept streaming into the markets.

With higher production costs, the incumbent capacity suffered from this development, with the consequence that the average revenue after variable costs and fixed capital costs was negative during the studied time horizon in Europe. At the resulting cost level, the newsprint price would have had to reach a level of 650 USD/t for the firms to earn positive revenue after fixed costs.

Uncoated, wood-containing printing and writing papers

In Finland the suggested capacity project for uncoated, wood-containing printing and writing paper in SATK did not prove profitable and the production increased only via extended use of incumbent capacity. In ROFE the annual production grew by 1.5 mill.t (an amount that equals the output of four or five new machines) from 1989 to 2004, but remained below the proposed level as the new machines with virgin fiber furnish did not enter. Table 5.16 shows the supply and price developments for PRWU.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
Finland	1.24	1.53	1.53	1.53	1.53	1.53	1.53	1.53
ROFE	7.13	8.41	9.09	9.28	9.71	9.95	10.46	10.75
Total	8.37	9.94	10.62	10.81	11.24	11.48	11.99	12.28
Price (FIM/t)	2781	2553	3232	2573	2597	2676	2684	2755
Price (USD/t)	690	598	581	602	608	627	628	644

Table 5.14: Production and prices of newsprint in Finland and Rest of Europe in BASE

	1990	1992	1994	1996	1998	2000	2002	2004
Finland (A)	-5	-19	4	-18	-17	-13	-12	-9
Finland (H)	-2	-12	11	-11	-10	-6	-5	-2
Finland (L)	-16	-34	-10	-32	-30	-26	-25	-21
ROFE (A)	6	-10	-12	-8	-7	-4	-3	-1

Table 5.15: Highest (H), lowest (L), and average (A) profit margins (% of price) for newsprint after variable production costs and fixed capital costs in Finland and Rest of Europe in BASE.

The industry suffered from excess capacity from the beginning. The idle capacity was taken to use through marking down the prices that did not recover as further capacity was installed. The price remained 6% below the base year level in 2004. A profitable outcome would have required the price of 770 to 800 USD/t, depending on the period. After the base year, PRWU price was at the most 73% of the PRWC price, suggesting a shift from PRWU consumption to better quality PRWC to be unlikely.

Due to excess capacity, the industry performed poorly in general (Table 5.17 presents the profit margin statistics for the industry). In Finland no incumbent machine was efficient enough to make profits after paying for the capital costs, which were assumed to be roughly 1100 FIM/t. In ROFE only some new machines produced profits after the capital costs.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
Finland	1.36	1.46	1.56	1.56	1.56	1.56	1.56	1.57
ROFE	4.19	4.56	4.72	4.87	5.11	5.36	5.63	5.75
Total	5.55	6.02	6.28	6.43	6.67	6.92	7.19	7.32
Price (FIM/t)	3182	2632	3284	2780	2811	2806	2813	3146
Price (USD/t)	790	616	591	651	658	657	659	737

Table 5.16: Production and prices for PRWU in Finland and Rest of Europe in BASE.

	1990	1992	1994	1996	1998	2000	2002	2004
PRWU								
Finland (A)	-6	-33	-14	-26	-23	-24	-24	-10
Finland (H)	-1	-27	-6	-19	-16	-17	-16	3
Finland (L)	-12	-45	-24	-36	-32	-34	-34	-18
ROFE (A)	2	-29	-34	-22	-18	-18	-17	5
PRWC								
Finland (A)	-13	-24	6	-11	-5	-3	-1	-1
Finland (H)	-8	-19	11	-5	3	4	6	6
Finland (L)	-17	-29	2	-16	-11	-10	-7	-7
ROFE (A)	-8	-24	-16	-13	-8	-7	-5	-4

Table 5.17: Highest (H), lowest (L), and average (A) profit margins after variable production costs and fixed capital costs (% of price) for uncoated (PRWU) and coated (PRWC) wood-containing printing and writing papers in Finland and in Rest of Europe in BASE.

Coated, wood-containing printing and writing papers

In Finland the capacity for coated, wood-containing printing and writing papers developed according to what was proposed and exceeded the base year level for the first time in 1995/1996 following a conversion of a PRWU machine for coated qualities. Thereafter, two other capacity projects advanced: in IHAM (KG) and in SATK (UPM).

We had suggested altogether five new LWC machines to start up after 1994 in ROFE: a new machine for Myllykoski in Central Europe, conversion of a Stora newsprint machine for LWC in France, two new machines for some other Central European producers, and a new machine for SCA in Sweden. The suggested new technologies were all defined to use furnish with 18% recycled fiber content. Although the price for PRWC reached the base year price and exceeded it in 1998, no new capacity was installed in ROFE in the 1990s. In 2004 all but one of the suggested new machines had entered at least 65%.

The supply and price developments for PRWC are presented in Table 5.18, and the profit summary is presented in Table 5.17.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
Finland	1.93	2.42	2.42	2.64	2.85	3.21	3.21	3.21
ROFE	4.19	5.13	5.13	5.13	5.13	5.13	5.35	5.90
Total	6.12	7.55	7.55	7.77	7.98	8.34	8.56	9.11
Price (FIM/t)	3818	3653	5033	3990	4107	4193	4304	4326
Price (USD/t)	948	855	906	934	964	982	1008	1014

Table 5.18: Production and prices for PRWC in Finland and Rest of Europe in BASE.

Uncoated, wood-free printing and writing papers

In Finland the production of uncoated fine papers increased by 0.5 mill. t from the base year to 2004 following the intensified use of existing capacity and a new machine installed in EKAR (UPM). In ROFE, production increased by 30%, as all the proposed capacity investments materialized. The capacity accumulated more slowly than suggested because a virgin fiber based machine had to wait for price to recover before it could penetrate the markets with profitable outcome in 2001. A new fine paper machine for Enso- Gutzeit was among the suggested investments in ROFE.

The applied price elasticity of demand was -0.10, implying any supply increase exceeding the demand growth to require a sharp price cut. The price dropped at first down to USD 100 less than in the base year at its lowest, and the base year price level was not reached before the final period. Finnish producers benefitted from the weakened *markka* and the access to cheaper primary pulp and, in Finland, only mills with a small scale or no integration to pulp production faced difficulties. During the early periods the entrance of new machines hurt the performance of the existing ones, some of which were forced to stop for several periods. But because the demand increased faster than capacity, all the producers earned profits in the final period. See Tables 5.19 and 5.20 for the summary of the market developments.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
Finland	1.02	1.16	1.27	1.32	1.32	1.51	1.51	1.51
ROFE	6.46	6.69	6.99	7.31	7.74	7.94	8.32	8.43
Total	7.48	7.85	8.26	8.63	9.06	9.45	9.83	9.94
Price (FIM/t)	4043	4102	5056	3941	3784	3969	4230	5664
Price (USD/t)	1003	960	909	923	886	929	990	1326

Table 5.19: Production and prices of PRFU in Finland and in Rest of Europe in BASE.

	1990	1992	1994	1996	1998	2000	2002	2004
PRFU								
Finland (A)	4	-7	6	-3	-6	-2	4	29
Finland (H)	8	-5	10	3	-1	3	8	32
Finland (L)*	-10	-22	-7	-18	-22	-18	-11	18
ROFE (A)	2	-9	-6	-1	-4	-1	3	27
PRFC								
Finland (A)	-4	-28	-7	-22	-14	-7	0	2
Finland (H)	2	-21	0	-13	-5	0	5	7
Finland (L)	-12	-40	-19	-36	-27	-19	-14	-12
ROFE (A)	5	-25	-24	-18	-10	-3	2	4

Table 5.20: Base scenario highest (H), lowest (L), and average (A) profit margins (% of price) after variable production costs and fixed capital costs for uncoated (PRFU) and coated (PRFC) wood-free printing and writing papers in Finland and Rest of Europe in BASE. *This machine is currently being rebuilt, suggesting better future performance than projected here.

Coated, wood-free printing and writing papers

The incumbent capacity for coated fine paper was in use in Finland and two new machines were installed, although later than suggested: in PPOH (Veitsiluoto) in 2001, and in UUMH (Metsä-Serla) in 2004. In ROFE, PRFC supply increased by 2.7 mill.t from 1989 to 2004 but only technologies with recycled fiber furnish entered on their proposed schedule, while the capacity employing virgin fiber accumulated with delay.

The price of PRFC first dropped from the base year level due to supply growth exceeding the growth in demand. In 1995 it started to recover, remaining, however, under the base year level, as can be observed in Table 5.21. Production with the incumbent machines integrated to virgin fiber was more profitable in Finland than in ROFE, but the production with the new recycled fiber furnish technology was even more profitable with the low waste paper price applied in the scenario. Table 5.20 provides the profit summary for PRFC.

Corrugating materials

Finland is not an internationally important producer of corrugating materials, liner (LNER) and fluting (FLUT). In the base year Finland provided less than 6% of the total European corrugated boards supply, and currently no new machines are planned by Finnish producers.

We did not differentiate testliner made of recycled fiber from kraftliner in BASE.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
Finland	0.30	0.69	0.77	0.77	0.77	0.77	1.03	1.22
ROFE	3.86	4.98	5.57	5.90	6.14	6.33	6.33	6.59
Total	4.16	5.67	6.34	6.67	6.91	7.10	7.36	7.81
Price (FIM/t)	4996	4184	5253	4232	4505	4804	5044	5164
Price (USD/t)	1240	980	945	991	1055	1125	1181	1209

Table 5.21: Production and prices for PRFC in Finland and in Rest of Europe in BASE.

Instead, we assumed an equal price and equal costs other than furnish costs for the both types. This approach, which was also applied to waste paper based fluting in comparison with semi-chemical fluting, drastically favors testliner to kraftliner, while with fluting grades the difference between the fiber costs is not so significant at the waste paper price applied in BASE. We suggested LNER and FLUT capacity additions after 1994 to be based on 100% secondary fiber furnish with a FLUT investment in Spain as an exception.

Only in the last period did some new FLUT capacity enter without affecting the operating rates of the old capacity. Instead, LNER capacity accumulated, forcing roughly 0.3 mill. t of the existing (white top kraftliner) capacity out of the markets. Differentiating testliner from kraftliner might correct the phenomenon (See Table 5.22 for the market summary).

In 2004 corrugated board industry accounted for close to 40% of the secondary fiber consumption in Europe.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
LNER								
Finland	0.36	0.00	0.40	0.30	0.33	0.45	0.45	0.45
ROFE	6.72	8.23	8.27	8.59	8.87	8.95	9.33	9.50
Total	7.08	8.23	8.67	8.89	9.19	9.40	9.78	9.95
FLUT								
Finland	0.36	0.42	0.42	0.42	0.42	0.42	0.42	0.42
ROFE	5.70	6.45	6.65	6.65	6.65	6.65	6.65	6.90
Total	6.06	6.87	7.06	7.07	7.07	7.07	7.07	7.32
Price (FIM/t)								
LNER	3023	2314	2945	2441	2548	2744	2792	3025
FLUT	1845	1751	2343	1914	2023	2129	2230	2253
Price (USD/t)								
LNER	750	542	530	572	597	643	654	708
FLUT	458	410	421	448	474	499	522	528

Table 5.22: Production and prices of corrugated boards in Finland and in Rest of Europe in BASE.

Household and sanitary papers

The European household and sanitary paper (SOFT) supply developed in the suggested manner. Initially some excess capacity was generated, causing price cuts. Thereafter, price fluctuated following the capacity increments. Due to the local character of tissue paper production, no new production capacity was suggested for Finland, where the markets for SOFT are mature. In ROFE production grew correspondingly with the demand growth, and the excess capacity gradually vanished. Relatively inelastic demand (price elasticity -0.3) was assumed, and the price was roughly 10% higher in 2004 compared with the base year, because the production was below the projected demand.

As all the additions in the production capacity were assumed to be solely based on recycled fiber, a 2 mill. t/a increase in the waste paper consumption in the industry resulted. See Table 5.23 for the summary of the market developments.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
Finland	0.15	0.17	0.17	0.17	0.17	0.17	0.17	0.17
ROFE	3.22	3.57	3.90	4.07	4.40	4.58	4.93	4.96
Total	3.37	3.74	4.06	4.24	4.57	4.74	5.10	5.12
Price (FIM/t)	5151	4772	5744	4855	4659	5171	5033	6112
Price (USD/t)	1278	1117	1033	1137	1091	1211	1178	1431

Table 5.23: Production and prices for household and sanitary papers in Finland and Rest of Europe in BASE.

Other paper and paperboard

The supply and prices for the rest of the products are summarized in Table 5.24.

There was no significant change in the share of the Finnish producers in the European supply of folding boxboard. Domestic FBBO production increased by 200 000 t via the conversion of a coreboard machine to production of recycled fiber- based board. In ROFE, FBBO production increased by 1 mill. t. All the investment projects were assumed to be based on the use of recycled fiber.

Coreboard producers suffered from low price-cost margin, causing fluctuations in the domestic production. For the Finnish producers, the period 1993 to 1994 was the most satisfactory due to the weakened Finnish *markka*. Thereafter the strengthened *markka* impaired the competitiveness of the Finnish mills. With little change in the demand-supply balance, the coreboard price movements were negligible.

We had proposed a significant expansion for the liquid packaging board (LQPC) capacity in Finland, as several firms have considered it as a promising future production alternative. Capacity expansion was also suggested for the Swedish producers. However, the only project providing additional capacity in the industry was the rebuilding of a machine by Assi Domän.

We assumed zero growth in sack kraft demand. With low price-cost margin, the production was sensitive to raw material prices.

	1990	1992	1994	1996	1998	2000	2002	2004
Supply (mill. t/a)								
FBBO								
Finland	0.50	0.54	0.60	0.71	0.71	0.71	0.71	0.71
ROFE	4.27	4.44	4.48	4.48	4.64	4.90	5.11	5.34
Total	4.76	4.98	5.08	5.19	5.35	5.61	5.82	6.05
CORE								
Finland	0.13	0.09	0.24	0.11	0.13	0.14	0.16	0.17
ROFE	0.51	0.57	0.44	0.57	0.57	0.57	0.57	0.57
Total	0.64	0.66	0.68	0.69	0.70	0.71	0.73	0.74
LQPC								
Finland	0.41	0.22	0.37	0.40	0.44	0.44	0.47	0.50
ROFE	0.68	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Total	1.08	1.13	1.27	1.30	1.34	1.34	1.37	1.41
SACK								
Finland	0.29	0.24	0.24	0.24	0.28	0.29	0.29	0.29
ROFE	1.59	1.59	1.61	1.56	1.57	1.44	1.43	1.37
Total	1.88	1.83	1.85	1.80	1.85	1.73	1.73	1.67
Price (USD/t):								
FBBO	983	1000	1093	1181	1241	1249	1285	1317
CORE	524	503	459	509	508	510	512	512
LQPC	971	975	822	850	879	948	994	1029
SACK	790	824	809	850	813	902	912	962

Table 5.24: Prices and production quantities for folding boxboard, coreboard, liquid packaging board, and sack kraft in Finland and Rest of Europe in BASE

6 Sensitivity Analysis

When not addressing the competition hypothesis yet, the following questions appear to be the most important in the appraisal of the sensitivity of the developments suggested by BASE to the changes in the underlying assumptions:

- The future development of the value of the Finnish *markka* depends on factors that are difficult to foresee. The *markka* has strengthened from its lowest level in 1993, but whether it will strengthen or weaken from its current level and, the extent of these changes, is uncertain. As a member of European Union, Finland has a choice of joining the European Monetary Union (EMU), in which case its currency would ultimately be integrated to other EMU currencies, leaving Finland no power to practice its own exchange rate policy. In one of the sensitivity analyses we will address the question of what changes would a stronger or weaker Finnish *markka* cause?

- How would the future of the Finnish forest industry differ from the one described above if the price of electricity increased considerably in Finland? According to some experts electricity prices could double or triple in Finland by the end of the century.

- What if we assume that the price of recycled paper is considerably higher than what was assumed in BASE? The markets for secondary pulp are under strong development and there is great uncertainty about future price development, which will be determined by the world balance between supply and demand of secondary fiber, recycling costs, and quality (yield) of the recovered paper.

- The development of the Finnish pulp production suggested by the base case was strongly based on the growth in pulpwood imports. The future potential of roundwood imports is, however, uncertain and depends on the development of the Russian forest sector. How would it change the results if the growth were solely based on the use of domestic raw material?

- In the base case there was a considerable growth in the domestic pulp supply because the capacity projects that were considered also encompassed some dormant projects, for instance a new mill in Kainuu. How would it change the developments in forestry and the domestic paper industry if we limited the growth in pulp supply by omitting some of the pulp capacity projects?

- The above considerations were derived from the supply side only. It is also important to test how sensitive the results are to demand side developments i.e., to the changes in the reference prices or the annual demand growth rates.

These questions are addressed below. Furhtermore, remember that timber prices in ROFE are assumed to equal the Finnish import prices for roundwood in 1989. This assumption also calls for sensititivy analysis. We made model runs by both increasing and decreasing the timber prices in ROFE by 10%. In both cases, the base case levels of consumption, production, and harvests in Finland and ROFE remained unaffected, which leaves little more to report.

6.1 Exchange Rate Variations

We produced two scenarios modifying the exchange rate development from BASE. In one scenario, the Finnish *markka* was made to return to its base year level in 1997 (REVA); and in another run the *markka* was revaluated from its 1993 level, but not as much as in the base case (DEVA). The modeled exchange rate developments in BASE, REVA, and DEVA are exhibited in Table 6.1.

		1990	1992	1994	1996	1997 - 2004
FIM/Foreign	BASE	1.00	1.06	1.38	1.06	1.06
	REVA	1.00	1.06	1.38	1.06	1.00
	DEVA	1.00	1.06	1.38	1.19	1.19
FIM/USD	BASE	4.03	4.27	5.56	4.27	4.27
	REVA	4.03	4.27	5.56	4.27	4.03
	DEVA	4.03	4.27	5.56	4.80	4.80

Table 6.1: Exchange rate development in the scenarios BASE, REVA, and DEVA.

The first three rows in Table 6.1 display the changes in the exchange rate of FIM with respect to its first-period average value against foreign currencies. The value 1.06 reads that the *markka* has depreciated by 6% from the base year, and 1.38 refers to a 38% depreciation from the base year. The last three rows present the development of the value of the US dollar against the Finnish *markka*.

It readily follows from a revaluation of the *markka* that export prices measured in the *markka* drop. It is highly unlikely that any producer operating in Finland, using domestic production factors, and mainly supplying export markets would benefit from a revaluation and increase its supply in comparison to BASE. The opposite is true when the *markka* weakens.

Table 6.2 shows the main changes in the two exchange rate scenarios relative to BASE.

	DEVA				REVA			
	1998	2000	2002	2004	1998	2000	2002	2004
Production:								
Finland								
CWIP	4	7	4	-	-	-2	-2	-2
NWIP	9	10	9	5	-	-2	-4	-3
PRWC	13	-	-	-	-7	-18	-18	-14
PRFC	-	37	18	-			-24	-20
CORE	2	8	2	5	-3	-	-3	-5
LNER	37	-	-	-	-9	-4	-	-
LQPC	-	6	7	-	-	-	-7	-3
ROFE								
PRWC	-	-	-	-	-	5	10	5
PRFC	-	-	-	-	-	-	1	3
Price:								
CWIP	-2	-3	-1	1	-1	-	-	-
NWIP	-2	-6	-7	-6	-	3	2	4
PRWC	-3	-	-	-0	2	2	-	1
PRFC	-	-4	-2	-1	-	-	3	1
CORE	-8	-6	-7	-8	4	5	4	5
LQPC	-1	-3	-5	-2	-	2	2	2

Table 6.2: Percentage changes in production and prices in foreign currency relative to BASE for selected products due to exchange rate alterations.

It can be seen from Table 6.2 that PRWC and PRFC are highly sensitive to the exchange rate. When Finland reduced its production of these products in REVA by rejecting some of the capacity plans, substituting production developed in ROFE. Consequently, almost the full impact of the revaluation was transferred to *markka* prices. In DEVA the weaker *markka* caused the capacity projects for coated fine papers to materialize earlier than in BASE, but the increased supply by Finland did not force the foreign capacity to reduce output even when the foreign prices dropped passing some of the devaluation advantage on to the customers. That was helped by the fact that the weaker *markka* also depressed the price of the market pulp.

In REVA, the decline in the production of paper and paperboard was reflected in a slight drop in sulphate pulp production. As domestic pulp consumption decreased, pulp exports from Finland to ROFE could have been increased, but due to revaluation the increase in exports was negligible. In DEVA, pulp production increased as both domestic and exports markets absorbed larger quantities of Finnish pulp.

The other products sensitive to exchange rates were coreboard and liquid packaging board produced with low profit margins in BASE. Naturally, although the production quantities remained the same, the exchange rate changes influenced the profitability of all the domestic production.

6.2 Increased Electricity Price

The price of electricity has traditionally been relatively low in Finland in comparison with competing countries [43], but according to some experts it is anticipated by the industry that the price of electricity might double or even triple by the end of this decade. Whether this will come true or not, uncertainty about the future development of the electricity price prevails.

In BASE we assumed energy prices to remain steady for all the periods, whereas in the following we discuss the results under the alternative energy price developments (scenarios ENER-1 and ENER-2) presented in Table 6.3.

		1989 - 1996	1997 - 1998	1999 - 2004
BASE	Electricity (FIM/MWh)	144	144	144
	Heat (FIM/GJ)	15	15	15
ENER-1	Electricity (FIM/MWh)	144	216	216
	Heat (FIM/GJ)	15	15	20
ENER-2	Electricity (FIM/MWh)	144	288	288
	Heat (FIM/GJ)	15	20	20

Table 6.3: Energy price development in the scenarios BASE, ENER-1, and ENER-2.

The most important changes with respect to the base case in the output and prices are displayed in Table 6.4. As expected, the papers for which energy-intensive mechanical pulp is used, PRWU and PRWC, were hurt by the rise in electricity price. Moreover, production of coated fine paper, coreboard, and liquid packaging board dropped in Finland from its BASE case final period value. The effect on PRWC supply was stronger than on PRWU supply because PRWU was produced only with existing capacity with sunk investment costs. In ENER-1, an investment project on PRWC and an investment project on PRFC were rejected; in ENER-2, two PRWC projects were canceled.

	ENER-1				ENER-2			
	1998	2000	2002	2004	1998	2000	2002	2004
Production								
Finland								
PRWU	-	-	-1	-1	-12	-12	-10	-1
PRWC	-7	-9	-9	-8	-7	-18	-18	-16
PRFU	-	-7	-	-	-1	-7	-	-
PRFC	-	-	-	-15	-	-	-	-15
CORE	-12	1	-8	-1	-10	1	-4	-2
LQPC	-	-	-3	-2	-	-	-7	-3
ROFE								
PRWU	-	-0	-	-	4	3	2	-
PRWC	-	1	5	5	-	6	11	5
PRFU	-	1	-0	-	-	1	-0	-
PRFC	-	-	-	3	-	-	-	3
Price								
PRWU	-0	-	-	1	-	-	3	-
PRWC	2	2	-	-0	2	2	-0	1
PRFU	-0	1	-0	-	-1	2	-0	-
PRFC	-	-	-	-	-	-	-	-
CORE	6	6	5	5	9	9	8	9
LQPC	-	-	2	1	-0	-	- 3	2

Table 6.4: Percentage changes in production and prices for selected products relative to BASE due to increased energy prices.

The drop in the domestic production of these papers was replaced by the producers in ROFE, so the prices remained at the base case level. In coreboard and liquid packaging board, the foreign competitors already faced their capacity limit, so the increase in prices partly compensated for the increase in the production costs.

6.3 Increased Waste Paper Price

We conducted four experiments regarding the price of waste paper. The scenarios were RCYC-1, RCYC-2, RCYC-3, and RCYC-4 with respective waste paper prices of 800 FIM/t, 1200 FIM/t, 1600 FIM/t, and 2100 FIM/t. When examining the results displayed in Table 6.5, remember that we applied one grade and one price for all the products, although different types of waste paper are used for different products, the most expensive grade being office paper waste that can be used as an input for fine paper and tissue paper production. For some paper grades, the prices used in these scenarios may already be realistic in the base year, and the scenarios thus fail to encompass the idea of increased price level. For some other grades the price applied is considerably higher than the prevailing price. With the projected pulp prices, the waste paper price should be roughly 2100 FIM/t for the production costs of primary and secondary pulp based fine papers to be of same order.

As only few of the domestic capacity projects suggested by us were based on the use of secondary fiber, it is expected that an increase in waste paper price will not impair the profitability or decrease the capacity operation rates in the domestic mills in comparison with BASE. Instead, due to the negative impact on investments in

	RCYC-1 (800 FIM/t)		RCYC-2 (1200 FIM/t)		RCYC-3 (1600 FIM/t)		RCYC-4 (2100 FIM/t)	
	Price	Supply	Price	Supply	Price	Supply	Price	Supply
CWIP	-2	-2	-3	-3	-3	-4	-3	-3
NWIP	-	-	-1	1	-1	1	-2	2
NEWS	7	-6	9	-8	9	-8	19	-17
PRWU	1		1	-	6	-1	12	-2
PRWC	2	-4	4	-7	5	-8	5	-10
PRFU	-1	-	-1	0	-1		-1	-
PRFC	-	-	-1	1	-1	1	-	-
PWPR	-2	2	-3	2	-3	2	-3	2
FBBO	1	-	6	-2	11	-5	17	-8
CORE	19	-2	38	-4	54	-5	78	-7
FLUT	3	-3	3	-4	19	-20	44	-46
LNER	1	-	3	-1	15	-5	26	-10

Table 6.5: Percentage changes in production and prices in Europe for selected products in 2004 relative to BASE due to alternative waste paper prices.

new capacity, the increase in waste paper price favors production with the established primary fiber-based capacity. Due to uncertainty about waste paper price development and future recycling legislation, the firms may want to delay their capacity decisions.

With low price-cost margin, the newsprint production was very sensitive to the waste paper price. Already in RCYC-1 the investments for annual capacity of 0.7 mill. t were put off during 1995 to 2004. Liner and fluting production is strongly based on the consumption of secondary pulp. In RCYC-1, the final period fluting production dropped by .28 mill. t/a from the BASE case. As expected, liner supply was not affected, as testliner was assumed to be a perfect substitute to kraftliner. In reality we should also expect the liner supply to be more sensitive to waste paper price than what is proposed here.

Tissue paper supply, although heavily based on secondary fiber, was not affected even in RCYC-4. Also fine paper production volumes still remained at their base case levels. The higher-quality waste paper with higher price is used to these grades. Thus, the price used in the scenario may not be outrageous.

Only in RCYC-4, the European waste paper consumption remained below 30 mill. t in the final period (being close to 26 mill. t.).

There were only few alternative investment proposals for the rejected ones and most of them already materialized in BASE. Also, when the applied waste paper price was already perceived to be too high by the firms, we cannot expect firms to invest in technologies based on chemical pulp that is even more expensive. So the chemical pulp consumption did not increase from BASE. Instead, as some of the capacity projects involved technologies using a mixture of primary and secondary pulp, the production of bleached softwood pulp slightly decreased in Finland.

6.4 Fixed Timber Imports

In the base case, timber trade between Finland and ROFE was subject to inertia constraint, implying that timber imports could not increase more than 25% from one period to next. Still, the imports of pine pulpwood expanded drastically, and it is

		1996	1998	2000	2002	2004
Timber	Harvest					
	PLOG	4	3	7	10	9
	PPWD	3	7	6	9	8
	NPWD	-2	4	3	5	8
	Price					
	PPWD	15	15	23	22	26
	NPWD	10	7	14	23	37
Pulp	Production					
	CWIP	-	-	-1	-6	-7
	NWIP	-	-	-2	-5	-7
	Exports					
	CWIP	4	-1	-6	-19	-14
	NWIP	-	-0	-5	-9	-17
	Price					
	CWIP	-	-	- 1	3	2
	NWIP	-	-	- 3	6	10

Table 6.6: Percentage changes in Finnish pulp and timber output and prices and pulp exports relative to the base case in 1992-2004 due to constraining the timber imports to 1989 level.

reasonable to have some doubts about the result: the Finnish pulp industry might not be willing to rely on the imported roundwood to the extent suggested by BASE when deciding on production capacity.

In the scenario that we call DOMTMBR, we examined how the base case results would be affected if the development of the Finnish forest industry were solely based on domestic timber. This was done by constraining the timber imports to 1989 levels. Table 6.6 presents the major impacts of our experiment relative to the base case. As could be anticipated, there was a drop in pulp production. That, however, did not significantly affect the supply of paper and paperboard in Finland. Instead, pulp exports to ROFE reduced. In 2004, the production of bleached softwood sulphate pulp was 3.5 mill. t and the production of hardwood sulphate pulp was 2.6 mill. t. The drop in NWIP production decreased the market pulp supply and induced a price increase. Softwood pulp prices rose less, as the Finnish pulp exports were to a large extent replaced by the imports from non-European countries.

The decrease in pulp production did not completely correspond to the change in timber imports, and the domestic timber harvests increased. In 2004, the domestic fellings were 56.5 mill. m^3. Still, the growing stock levels in the final period did not change significantly from the base case. The relative growth in the regional growing stock levels from 1989 to 2004 deviated only 1 to 3 percentage points from the base case values reported in Section 5.3.

6.5 Limited Growth in Domestic Pulp Supply

We also examined the impacts of limiting the growth in pulp supply by omitting the new pulp mill projects in Kaskinen (POHM) and Kajaani (KAIN). All the remaining pulp projects are located in Southern Finland.

In this scenario, which we refer to as LOWPULP, the production of bleached softwood sulphate pulp was 3.5 mill. t, and the production of hardwood sulphate pulp was 2.7 mill. t in 2004. Imports of pine pulpwood decreased from the base case level, but were still 4.5 mill. m^3 in 2004. The imports of hardwood pulpwood remained at the base case level. The prices of domestic pulpwood decreased as the drop in pulpwood demand mostly hit the domestic timber markets. Again the reduced pulp supply showed only in pulp exports.

6.6 Changes in Demand Growth Forecasts

The paper and paperboard demand growth rates may decline in the future for several reasons; the problems of waste management are among the most important. The amount of material in the waste stream can be reduced by increased recycling, by technological development, or by source reduction, i.e., by directly reducing the amounts consumed [31]. The demand for packaging materials is especially open to source reduction. For instance, consumers may avoid buying products with redundant packaging, and the use of cardboard containers can be reduced via increased use of reusable containers. The demand for paper products may also decline if the product prices increase due to legislative enforcement of recycling.

In the scenario we call LOWDEM, we cut the annual demand growth rates for paper and paperboard to 50% of their base case value. With most products this would mean that the current capacity would be sufficient to supply the estimated reference demand in 2004. The only products for which additional capacity would be required are FBBO, FLUT, SOFT, and PRFU.

We considered this scenario to be of interest, not only as a sensitivity analysis, but also to experiment, whether the capacity grows from the 1994 level despite the stagnant development of demand. Excess capacity has been a frequent problem in forest industries.

Table 6.7 displays the most important changes in the activity levels relative to BASE. The capacity additions that took place after 1994 were mostly not beneficial at the industry level, as they provided excess capacity with respect to the 2004 reference demand.

Finnish forest industry was not forced to decrease its production of any of the printing and writing papers from the 1994 levels, but none of the domestic capacity projects was profitable in this scenario. Also, there was little or no change in the Finnish supply of fluting, folding boxboard, and tissue paper relative to BASE. In these products it was the producers in ROFE that cut their investments. For Finnish kraftliner production the low demand growth was fatal; regardless of the low demand, 2.2 mill. t of low- cost testliner entered the markets, replacing kraftliner. The Finnish producers had to cut their supply by almost 50%. Furthermore, in addition to a new pulp mill in Rauma, there was only a 0.12 mill. t increase (in KAIN) in domestic softwood sulphate pulp production by 2004. The production of hardwood pulp remained at the 1994 level.

Although the newsprint capacity addition after 1994 corresponded to less than two new machines, it was more than what would have been beneficial to the industry. European newsprint supply equalled 11 mill. t in 2004. These investments (100% RCYC) were relying on the low-priced secondary fiber, and would have been rejected with the slightest waste paper price increase.

European PRWU production increased by less than 0.5 mill. t from 1994 to 2004. As we did not require firms to decide to take the 'entire machine or nothing', several firms increased their capacity by 14% - 46% of the size of a new machine, which can be

	1992	1994	1996	1998	2000	2002	2004
Prices:							
CWIP	-2	-6	-9	-10	-10	-12	-12
NWIP	-5	-1	-1	-2	-5	-8	-7
NEWS	-3	-6	-9	-7	-7	-4	-6
PRWU	-1	-2	-9	-9	-5	-1	-11
PRWC	-3	-6	-8	-8	-7	-7	-6
PRFU	-3	-4	-7	-7	-9	-14	-35
PRFC	-2	-5	-8	-13	-15	-19	-20
PWPR	-1	-3	-7	-5	-14	-15	-19
FBBO	-2	-14	-15	-16	-11	-9	-7
CORE	-	-	-	-1	-1	-3	-4
FLUT	-1	-1	-7	-11	-13	-14	-13
LNER	-4	-3	-8	-10	-17	-20	-25
LQPC	-3	-3	-4	-9	-15	-20	-18
SOFT	-9	-5	-14	-10	-19	-17	-32
Consumption:							
NEWS	-	-	-	-4	-6	-10	-10
PRWU	-2	-3	-4	-6	-8	-11	-10
PRWC	-	-	-	-3	-7	-9	-14
PRFU	-2	-4	-6	-8	-10	-11	-11
PRFC	-3	-5	-7	-6	-7	-6	-9
PWPR	1	2	4	3	9	10	13
FBBO	-2	-	-2	-3	-7	-10	-13
CORE	-1	-2	-3	-4	-5	-5	-6
FLUT	-2	-3	-1	-	-	-	-3
LNER	-1	-4	-4	-6	-6	-7	-7
LQPC	-	-3	-4	-4	-3	-3	-5
SOFT	-1	-5	-6	-10	-10	-14	-11

Table 6.7: Percentage changes in prices and consumption for selected products relative to BASE due to cut of demand growth estimates by 50%.

considered unrealistic. In this situation there is great risk of overcapacity, if the actual investment decision cannot be coordinated as is done in the model.

The increase in fine paper production was high: the supply of both uncoated and coated grades increased by roughly 1 mill. t. It was, however, only the recycled fiber-base projects in ROFE that advanced. An unrealistically low waste paper price was applied to these products.

The operating margins for the least profitable active technology varied from 0% to 5% in the second period, and from 0% to 12% in the last period, which means that the prices could only cover the variable production costs of the least profitable active mills. In competitive markets where the profit margins in the industry are not especially high, the low demand makes the firms increasingly sensitive to excess capacity and to factor prices. Consequently, to make the results of this scenario more reliable, the price of waste paper would require more accurate treatment.

6.7 Worst Case Scenario

Our last scenario with perfect competition combines elements of three earlier scenarios: REVA, ELEC-2 and DOMTMBR. In this scenario, which we call WORST, we assumed the exchange rates to follow the development suggested by REVA. The energy price development was taken from the scenario ELEC-2. Furhtermore, we tied timber imports to Finland to their base year level, as was done in DOMTMBR.

In WORST, both CWIP and NWIP production further dropped from their DOMTMBR levels. In 2004, production of CWIP totalled 3.4 mill. t and production of NWIP totalled 2.5 mill. t. CWIP exports did not change from the base case level; NWIP exports dropped but less than in DOMTMBR. In 2004, domestic harvests totalled 55 mill. m3 and the total roundwood consumption in the domestic forest industries totalled 60 mill. m3.

Regarding the paper products, the main change in the domestic production levels in comparison with ELEC-2 or REVA was the furhter decrease in PRFC and PRWC production. This means that none of the domestic investment plans concerning PRWC and PRFC materialized in WORST. In comparison with ELEC-2 or REVA, the changes in the total European supply of the different paper and paperboard products were all withing a range of -3% to 1%

7 Scenario with Cournot Hypothesis

We may presume that the markets for pulp and paper products might not be competitive for several reasons, and the issue does not lack real-world evidence. One indication is that it has been common for the forest industry firms to take downtime during severe times, i.e., to voluntarily reduce production to be able to maintain a certain price level instead of going into price competition. This kind of coordination appears to be of a tacit nature, although examples of more direct collusion are also found. For instance, in 1991 the Commission of European Union brought a charge against 19 producers of folding boxboard, including several Finnish companies, for colluded pricing with respective production restrictions having taken place since a secret meeting in 1985. After further investigations, the Commission imposed fines on the firms involved. These kind of incidents are not unheard of in the markets of the other forest industry products either: Finnish, Swedish, and North American sulphate pulp producers faced similar charges in the European markets in the 1980s. What is remarkable is the fact that the tendency in the forest industry has been toward further concentration, which is not likely to promote competition, although the increased concentration does not automatically lead to improved performance in the industry. For instance, after the 1985 of the price agreements between the folding boxboard producers, the number of firms in the industry has been reduced due to arrangements between the alleged cartel members, and around 60% of the folding boxboard capacity was controlled by the five largest firms in 1992 [36]. Similarly high, 45 to 70% concentration rates appear for most pulp and paper products.

Various patterns of imperfect competition are identified by the economic theory, and without empirical research it is not straightforward to assess which pattern, if any or a combination of several, has taken place. The most well-developed exemplars of the noncooperative deviations from the perfect competition are quantity- and price-setting oligopolies, with Cournot and Bertrand type oligopolies as special cases. In capacity-constrained industries the assumption of Cournot competition on quantities can generally be regarded as being more justified. However, the industry-wide rate of capacity utilization is subject to variation, which suggests that the form of competition in an industry need not be exogenous. Scherer ([41], p.206) writes: "There is evidence that industries characterized by high overhead costs are particularly susceptible to pricing discipline breakdowns when a cyclical or secular decline in demand forces member firms to operate well below designed plant capacity. This tendency appears to be especially marked in industries... using highly capital intensive production processes." Also, the work of Kreps and Scheinkman [27] suggests that the form of competition in the industry might indeed be endogenous. In the forest industry this idea looks particularly attractive, because due to cyclical demand, the industry is prone to excess capacity but at times it is clearly capacity constrained. With a capacity utilization rate of 95% or more, firms hardly have incentive to undercut the existing price level. However, due to exogenous shocks in demand, the firms may at times be driven to compete on prices till their capacity is used efficiently. On the other hand, as such an undercutting is relatively easy to detect in paper markets [5], the firms may still avoid underpricing in favor of long-term profits, while anticipating the threat of price wars.[1] Life without excess capacity with a threat of price competition would still be preferable.

[1] An ample amount of theoretical and empirical (e.g., [12], [37], [3]) papers exists on this subject.)

If we ignore the possibility of excess capacity having been designed for entry deterrence, there are several natural reasons why excess capacity may develop. (See [30] for a comprehensive discussion.) The demand shocks and the inability to coordinate lumpy investments appear to be the most plausible reasons in the pulp and paper industry. The pulp and paper industry is relatively well established, and it is generally appreciated that capacity additions in the industry are triggered due to demand growth anticipations, rather than due to the desire to increase one's market share although this can also happen, especially if the firms believe they will be able to replace high cost capacity of competitors aided by technological innovation. Generally, the technology in the industry is, however, well known and available to all firms. Due to a long lead time, the capital stock decisions have to be made few years before the firms learn what the actual demand will be. Furthermore, because of the large scale of the modern machines there is no room for several firms to invest simultaneously. Still, with several firms in the markets, it is extremely difficult to coordinate the industrywide capacity expansion.

In the following, we assume that the firms in the paper industry try to avoid spoiling the prices due to accumulation of excess capacity, and that they choose their capacity recognizing the impact of their output decision on prices, but ignoring their potential ability to influence the behavior of their rivals. Hence, we examine oligopolistic conduct by assuming Cournot-type quantity setting behavior for the paper producers. As an exception, the heterogenous product group 'other paper and paperboard' was still maintained competitive. Note that with our myopic agents, capacity expansion is here combined with the choice of production levels, as we let the firms to make immediate use of new capacity, if they consider it profitable.

It sounds intuitive that a Cournot equilibrium under free entry is found near the competitive outcome when the number of firms in the industry is large, with no individual firm having a significant market share.[2] We do not allow free entry, but the number of producers is large in many paper products. It is of interest to see if an outcome close to that of perfect competition results in our experiment. Competitive approximation would be appealing to use due to the clarity it provides. Then we would not have to worry whether the firms compete on prices or quantities or both, if the industry structure determined the outcome to be same in any case.

This chapter is organized as follows. We first summarize some of our most important results derived using the Cournot hypothesis (Section 7.1). Thereafter we take a closer look at the developments of the factor markets (Section 7.2) and of the markets for paper and paperboard (Section 7.3), where the emphasis is on the printing and writing papers.

7.1 Main Results

The most important result is the fact that although the firms in paper industry are many and although competition seems to get fierce at times due to unfavorable demand capacity ratios - for instance, the entire German paper industry operated at a net cash

[2]Proofs for such a convergence of a Cournot oligopoly, where the same U-shaped average cost curve is faced by all the firms, to competitive markets are given, by Novshek [35] and Conlisk [10]. The model by Gaskins [19] suggests that in homogenous product industry, where there is a "dominant" firm leading in price but lacking any cost advantage, and where the entry rate is linearly related to the current price, the industry will in the stationary state constitute of a set of identical firms charging the price equal to marginal production costs.

loss of more than 5% in 1993 [9]- there were clearly opportunities for noncompetitive behavior with all the paper and paperboard products. Still, it should be borne in mind that we did not allow free entry, but had prespecified the number of firms and the potential additions to capacity. With free entry the results could have converged closer to a competitive outcome. On the other hand, entry requires immense capital input in order for an entrant to reach the efficient scale of operations, and it is unlikely that a firm without prior experience in the pulp and paper industries would enter. Another point that should be emphasized is that, although we refer to the results of BASE as a competitive outcome, these results were seldom competitive from a long term perspective, as due to a nonmarginal price of new capacity and the capacity constraints, the price was not necessarily equated to the marginal costs of the least profitable active firm.

The results suggest that, with the current size distribution of the firms in the paper industry, it is relatively safe to adhere to the perfect competition hypothesis when modeling the use of the existing capacity in the industry, given the assumptions of demand and factor costs made by us. Instead, allowing the firms to consider the impact of their capacity decision on the prices would, in most products, affect the choices of the most significant firms. This result is attached to an interesting feature encountered by us, which may be regarded a drawback of the use of the Cournot hypothesis as contradicting the real-world developments in some cases. Namely, the same phenomenon that makes a sequential Cournot game converge to perfect competition under free entry, makes the Cournot competition here even out the initially heterogenous firm sizes. When the cost functions of the rivalling firms do not differ substantially, a Cournot-Nash equilibrium is found at a point where the firms are of roughly equal size. In the presence of capacity constraints, firms with more capacity are able to produce more than in the unconstrained case. But when all the firms are given an equal opportunity to expand (i.e., the same technology available with the same investment costs), the firms with the smallest initial capacity are most eager to invest in a Cournot oligopoly. When the demand function is downward sloping and the production costs for an additional unit are equal for all the firms, it is most profitable for the smallest firm to acquire an additional capacity unit, as the resulting price decrease is distributed over a less significant initial supply. This phenomenon is inherent to the optimality conditions (3.19) - (3.23) for a firm. Paradoxically, significant firms will expand only when they are no longer of significant size but are of average size.

On the other hand, the fact that the competition hypothesis, although affecting capacity decisions, had little impact on the production levels with the established capacity suggests that the firms were capacity constrained to produce their competitive output, and perhaps even their free Cournot output. That is inherent in the high cost of capital adjustment that become sunk after investment.

It is expected that the gains from the Cournot competition for the producers are greatest in industries controlled by only a few firms or in industries with inelastic demand, i.e., in the markets where a significant price increase can be achieved via a small supply reduction. Thus, the results for the products with these qualities are not surprising. The five products with the most inelastic demand with respect to price are PRWU, PRFU, SOFT, CORE, and FBBO, whereas CORE and LQPC are examples of products with few producers. The price in the final period was at least 8% higher than in BASE for all the products mentioned above, while the production volumes decreased most by CORE and LQPC (by 9% to 14% depending on the period).

The high-cost fringe producers benefitted from the higher price level of imperfect competition resulting from the significant producers cutting their production and/or capacity investments. In some cases they were able to expand by investing in technology, which was not profitable under perfect competition. For several products, corrugated materials for instance, Finnish producers were able to exploit their fringe position by increasing their output relative to the base case. This was helped by the fact that the drop in production and investments of the large firms also had factor price effects.

When examining the results below, note that as the base year production in the model has been tied to the base year actual production in both BASE and this scenario, which we call OLIGO, the two scenarios may differ only after the first period.

7.2 Factor Markets

Timber

In OLIGO, the pulpwood consumption by the Finnish forest industry was roughly 49 mill. m^3 in 2004. For each pulpwood type the demand declined by almost 1 mill. m^3 from the base case. For pine pulpwood this caused a 0.6 mill. m^3 drop in domestic fellings relative to BASE; for birch only imports diminished from BASE. Prices also decreased in comparison to BASE: 4% to 7% for pine, 7% to 9% for spruce, and roughly 3% for birch.

Pulp

Price-making behavior of the paper producers shrank the capacity expansion potential of the domestic pulp producers: the growth of domestic pulp capacity seemed to follow the base case development with one period lag. In 2004, the domestic production of bleached softwood sulphate pulp was 3.6 mill. t (a 0.1 mill. t drop from BASE), and the production of bleached hardwood sulphate pulp was 2.6 mill. t (down 0.2 mill. t). The volume of CWIP exports stayed at the BASE level, although the pulp consumption in ROFE decreased as well. There the imports from non-European countries decreased. For NWIP both the domestic consumption and exports dropped.

In Rest of Europe, Cournot competition affected the projected paper capacity most, which was dominantly based on secondary fiber. There the sulphate pulp consumption declined by 0.5 mill. t in comparison with BASE.

The changes in production, consumption, and prices of bleached sulphate pulp in Europe in OLIGO with respect to BASE are provided in Table 7.1. The decrease in pulpwood prices was not enough to compensate for the decrease in pulp prices, but the profits of the pulp producers were reduced, as is evident in Table 7.2.

		1992	1994	1996	1998	2000	2002	2004
CWIP	Production							
	Finland	-	-	-	-	-1	-2	-3
	ROFE	-	-	-	-3	-1	-	-
	Consumption							
	Finland	0	-4	-5	-10	-12	-10	-6
	ROFE	-4	-2	-1	-1	-1	-2	-3
	Price	-7	-5	-3	-4	-6	-7	-6
NWIP	Production							
	Finland	-	-	-	-	-6	-9	-8
	ROFE	-	-7	-7	-5	-1	-	-
	Consumption							
	Finland	3	-3	-5	-3	-7	-8	-4
	ROFE	-3	-8	-8	-6	-3	-3	-3
	Price	-8	-3	-2	-3	-5	-3	-1

Table 7.1: Percentage changes in European production, consumption, and prices of bleached sulphate pulp relative to BASE due to Cournot competition in paper industries.

		1990	1992	1994	1996	1998	2000	2002	2004
CWIP	Finland	-24	-8	14	-3	-14	-8	-4	1
	ROFE	-9	-3	-8	-5	-13	-11	-10	-7
NWIP	Finland	-7	9	12	-12	-10	-8	-4	-3
	ROFE	-3	5	-12	-14	-13	-12	-8	-5

Table 7.2: Average profit margins (% of price) after variable production costs and fixed capital costs for bleached sulphate pulp in OLIGO.

7.3 Markets for Paper

Newsprint

With newsprint, the change in the competition hypothesis showed in the capacity expansion only. No new capacity was suggested for Finland, and regardless of some European top 10 newsprint producers (UPM, EG, and KG) having mills in Finland, the domestic NEWS production remained at the base case level. In ROFE the main producers expanded their production less than in BASE. After 1995, Holzmann, MoDo, SCA, and a fringe firm each installed one new machine, while in BASE, UPM, Haindl, and Norske Skog also had new machines. The change in investment behavior demonstrates that the producers are able to perceive the effect of their actions on prices. Altogether, European production was 11.6 mill. t/a in 2004, which is 0.6 mill. t/a less than in BASE. The price rose accordingly and the profit margins improved, permitting the average European producer to operate profitably.

With no incumbent capacity being idle, the industry was still capacity constrained as in the competitive case. Therefore, it is likely that at least some firms would have wanted to produce more, their capacity allowing.

The changes in newsprint supply and demand in OLIGO relative to BASE, as well as profit margins after variable costs and fixed capital costs are given in Table 7.3.

	1990	1992	1994	1996	1998	2000	2002	2004
Price	-	4	5	3	4	3	4	6
Production								
Finland	-	-	-	-	-	-	-	-
ROFE	-	-3	-4	-3	-4	-3	-4	-6
Profit margins								
Finland (A)	-5	-11	10	-10	-7	-5	-4	0
Finland (H)	-2	-6	15	-5	-3	0	1	5
Finland (L)	-16	-23	-2	-22	-18	-16	-14	-10
ROFE (A)	6	-4	-5	-4	-2	-	1	5

Table 7.3: Percentage changes in NEWS price and supply in Europe relative to BASE and the highest (H), lowest (L) and average (A) profit margins (% of price) after variable production costs and fixed capital costs in Finland and in Rest of Europe for NEWS in OLIGO.

Uncoated wood-containing printing and writing papers

Given the highly inelastic demand function and zero cross-price elasticity between PRWU and other paper grades applied by us, UPM would not have built a new machine in Jämsänkoski in 1993, if it had behaved like a Cournot firm. In the model, that new machine was forced into the solution as a de facto materialized capacity addition. Simultaneously, UPM, like Myllykoski Oy, reduced its production with its other machines. Two UPM machines were taking downtime even in the last period.

In Rest of Europe the investment behavior changed with the competition hypothesis: instead of Myllykoski investing in new (recycled fiber-based) capacity, a fringe firm installed a machine not installed in BASE. Furthermore, SCA chose to delay its investment in a new machine with respect to the schedule suggested by BASE.

The price rose drastically, and so did the profit margins of the firms in the industry. Relatively inelastic demand and a high number of fringe firms reluctant to cut their supply but unable to expand their capacity (due to the fact that just one capacity project was defined for the fringe) provide some explanation for this behavior. Large firms, UPM and Myllykoski, had an opportunity to cut their production without replacement supply streaming onto market by the fringe firms. The total profits for the industry were higher in OLIGO than in BASE for all the firms. The relative deviations in OLIGO from BASE are shown in Table 7.4, which also displays the profit margins in OLIGO.

The results are obviously unrealistic. If the price of PRWU were so close to price of PRWC (even exceeding it as was the case in the second period), substitution would soon take place. Also, including non-European competition could change the results.

We made two test runs regarding to Cournot behavior on PRWU and found that the results were not sensitive to the number of fringe firms, but that exactly the same outcome was achieved when we cut the amount of the most insignificant foreign firms from 30 to 15. The results were also completely insensitive to a 50% increase in the costs other than wood fiber production costs of these 30 fringe firms.

Coated wood-containing printing and writing papers

For coated wood-containing printing and writing papers the results were more realistic than for SC paper. The number of firms in the industry was considerably smaller (15),

	1990	1992	1994	1996	1998	2000	2002	2004
Price	-	46	46	37	31	34	38	28
Production								
Finland	-	-24	-30	-38	-39	-34	-28	-22
ROFE	-	-1	1	4	5	3	-	-1
Profit margins								
Finland (A)	-6	10	25	12	10	12	14	17
Finland (H)	-1	16	29	16	14	16	18	22
Finland (L)	-12	4	20	6	4	6	8	12
ROFE (A)	2	13	9	12	11	12	15	18

Table 7.4: Percentage changes in PRWU consumption, production and prices in Europe relative to BASE due to Cournot competition in paper industries, and the highest (H), lowest (L), and average (A) profit margins (% of price) after variable costs and fixed capital costs in Finland and Rest of Europe for PRWU in OLIGO.

	1990	1992	1994	1996	1998	2000	2002	2004
Price	-	3	-	-	2	3	2	3
Production								
Finland	-	-8	-	-	-7	-13	-9	-7
ROFE	-	-1	-	-	-	1	-	-5
Profit margins								
Finland (A)	-12	-16	7	-9	-2	1	2	4
Finland (H)	-8	-12	11	-4	2	8	9	10
Finland (L)	-16	-20	3	-14	-6	-4	-2	-1
ROFE (A)	-8	-18	-14	-12	-5	-2	-1	1

Table 7.5: Changes in PRWC price, consumption, and production in Europe in OLIGO in comparison to BASE (%), and the highest (H), lowest (L), and average (A) profit margins (% of price) for PRWC after variable costs and fixed capital costs in Finland and Rest of Europe in OLIGO

and the demand was more elastic. The incumbent capacity was only affected in the second period, with Kymmene and Burgo reducing their production. The investment behavior deviated from that in BASE: Myllykoski and a fringe firm chose to carry out their investments earlier than in BASE, and UPM postponed its new machine for a few periods. Kymmene, Burgo, and Stora decided not to expand their capacity at all, and MoDo-MD Papier increased its capacity with only 50% of the size of a new LWC machine. Table 7.5 presents the relative deviations from BASE, as well as a profit margin summary.

Uncoated wood-free printing and writing papers

Due to the inelastic demand, PRFU producers succeeded in raising the price from some 1320 USD/t to 1680 USD/t by cutting their production by less than 4%. The price increase shows readily in the profit margins (Table 7.6), which are apparently unrealistic. In the final period the market leaders, Kymmene and Enso-Gutzeit (Veitsiluoto was included in Enso-Gutzeit) contracted their supply. In the earlier periods all the top five producers reduced their production, while the smaller producers supplied more than or the same as in BASE.

	1990	1992	1994	1996	1998	2000	2002	2004
Price	-	54	58	52	57	55	54	27
Production								
Finland	-	-12	-2	-2	-2	-10	-3	-
ROFE	-	-4	-6	-5	-5	-4	-6	-4
Profit margins								
Finland (A)	4	33	42	34	35	37	39	44
Finland (H)	8	35	44	37	37	40	42	46
Finland (L)	-10	24	34	25	25	28	31	36
ROFE (A)	2	32	34	34	35	37	39	44

Table 7.6: Changes in PRFU price, consumption, and production in Europe in OLIGO in comparison to BASE (%), and the highest (H), lowest (L) and average (A) profit margins (% of price) after variable costs and fixed capital costs in Finland and Rest of Europe for PRFU in OLIGO.

	1990	1992	1994	1996	1998	2000	2002	2004
Price:	-	1	1	4	1	-	2	3
Production:								
Finland	-	1	-	-	-	-	-16	0
ROFE	-	-1	-1	-3	-1	-	-	-4
Profit margins:								
Finland (A)	-4	-23	-4	-16	-10	-5	2	6
Finland (H)	1	-16	3	-8	-3	2	8	10
Finland (L)	-12	-37	-15	-29	-23	-17	-10	-7
ROFE (A)	5	-22	-22	-14	-8	-2	5	7

Table 7.7: Changes in PRFC price, consumption and production in Europe in OLIGO in comparison to BASE (%), and the highest (H), lowest (L), and average (A) profit margins (% of price) after variable costs and fixed capital costs in Finland and Rest of Europe for PRFC in OLIGO.

Industrial profit margins as high as those shown in Table 7.6 make market entrance lucrative. However, inelastic demand poses a great risk, because market price is highly sensitive to demand fluctuations. Consequently, the industry is extremely sensitive to the excess capacity.

Coated wood-free printing and writing papers

Of the printing and writing paper products, PRFC was least affected by the change in competition hypothesis. The fringe was not assumed to expand its capacity and the capacity decisions were in the hands of the leading firms, of which we proposed new capacity for the KG, MS, Veitsiluoto, AWA, the Marchi Group, and Stora. Stora chose to install one new machine instead of the two suggested by BASE. Other changes were less significant.

Profit margins after fixed capital costs displayed in Table 7.7 improved from BASE, but remained negative for some smaller, nonintegrated machines.

Other paper and board products

The impacts of the Cournot competition on the other paper products in comparison to the base case are summarized in Table 7.8. The fact that the Finnish producers were relatively unimportant in the markets for these products, except for liquid packaging board (Enso-Gutzeit) and coreboard (UPM and Enso-Gutzeit), showed in the results. High-cost domestic producers now output their capacity, charging higher prices than in BASE, as they benefitted from the fact that the leading producers contracted their supply.

Coreboard price rose drastically (lacking substitutes), but the resulting price level does not find its match in reality, where the price has remained at a relatively low level. The fact that the capital input required for starting coreboard production is fairly unimportant in comparison with the other paper and paperboard products lowers the threshold of entry and makes the development suggested by OLIGO impossible in practice. We experimented with this in another model run by introducing an abundant amount of coreboard investment alternatives for the firms not in the market. As a result, plenty of new capacity/firms entered the markets under Cournot competition. Consequently, the incumbent firms further reduced their production and experienced loss in comparison with the base case, although the price in the final period was still 16% higher than in the base case.

The most important producers cut their high-cost kraftliner production by .4 mill.t altogether. This favored not only the Finnish firms but also the other Scandinavian producers that had divested their kraftliner capacity in BASE. Due to high-cost fringe firms expanding their production, the total output deviated from the base case by less than .2 mill. t in 2004. Still, all the producers benefitted from the Cournot competition.

In fluting, the change in the competition hypothesis showed in the investment behavior. All the firms that had investment plans for 1995 to 2004 were less willing to implement them. Even the fringe was less eager to expand its capacity.

In tissue paper, the two biggest firms divested part of their highest-cost production capacity. Interestingly, the production of the third-biggest firm was no more affected, although that firm had some of the same type of technology that was divested by the two largest firms. Note that the sizes of the firms were roughly known, but their furnish-capacity structure was not known. With different capacity structure the outcome could have looked different.

	1992	1994	1996	1998	2000	2002	2004
Price							
SACK	11	14	8	13	3	2	-2
FBBO	25	17	10	5	5	4	8
CORE	145	166	144	145	146	146	147
FLUT	2	2	-	-	-	-	2
LNER	15	19	12	11	8	8	5
LQPC	19	37	34	30	23	19	17
SOFT	29	34	26	34	25	29	12
Consumption							
SACK	-6	-7	-4	-7	-2	-1	1
FBBO	-8	-6	-4	-2	-2	-2	-4
CORE	-14	-14	-14	-14	-14	-14	-14
FLUT	-1	-1	-	-	-	-	-2
LNER	-4	-5	-3	-3	-3	-3	-2
LQPC	-9	-15	-14	-13	-11	-10	-9
SOFT	-7	-8	-7	-8	-7	-8	-4
Production							
ROFE							
SACK	-10	-11	-8	-9	-1	-1	2
FBBO	-10	-7	-4	-2	-3	-2	-4
CORE	-28	-4	-25	-23	-22	-20	-19
FLUT	-1	-2	-	-	-	-	-2
LNER	-9	-6	-5	-5	-3	-3	-2
LQPC	-14	-14	-10	-8	-6	-2	-
SOFT	-8	-8	-7	-9	-7	-8	-4
Finland							
SACK	22	22	22	5	-	-	-
FBBO	12	-	-	-	-	-	-
CORE	75	-32	42	27	24	8	2
FLUT	-	-	-	-	-	4	4
LNER	-	13	52	38	-	-	-
LQPC	10	-16	-25	-25	-20	-24	-25
SOFT	-	-	-	-	-	-	-

Table 7.8: Percentage changes in price, consumption and production of other paper products in Europe in OLIGO relative to BASE

8 Mergers

As discussed above, a Cournot hypothesis is unable to explain why some firms develop to hold dominant market shares. On the contrary, a convergence toward homogenous firm size is expected. Mergers and acquisitions provide means for significant firms to maintain or increase their market share without hurting market prices. During recent years, fusions have been frequent in the forest industry, but more are expected. Here we consider the impacts of the following hypothetical mergers between the Finnish firms:

- Kymmene (KG) and United Paper Mills (UPM)
- Metsä-Serla (MS) and Enso-Gutzeit (EG), including Veitsiluoto
- Enso-Gutzeit with Veitsiluoto, and Kymmene

8.1 Kymmene and United Paper Mills

A merger between United Paper Mills and Kymmene would create a leading European producer of all printing and writing papers except PRFC. The two firms complement each other's product palette, as the newsprint and PRWU capacity of the merged firm would mainly be provided by UPM and most of the PRFU capacity and two-thirds of the PRWC capacity would come from KG. Kymmene also manufactures PRFC, and both firms are important producers of sack kraft.

The merged firm would be able to offer a complete range of printing and writing papers to its customers, which would result in some benefits in marketing. The broader product palette would also grant some degree of market risk diversification, while still

		SACK	NEWS	PRWU	PRWC	PRFU	PRFC
BASE	UPM	.16	1.59	1.07	0.93	0.25	0.04
	KG	.13	0.40	0.10	1.53	1.06	0.49
	Total	.29	1.99	1.17	2.45	1.31	0.53
OLIGO	UPM	-	-.26	-.35	-	-	-
	KG	-	-	-	-.22	-.25	-
	Total	-	-.26	-.35	-.22	-.25	-
UPM+KG	Total	-.05	-.26	-.42	-.57	-.42	-

Table 8.1: Production (mill. t/a) by United Paper Mills and Kymmene for selected products in 2004 in BASE and the deviations (mill. t/a) from BASE in OLIGO and in the scenario where United Paper Mills and Kymmene are fused (UPM+KG).

	Production		Consumption	Price
	Finland	ROFE		
SACK	-18	2	-1	2
PRWU	-6	1	-0	1
PRWC	-12	4	-2	1
PRFU	-13	1	-1	5

Table 8.2: Percentage changes in demand, supply, and prices in European markets in 2004 relative to OLIGO due to a merger between United Paper Mills and Kymmene.

keeping companies concentrated on publishing papers. However, the fact that the products of the two firms chiefly complement each other leads us to expect little change in the post-merger market prices of printing and writing papers with respect to the pre-merger prices. In sack kraft markets the new firm might use its new leading position to influence the market prices.

The impacts of the fusion on the output of the merged firm are summarized in Table 8.1, where we can observe that the two firms cut their PRWC and PRFU supply from OLIGO levels. That was done by coordinating investments. United Paper Mills had a PRFU capacity project that was now rejected. Also, an LWC investment was proposed for both firms, but as PRWC capacity of the merged company was already 1.5 times the capacity of the market leader KG's original capacity, the merged firm did not increase its LWC capacity at all. It sounds intuitive that an important benefit from a merger would result from an ability to coordinate investments of a competitor with expansion potential. However, from Table 8.2 showing the total market effects of the fusion, we notice that the final period production quantities in ROFE increased. This is because the rest of the firms expanded their output. This decreased the price effect of the merger, and, in fact, resulted in the merged firm experiencing *loss* in comparison with the initial Cournot outcome with all the products in Table 8.1.

8.2 Enso-Gutzeit and Metsä-Serla

Both Enso-Gutzeit (Veitsiluoto is here included in EG, although EG currently possesses no more than 30% of the Veitsiluoto shares) and Metsä-Serla are relatively diversified, and together they have production falling into almost all the SF-GTM product categories. A merger would provide a capacity increase in several products without a need to invest in new capacity. In FLUT and FBBO the productive capacity would double, and with most products (NEWS, PRWC, PRFU, PRFC, FLUT, SOFT, FBBO) the company would rank among the five or six top producers in Europe. However, it would hardly shake the markets if the two firms joined, as the merged company might want to change its behavior with respect to OLIGO only regarding its fine paper production, as is evident in Table 8.3. As can be seen from Table 8.4, there was a minor increase in fine paper prices. However, as in the merger of Kymmene and UPM, the only ones to gain from the price increase were the rivals.

Hence, the gains to merger would again derive from the facts beyond our model, namely, savings in marketing and other fixed operations. Further, if necessary, a merger might facilitate selling out certain branches once they were combined to enable the

		FBBO	LNER	LQPC	NEWS	PRWC	PRFU	PRFC
BASE	EG	.36	.15	.44	1.04	.69	.99	.68
	MS	.24	.30	.03	-	.37	.16	.36
	Total	.60	.45	.47	1.04	1.06	1.15	1.04
OLIGO	EG	-	-	-.13	-	-	-.12	-
	MS	-	-	-	-	-	-	-
	Total	-	-	-.13	-	-	-.12	-
EG+MS	Total	-	-	-.13	-	-	-.22	-.22

Table 8.3: Production (mill. t/a) by Enso-Gutzeit and Metsä-Serla for selected products in 2004 in BASE and production deviations (mill. t/a) from BASE in OLIGO in the scenario where Enso-Gutzeit and Metsä-Serla are fused (EG+MS).

	Production		Consumption	Price
	Finland	ROFE		
PRFU	-8	1	-1	3
PRFC	-18	2	-1	1

Table 8.4: Percentage changes in demand, supply, and prices in European markets in 2004 relative to OLIGO due to a merger between Enso- Gutzeit and Metsä-Serla.

merged firm to more powerfully focus on its key businesses.

8.3 Enso-Gutzeit and Kymmene

The benefits of a merger between Enso-Gutzeit and Kymmene would derive from printing and writing paper markets, as the merged firm would be a leading producer of fine papers, LWC, and newsprint. Both firms supply several grades of printing and writing papers, but the capacity for other products (CORE, SACK,...) would be supplied by either Enso-Gutzeit or Kymmene.

The changes induced by a merger are provided in Table 8.5. Deviations from OLIGO are seen in PRWC and fine papers. In uncoated fine paper, the two firms even cut their supply from the base year level; in coated fine paper, a new machine was rejected. For PRFU, the profit of the merged firm was higher than the pre-merger joint profit of the two firms in OLIGO. But on the other hand, one may ask whether the drop in production from the 1989 level can be considered realistic. See Table 8.6 for the total market effects.

		NEWS	PRWU	PRWC	PRFU	PRFC
BASE	EG	1.04	.06	.69	.99	0.68
	KG	.40	.10	1.53	1.06	0.49
	Total	1.44	.16	2.22	2.05	1.17
OLIGO	EG	-	-	-	-.12	-
	KG	-	-	-.22	-.25	-
	Total	-	-	-.22	-.37	-
EG+KG	Total	-	-	-.29	-.75	-.26

Table 8.5: Production (mill. t/a) by Enso-Gutzeit and Kymmene for selected products in 2004 in BASE and production deviations (mill. t/a) from BASE in OLIGO and in the scenario where Enso-Gutzeit and Kymmene are fused (EG+KG).

	Production		Consumption	Price
	Finland	ROFE		
PRWC	-2	-1	-0	0
PRFU	-1	-5	-4	22
PRFC	-20	2	-1	1

Table 8.6: Percentage changes in demand, supply, and prices in European markets in 2004 relative to OLIGO due to a merger between Enso-Gutzeit and Kymmene.

8.4 Conclusions

None of the mergers discussed above would have a drastic impact on the total market supply in comparison with a situation where the firms operate individually realizing the impact of their production and investment decisions on market prices. In fact, in all but one of these cases it happened that, when the merged firm tried to dominate the industry by restricting its output, the reaction of the competitors was such that the profits of the merged firms were actually lower than the pre-merger joint profits. The non-merged firms benefitted from the situation by expanding their market share. It should be noted that the above result is equivalent to the situation where the two firms behave collusively, which indicates that, under Cournot competition in the paper industry, there are no gains from collusion if all or a significant group of the fringe firms do not participate.

The result may sound counterintuitive, as a merged firm always has the option to produce the aggregated pre-merger output and, provided that the change in the structure of the industry does not induce competitors to deviate from Cournot behavior, earn the pre- merger profits. But because the firms under Cournot oligopoly choose their production given the production of the others, the original production level is no longer profit maximizing to the merged firm. Salant et al. [38] discuss this puzzling phenomenon, and, interestingly, assert that the simple static framework is not to blame, but that the phenomenon may also appear in more complex Nash equilibrium models containing dynamics or heterogenous products.

Finally, the advantages of the mergers that we explored would mainly consist of diversification of risk, savings earned on cutting the coinciding operations, and improved customer service via an extended range of products. How these advantages would contribute to income statements of the firms remains to be examined.

9 Summary and Conclusions

9.1 Summary of the Scenario Results

In the preceding sections we have documented a set of scenarios for the Finnish forest industry created with a partial equilibrium model that focuses on the Finnish forest sector but considers rival forest industry in Rest of Europe as well. The base scenario was created by applying a competitive markets hypothesis that has been traditionally used in forest sector models. Several alternative scenarios to this base case were produced by adhering to the assumption of competitive markets but modifying assumptions of future development of exchange rates, price of waste paper, electricity price, timber supply, and paper demand. An alternative competition hypothesis, a Cournot oligopoly in paper and paperboard industries, was applied to assess the sensitivity of the results to the choice of market hypothesis and to study the impact of potential market power possessed by the firms on the behavior of the sector. Under the Cournot hypothesis, we also explored the possible changes in the behavior of the firms due to hypothetical mergers.

The scenarios and their deviations from the base scenario were the following:

Perfect competition in all markets:	
BASE	The base case.
REVA	*Markka* strengthens to 4 FIM/USD in 1997.
DEVA	*Markka* maintains the exchange rate 4.8 FIM/USD during 1995 to 2004.
ELEC-1	Electricity price rises 50% in 1997 in Finland.
ELEC-2	Electricity price rises 100% in 1997 in Finland.
RCYC-1	Waste paper price in Rest of Europe rises 100%.
RCYC-2	Waste paper price in Rest of Europe rises 200%.
RCYC-3	Waste paper price in Rest of Europe rises 300%.
RCYC-4	Waste paper price in Rest of Europe rises 425%.
DOMTMBR	Timber imports are kept at their 1989 level.
LOWPULP	Two domestic pulp mill projects are excluded from the model.
LOWDEM	Annual demand growth for paper products drops 50%.
WORST	The scenario that combines the scenarios REVA, ELEC-2, DOMTMBR.
Cournot competition in paper and paperboard markets:	
OLIGO	The base case with the Cournot hypothesis.
UPM+KG	A merger between the United Paper Mills and Kymmene.
EG+KG	A merger between Enso-Gutzeit and Kymmene.
EG+MS	A merger between Enso-Gutzeit and Metsä-Serla.

The domestic pulp industry

In all but one of our scenarios we suggested a considerable pulp capacity increase in Finland by 2004: 0.5 mill. t for bleached softwood sulphate pulp (in addition to the new mill in Rauma) and 1 mill. t for hardwood sulphate pulp. For flexibility, the modelled capacity expansion options included two dormant pulp mill projects: new pulp mills in Kaskinen (POHM) and Kajaani (KAIN). These projects were excluded from the scenario LOWPULP.

In the competitive scenarios other than LOWDEM, DOMTMBR, and WORST, all the suggested capacity projects for bleached softwood sulphate pulp (CWIP) materialized. There was more variation within the capacity projects on bleached hardwood sulphate pulp (NWIP). The investment in a new production line in POHM did not prove feasible in any of the scenarios, and a new pulp line in IHAM (Voikkaa) materialized in all of them except in LOWDEM. In the base case the production of CWIP totalled 3.7 mill. t, and production of NWIP totalled 2.8 mill. t in 2004.

The growth in the pulp industry relied to a large extent on imported timber. Imports for pine pulpwood increased by almost 4 mill. m^3 and imports for hardwood pulpwood increased by 1.5 mill. m^3 from the 1989 level. When we experimented with prohibiting any changes in pulpwood imports from the base year levels (DOMTMBR), the annual CWIP production increased to 3.5 mill. t and NWIP production increased to 2.6 mill. t by 2004. The reduction in pulp production from the base case did not jeopardize the expansion of the domestic paper industry, as it affected only the pulp exports.

When the investments were reduced due to demand-side considerations (OLIGO, REVA), the Kajaani pulp mill was more vulnerable than the projects in southern Finland in EKAR. When we limited the imports of roundwood (DOMTMBR, WORST) the case was reversed. Moreover, in the low demand growth scenario, there were no additions in pulp capacity after the Rauma mill.

There are several reasons why we consider the increase in pulp production suggested by BASE unrealistic or risky. First, regarding the evident options for imperfect competition in paper and paperboard industries as well as the uncertainty concerning developments in recycling that may push the firms to postpone their investment decisions, the markets apparently will not grow to absorb the proposed amount of market pulp. Second, the future potential for roundwood imports is uncertain, as it relies greatly on the developments of the forest sector in Russia and on the potential of the Russian forest industry to utilize the timber resources close to the Finnish border regions. Last but not least, in light of the recent public debate, the pulp mill project in Kajaani, if it ever enters discussions again, would apparently be identified internationally as a threat to the old forests in the Kainuu region and would harm the reputation of the entire forest sector in Finland. Instead, as chemical pulp supply is not sensitive to energy price development, we would regard it as being relatively safe for the Finnish pulp industry to increase its production capacity by a quantity suggested by the scenario OLIGO or DOMTMBR (that is by roughly 0.7 mill. t in addition to Rauma mill). Finnish membership in the European Union is likely to provide Finnish producers some protection against the market risk deriving from the pulp imports from non-European countries.

When the results above are considered it should be remembered that due to cyclical pulp markets we used five-year average pulp prices, which means that the applied price level was lower than base year (or current) level. Higher reference prices for pulp would imply improved profits for market pulp producers, but on the other hand might reduce the market pulp demand in the longer run.

Due to fiber degrading, increased recycling is not necessarily a threat to primary pulp. We did not allow the existing paper machines to switch from primary pulp to secondary pulp due to the relatively short time horizon of the study, although conversion of existing technologies to secondary pulp will take place to some degree. The issue of the right balance between primary and secondary pulp will be subject to further study, as we need to introduce recycling dynamics into the SF-GTM.

Finally, although the pulp markets were assumed to be competitive, alternatives to a competitive hypothesis would be worth exploring.

The domestic paper industry

Finnish firms are important producers of printing and writing paper and currently, they are leading suppliers of four grades: newsprint and uncoated magazine paper (United Paper Mills), and coated magazine paper and uncoated fine paper (Kymmene). Myllykoski is among the top producers of uncoated magazine paper, and Enso- Gutzeit, if it acquired Veitsiluoto, would be an important fine paper producer.

We introduced several printing and writing paper investments to the Finnish producers in the model and did not restrict any firm that had several options to select just one. As seen from Table 9.1, we suggested four new paper machines to UPM: a newsprint (NEWS) machine in ROFE, machines for uncoated (PRWU) and coated (PRWC) magazine paper in Rauma (SATK), and a machine for uncoated fine paper (PRFU) in Joutseno (EKAR). We scheduled two machines for Myllykoski (MK) in ROFE, one for coated and one for uncoated magazine paper. For Enso-Gutzeit (EG) we defined an option to build a new machine for uncoated fine paper in ROFE, and for Kymmene (KG) we proposed a PRWC machine in Voikkaa (IHAM) and a machine for coated fine paper (PRFC) in ROFE. Finally, for both Metsä-Serla (MS) and Veitsiluoto (VL), which was included in Enso-Gutzeit in the Cournot scenarios, we proposed a new machine for coated fine paper grades.

Tables 9.1 and 9.2 display the status of these investment projects in 2004 in the selected competitive and Cournot scenarios. The domestic investments for PRWC and PRFC were sensitive to exchange rate and electricity price developments. The investment for an integrated PRFU machine was only sensitive to low demand growth. The new PRWU paper machine in Finland did not enter in any of the scenarios.

	BASE	REVA	ELEC-1	ELEC-2	RCYC-1	LOWDEM	WORST
NEWS							
UPM ROFE	100	100	100	100	68	0	100
PRWU:							
UPM Rauma	10	0	0	0	0	0	0
MK ROFE	100	100	100	100	100	17	100
PRWC:							
UPM Rauma	100	68	100	17	100	36	0
MS Lohja*	100	100	100	100	100	100	100
KG Voikkaa	100	0	4	0	100	0	0
MK ROFE	85	100	96	100	70	0	100
PRFU:							
UPM Joutseno	100	100	100	100	100	0	100
EG ROFE	100	100	100	100	100	100	100
PRFC							
MS Lohja	100	0	3	2	100	0	0
VL Oulu	100	77	100	100	100	0	0
KG ROFE	100	100	100	100	100	100	100

Table 9.1: Status of the new capacity projects suggested for the Finnish firms in 2004 in selected competitive scenarios (% of the proposed maximum capacity operation). Due to the lack of indivisibilities in the SF-GTM, a low figure, like 4%, should be understood as a rejected proposal. * Forced conversion of a SC machine to PRWC. Abbreviations are explained in the text.

	OLIGO	UPM+KG	EG+MS	EG+KG
NEWS:				
UPM ROFE	0	0	0	0
PRWU:				
UPM Rauma	0	0	0	0
MK ROFE	2	11	2	7
PRWC:				
UPM Rauma	100	0	100	100
MS Lohja*	100	100	100	100
KG Voikkaa	24	0	24	0
MK ROFE	100	100	100	100
PRFU:				
UPM Joutseno	100	0	100	100
EG ROFE	100	100	100	100
PRFC				
MS Lohja	100	100	0	100
EG-VL Oulu	100	100	88	0
KG ROFE	100	100	100	100

Table 9.2: Status of the new capacity projects suggested for the Finnish firms in 2004 in selected scenarios (% of the proposed maximum capacity operation). Due to the lack of indivisibilities in the SF-GTM, a low figure, like 4%, should be understood as a rejected proposal. * Forced conversion of a SC machine to PRWC. Abbreviations are explained in the text.

The focus of the Finnish forest industry on the printing and writing papers became evident when we turned from the perfect competition hypothesis to Cournot oligopoly. In the Cournot game, the leading LWC paper producer, Kymmene, was no longer willing to expand its LWC capacity. In tight SC paper markets Myllykoski again considered installing a new machine, and this time rejected the plan. United Paper Mills now forsook its plans for a second newsprint machine into Stracel mill in ROFE, and although UPM is not an important producer of PRWC and fine paper, its merger with Kymmene resulted in the rejection of the investment projects on these grades, because the merged firm readily obtained additional capacity via the fusion. A merger between Enso-Gutzeit and Metsä-Serla dropped another one of the parallel PRFC investments from consideration, and the same occurred in the merger between Enso-Gutzeit and Kymmene. The fine paper investments in ROFE were based on secondary fiber that was assumed to be so cheap that these investments were totally insensitive to any market condition. With higher waste paper price we would expect the fusion between Enso-Gutzeit and Kymmene to also lead to the rejection of a PRFU machine. However, any gains from the merger due to an increased ability to coordinate investments were diluted by the fact that the competitors exploited the opportunity to increase their market share.

There were not many investment projects mapped out for the other paper and board products, and the production of these qualities did not grow significantly in the model. The most profitable of these products were folding boxboard and tissue paper. In competitive scenarios several other products faced difficulties, often due to new waste paper-based capacity entering the markets in ROFE. With some of these products, e.g., corrugating materials, the noncompetitive markets not only improved profitability, but also increased the output of the high-cost domestic mills.

Wood consumption in Finland

The domestic harvests ranged between 51.1 mill. m^3/a (LOWDEM) and 56.5 mill. m^3/a (DOMTMBR); the imports varied between the 1989 imports of 4.9 mill. m^3/a in DOMTMBR and 10.6 mill. m^3/a in REVA. The total primary wood consumption was 58.2 mill. m^3/a (LOWDEM) at the minimum and 64.8 mill. m^3/a (DEVA) at the maximum. The most scarce timber grades were pine pulpwood and birch pulpwood. Pine pulpwood can in some degree be replaced by spruce pulpwood, which relieves the pressure to increase the imports of pine pulpwood.

Recycling

All the recycled paper-based capacity investments materialized in the base case with low waste paper price (400 FIM/t in ROFE). This hurt the existent capacity, especially in the NEWS, PRWU and linerboard industries. In the base case, the total waste paper consumption in Europe was 34 mill. t in 2004, and only in RCYC-4 it remained below 30 mill. t.

It should be noted that the new capacity that is due to the low price of secondary fiber mostly belongs to the producers with the existing virgin fiber-based capacity. It is not in their interest to bring great amounts of new capacity into the markets thus driving the prices down. The uncertainty over the waste paper prices and the legislationary development are factors likely to delay capacity expansion. This uncertainty can temporarily benefit the industry, if it serves to protect it from the excess capacity.

9.2 Discussion on Further Research

Our experiments with Cournot competition indicate that in all the markets for paper products there are opportunities for noncompetitive behavior. That is, the market outcome under Cournot oligopoly deviates from the one under competitive markets. Still, depending on the product, there were only a few firms, if any, that changed their output decisions for their existing capacity when turning from competitive to Cournot behavior. The high and sunk capacity adjustment costs in the industry provide some explanation for this. Even if the markets were competitive, the firms in their short-run equilibrium may be short of the capacity to produce their long-run competitive output.

The competition hypothesis affected the capacity choices of the significant firms, but again it had little impact on the fringe firms. However, as new machines with a capacity of 300 000 t/a are becoming the rule in the paper industry,[1] it would be questionable to assume that small firms can expand their capacity and consider that their actions have no influence on the market price. For printing and writing papers, for instance, adding such a machine would provide a 4 to 5% increase to the 1989 output levels. Such an increase is typically more than the average annual demand growth for any of these products. Less significant firms may well recognize that an additional machine may bring down the prices, but for them a drop in the price level hurts least, if they can still expect a profitable outcome. On the other hand, a firm with abundant existing capacity may want to be more careful in its capacity decisions, as a decrease

[1] As exceptions CORE, SOFT, SACK and FLUT are still produced in the more modest scale.

in price would spoil the markets for its existing capacity as well. When the firms are facing a downward sloping demand curve, the marginal return on capital is inversely proportional to firm size, if the same technology is available to all the firms at the same costs.[2] These circumstances hold in our analysis, and result in convergence to more homogenous firm sizes with certain products.

A way for a firm to become significant or maintain its market share without harming the markets is to grow via mergers. The pulp and paper industry is evermore concentrated, and the latest major acquisition, SCA over PWA, increasing concentration in tissue paper, corrugated boards and fine paper, was confirmed in February 1995. By the time this is printed, there may already be more mergers. It appears from our results that under the current industrial structure, a major benefit from a merger derives from the potential savings on fixed costs. Mergers also increase concentration, which helps in coordinating investments. But adhering to Cournot competition, the exogenous change in the structure of homogenous product industry may produce loss to the merged firms, while benefiting the rivals.

All this makes us to ponder the question of why the convergence toward homogenous firms has not occurred in pulp and paper industry. A large volume provides economies of scale, but at a certain size one would expect that argument to be less significant. When considering mergers as a contributing factor to heterogenous firm sizes, instead of a remedy for homogeneity, without deeper analysis it appears plausible that difficulties in financing the large investments or risk aversion of the small firms play the most important roles in the explanation. This may be enforced by cyclical markets. Due to capacity constraints the firms may, in times of high demand reduce their production or behave collusively to charge higher prices. Because the capacity is there, however, this does not mean that they cannot expand their output or start a price war during the times of low demand, if any individual firm tries to increase its market share. Fierce competition in times of weak demand can be interpreted as a signal for other firms not to increase capacity or to enter the market. The small firms may find it difficult to raise capital in either case. During period of high demand they face the question of how to survive during a period of weak demand, which might begin just when the new machine is ready to start, and which could destabilize the industry. On the other hand, during weak demand, with excess capacity it may be impossible for a small firm to arrange the required capital at all.

Apparently, there is need for empirical analysis to elucidate how the markets for forest industry products function and what objectives guide the behavior of the firms. We may want to reject perfect competition, because the capacity decisions of the significant firms can be affected by their price impacts. On the other hand, Cournot competition gives results that contradict the reality in some cases, as it fails to rationalize why there are big firms in the first place. We feel that some kind of evolutionary model with a richer set of decision rules would be of interest. The rules might involve some degree of dynamic reasoning for the agents pursuing long-run sustainability. Furthermore, introducing cyclical demand or stochastic demand shocks in lieu of steady demand development would provide us with an option to endogenize the competition pattern by letting the capacity utilization rate trigger the industry to compete either on prices or quantities. It will be interesting to explore if these modifications result in increased concentration in the industry.

[2]Note that in a deterministic setting, the potential differences in the firms' attitudes toward risk have no role.

We believe that the SF-GTM model will also prove useful in future policy analysis, although some of the data may need to be revised. Which data would require deliberation, depends on the objectives of the user, as a lot can be done via sensitivity analysis alone. There is a variety of tasks for which the model can be used in its current form, and it is relatively easy to modify it to allow for more uses. This study provides some insight to the behavior of the model.

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