

Projecting Pulpwood Prices under Different Assumptions on Future Capacities in the Pulp and Paper Industry

Torjus F. Bolkesjø

Bolkesjø, T.F. 2005. Projecting pulpwood prices under different assumptions on future capacities in the pulp and paper industry. *Silva Fennica* 39(1): 103–116.

Capacity changes in the pulp and paper industry affect demand for pulpwood and thus pulpwood prices. This paper analyzes the impacts on roundwood prices in Norway of two possible capacity changes (one new machine and one close-down) that currently are high on the agenda in the Norwegian paper industry, and assesses the generality of the results obtained from these case studies. The two cases are implemented exogenously into a regionalized partial equilibrium forest sector model, and the capacity change scenarios are compared with a business as usual scenario assuming no demand shocks. The projected pulpwood prices change significantly in regions near mills where capacity shifts, at least for the close-down case, but only moderately at an aggregated national level. The reduction in prices under the close-down studied is higher than the price increase from the possible capacity increase case. The asymmetric price responses projected for the two case studies are supported by sensitivity analyses on other regions and cases (technologies). For the capacity increase case it is shown that the level of the projected pulpwood price is sensitive to assumptions on base-year prices and transport costs of imported roundwood, but the magnitudes of the price increases projected as a result of increased demand are less affected by these assumptions.

Keywords paper industry, capacity, partial equilibrium model, pulpwood, prices, Norway

Author's address Norwegian University of Life Sciences, Dept. of Ecology and Natural Resource Management, Høyskoleveien 14, NO-1432 Ås, Norway

E-mail torjus.bolkesjo@umb.no

Received 30 January 2004 **Revised** 9 August 2004 **Accepted** 26 January 2005

1 Introduction

In Scandinavia about 50 percent of the roundwood is sold as pulpwood, a raw material in paper and paperboard production. Pulpwood price prospects and the impacts of possible major shocks affecting the pulpwood market represent valuable information for policy makers, forest owners and forest industries.

Long-run price and quantity projections have a relatively long history in the forest economics literature. Most studies are based on complex models of demand, supply and trade relations over various geographical areas. Zhu et al. (1999), Solberg et al. (2003) and Trømborg et al. (2000) are recent long-run forest sector market projections where the timber markets are explicitly addressed, all at a global level. A common experience from many of these studies seems to be that capacity changes form a key factor which affects the projections significantly. An increasing share of the forest industrial capacity falls under large, global companies, and as shown in several econometric studies, a large number of determinants, and complex structures characterize the investment behavior in the pulp and paper industry (see e.g. Lundmark 2001, Lundmark and Nilsson 2001, Bergman and Johansson 2002, Lundmark 2003). As such, identifying possible capacity changes represent a major challenge methodologically within forest sector modeling.

In Norway, two potential changes in the production capacity of the forest industry are high on the agenda; one new machine in an existing mill and one close-down. These possible changes are regarded as being among the most critical factors with respect to the Norwegian pulpwood price development in the coming years. High transport costs characterize the roundwood markets, implying significant regional variations with respect to roundwood prices. Regarding capacity changes, the impacts on roundwood prices will vary dependent on the distance to the actual mill and the magnitude of alternative demand for the fiber regionally. The regional aspects require a relatively detailed model with respect to the number of regions when assessing the impacts of forest industrial capacity changes. Besides being of interest due to its relevance, findings obtained from specific case studies may also give

insight that can be generalized to other demand shock cases.

The objectives of this study are to examine how the two possible demand shocks described above are likely to affect pulpwood prices and to assess the generality of the results to other regions and capacity change cases. A regionalized forest sector equilibrium model is applied for the analysis. The specific capacity change plans were exogenously implemented into the model since the modeling framework fails to identify these changes when modeling capacity changes endogenously. In order to isolate the effects of the capacity changes, the demand shock scenarios are compared with the model outcome from a “business as usual” scenario. To assess the generality of the results obtained, the issue of asymmetric price responses to positive versus negative shocks of pulpwood demand is given particular attention by analyzing impacts of symmetric increases and decreases in production capacities of various Norwegian paper mills. The model applied – which provides a relatively detailed description of the Norwegian forestry and forest industry – is presented in the next section along with the main input data sources and the assumptions of the capacity change scenarios. The results are presented and discussed in section three, while the last section provides the main findings and conclusions.

1.1 Background – Historical Market Development and Current Situation

In Norway, pulpwood prices have had a decreasing trend for the last three decades. Harvest levels, however, have been more or less unaffected (Fig. 1), indicating that positive shifts in the Norwegian timber supply have taken place in this period¹⁾. Increased standing timber stock as a result of higher annual forest growth than harvest is most likely the main driver behind the shifting supply.

On the demand side, the Norwegian pulp and paper industry annually produces just above 2 million metric tons of paper, in addition to about 0.7 million metric tons of market pulp. Almost 40 percent of the paper produced is newsprint, and uncoated printing and writing paper takes

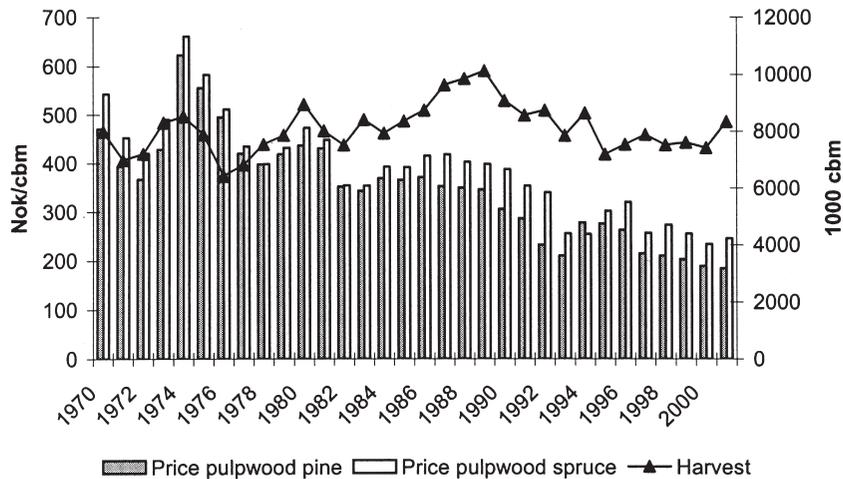


Fig. 1. Pulpwood prices (NOK/m³) and harvest in Norway 1970–2002 (fixed 2000 NOK).

an equal share. Norwegian paper mills are typically integrated pulp and paper mills using spruce pulpwood as the main raw material. The total virgin fiber consumption has been quite stable over the last decades, but to some extent centered to fewer and larger mills, and the paper industry has to some extent substituted imported fiber for domestic. There is, however, scarcity of examples from recent history that can be utilized to assess the impacts from the possible changes of capacity described above.

2 Methodology and Data

2.1 Model

A regionalized partial equilibrium forest sector model is used for the analysis. The model, called NTM II (Norwegian Trade Model II) is an improved version of NTM, which was developed by Trømborg and Solberg (1995). These models have the same basic structure as GTM (the Global Trade Model), developed at IIASA and outlined by Kallio et al. (1987), and further developed and applied on the Finnish forest sector by Kallio and Ronnilla (1992) and Ronnilla (1995). The European model, described by Kallio et al. (2004), and applied by Solberg et al. (2003), forms the

most recent model development in Europe. A mathematical description of NTM II is provided by Bolkesjø (2004).

Fig. 2 shows the components included in NTM II. The model solve one single mathematical optimization problem, but for understanding the model structure it is convenient to divide the overall model into four components:

- 1) The supply of roundwood is based on econometric models where harvest is a non-linearly increasing function of the roundwood price. The actual (observed) price and quantity supplied for a given base-year determine the level of the supply curve for the first year to be modeled, and the supply function shifts periodically according to changes in standing timber stock.
- 2) The forest products supply is modeled by activity analysis using input-output coefficients for the different input categories; six types of roundwood, three types of chips, two types of pulp, sawdust, recycled paper, labor, energy, capital and other variable costs.
- 3) Econometric models describe the demand for forest products in a similar manner as for the roundwood supply. The demand is a decreasing function of the product price where the slope is based on econometrically estimated elasticities. The demand shifts periodically according to exogenously given changes in GDP (Gross Domestic Product) and product specific GDP elas-

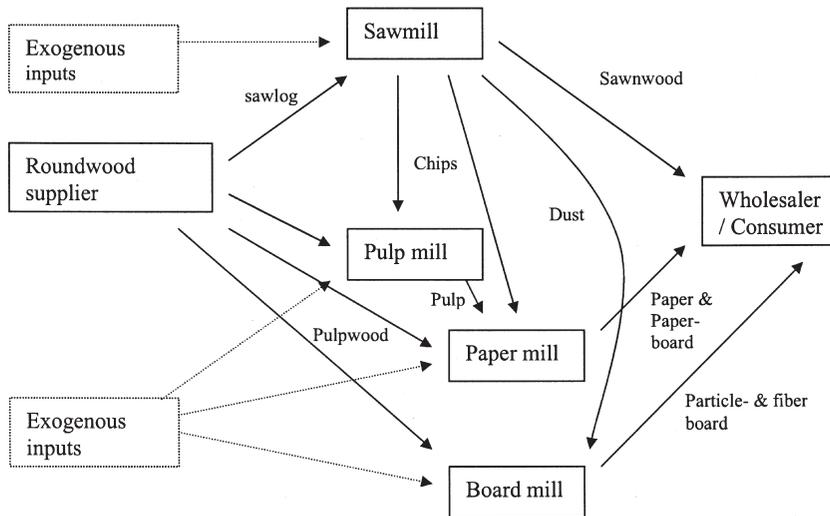


Fig. 2. Components and basic structure in NTM II.

ticities which, like the price elasticity estimates, are taken from econometric studies of forest products demand. The demand function is made linear in the updated base-quantities.

- 4) The last component models trade of all timber assortments and end-products between all regions. Commodities can be transported by truck, train or ship (when possible). Trade occurs when the price difference between two regions exceeds the transport costs.

NTM II consists of 19 domestic regions. In general, each county (Fig. 3) represents one region in the model, but there are some exceptions. Oslo and Akershus are merged, and Finnmark, which has very limited forestry and forest industrial activity, is excluded. Hedmark and Oppland are divided in two regions; north and south. In addition, Sweden forms one region and there are two regions for respectively export and import to/from countries other than Sweden. Sawlog and pulpwood for Norway spruce, Scots pine and an aggregate of non-coniferous species define the six roundwood assortments. The commodities produced in the Norwegian forest industry are aggregated to 13 intermediate and final products; 3 sawnwood categories, 3 pulp grades and 5 paper grades, particle board and fiberboard.

The objective function of the model maximizes



Fig. 3. Norwegian counties (with a few exceptions representing the regions of NTM II).

the net economic surplus of the whole sector (the sum of consumers' surplus plus producers' surplus minus the transport costs), under given production possibility constraints. As shown by

Table 1. Main characteristics of the Norwegian pulp and paper industry, and assumed forest products demand elasticities.

Product	Number of mills ^{a)}	Total capacity (1000 tons/year)	Capacity utilization in 2000 (%) ^{b)}	Price in base-year (NOK/ton) ^{c)}	Price elasticity	GDP elasticity
Newsprint	3	895	≈ 100	4550	-0.5	0.5
Uncoated writing paper	5	900	95	5211	-0.9	0.5
Coated writing paper	2	110	≈ 100	5892	-0.9	0.5
Linerboard	2	352	≈ 100	4842	-0.3	0.8
Other paper ^{d)}	7	286	85	6976	-0.3	0.8
Mechanical ^{e)} pulp	3	210	90			
Chemical pulp	3	393	≈ 100			

a) Some mills are producing more than one paper grade.

b) The annual production is usually slightly lower than the technical capacity due to maintenance stops etc. Therefore capacity utilization is set to ≈ 100. For uncoated writing paper, one relatively small mill utilized only 60% of the capacity in 2000.

c) Delivered to wholesaler/printing works. In 2000 1US\$ ≈ 8.8 NOK.

d) "Other paper" includes greaseproof, tissue, fluting and a minor part of other paperboard products.

e) Prices, price- and GDP elasticities are not included for the pulp grades as these products are regarded as intermediate products in the model having no final demand.

Samuelson (1952), the optimal solution gives the market equilibrium conditions obtained under perfectly competitive markets. As such, the equilibrium price, production, consumption, intermediate use, and trade are calculated for all products, regions and periods²⁾. New capacity in the forest industry can be determined endogenously by the model: Whenever the total investment and production costs of new plants are lower than the endogenously determined market price, new investments will take place, with a new technology (i.e. production inputs) specified for each product. Or alternatively, new capacity can be included exogenously, as was the case for the present study. The model solves the optimization problem for each year to 2010, starting at the base-year 2000.³⁾

2.2 Data

NTM II demands comprehensive data from the entire forest sector. All data are not reported within this article, but the main characteristics of the pulp and paper sector are reported in Table 1. For interested readers, all data are available in Bolkesjø (2004). The cost structure (input-output coefficients and prices) and capacity in the pulp and paper industry were collected directly from each mill while data for the sawmilling industry

were obtained from The Norwegian Sawmilling Industries Association (2001). The price and GDP elasticities were based on recent econometric forest products demand studies (e.g. Chas-Amil and Buongiorno 2000, Simangunsong and Buongiorno 2001).

All exogenous input prices were assumed constant in real terms over the forecasting horizon. Official statistics were used with respect to forest products prices and imported and exported quantities for the base year (Statistics Norway 2001a). The GDP growth, driving the demand for forest products was assumed to be 1.5% per year in all regions. It was assumed that the forest industry has an annual general capacity growth of 0.5%, in addition to the capacity changes described below.

For the roundwood supply, data for the base-year quantities and prices were obtained from Statistics Norway (2001b), while data for standing stock and timber growth were obtained from Tomter (2000). The price elasticity estimates were based on Rørstad and Solberg (1992), Bolkesjø and Baardsen (2002) and Bolkesjø and Solberg (2003). There are not much empirical evidence available on volume elasticities of timber supply, at least not in Norway. Bolkesjø and Baardsen (2002), however, estimated it to 0.7 for self-employed forest owners. Based on comparisons of timber supply from self-employed forest owners

Table 2. Main characteristics of supply of spruce pulpwood of domestic regions

	Base-year harvest level (1000 m ³)	Base-year roundwood price (NOK/m ³)	Stumpage price elasticities
Østfold	154	283	0.6
Oslo/Akershus	218	271	0.6
Hedmark-sør	452	243	0.6
Hedmark-nord	177	233	0.6
Oppland-sør	397	272	0.6
Oppland-nord	50	242	0.6
Buskerud	310	278	0.6
Vestfold	119	272	0.6
Telemark	286	288	0.6
Aust-Agder	95	299	0.6
Vest-Agder	37	312	0.6
Rogaland	12	292	0.4
Hordaland	21	271	0.4
Sogn og F.	21	270	0.4
Møre og R.	15	280	0.4
Sør-Trøndelag	120	299	0.5
Nord-Trøndelag	221	286	0.5
Nordland	65	284	0.4
Troms	0	310	0.4

and other forest owners (e.g. Rørstad and Solberg 1992), the estimate of the volume elasticity of the aggregate Norwegian roundwood supply was set to 0.5. Base-year prices and quantities and the assumed price elasticities of spruce pulpwood supply are shown in Table 2.

Timber import possibilities play an important role when modeling price impacts of timber demand shocks. In NTM II, the “rest of the world” region is based on the consumption of forest products in the European Union (EU). Production in the “rest of the world” (ROW) was estimated to balance consumption in the model, and harvest was estimated to balance the use of raw materials in the forest industry in order to close the model.

Timber import to Norway takes place when the endogenously determined price for imported timber, including transport costs to the specific Norwegian region, is less than the price for domestic wood (including transport costs domestically). In a perfect market, which is assumed in the model, the timber price delivered at the mill is equal for deliveries from all regions. For spruce

pulpwood, the elasticity of supply for imported wood was assumed to be 0.8 (in line with Kallio et al. (1987) and Ronnila 1995).

2.3 Assumptions Regarding Capacity Changes

A base scenario (“base”), following the assumptions described above, forms a benchmark for comparison with the capacity change scenarios. The capacity change scenarios described below have been high on the agenda in the Norwegian forest sector lately. In these scenarios, called “close-down”, “new machine” and “both”, it was assumed that the following changes of capacity will take place:

Close-down: In this scenario the oldest newsprint mill in Norway, Norske Skog Union, situated in Telemark county, is assumed to close down in 2005. All other assumptions are in line with “base”.

New machine: In this scenario, we assume that Norske Skog will carry through their plans of building a new newsprint machine at their mill at Skogn in Nord Trøndelag county. The new machine will have an annual capacity of approximately 450 000 tons⁴). The assumed input-output coefficients for this machine were collected from Norske Skog. All other assumptions coincide with “base”.

Both: “Close-down” and “new machine” simultaneously.

When producing at full production capacities, Norske Skog Union uses approximately 570 000 m³ of spruce pulpwood, while Norske Skog Skogn uses about 960 000 m³ spruce pulpwood (these figures include chips from wood processing industries).

3 Results and Discussion

Simple time-series models quite often outperform more complex models containing policy relevant causal information in short-run forecasting accuracy (see e.g. Allen and Fildes 2001). If deterministic exogenous shifts in the market occur, however, more sophisticated models including more of the demand/supply relations and general

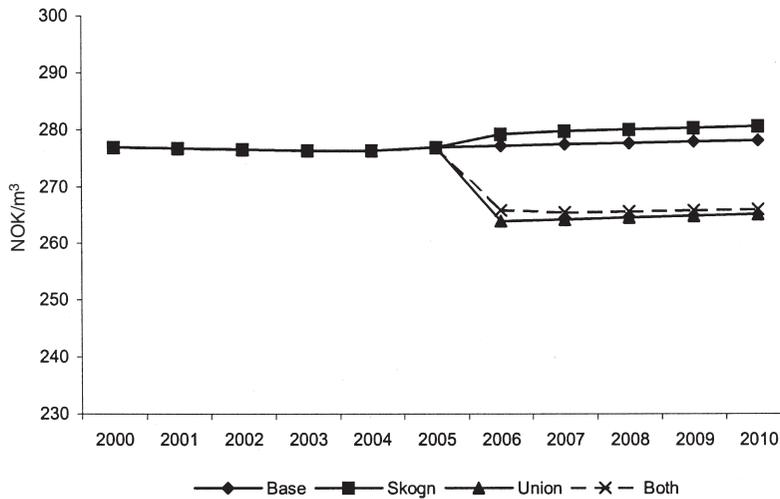


Fig. 4. Projected average spruce pulpwood prices (NOK/m³) in Norway, under different capacity scenarios.

market framework are required. When comparing the prices presented in this section with the historical ones shown in Fig. 1, one should note that the equilibrium prices computed by NTM II are prices delivered at the mill site (transport costs are included), while those in Fig. 1 are delivered at roadside (transport costs are excluded).

3.1 Projected Pulpwood Prices at an Aggregate National Level

The price projection for the base scenario shown in Fig. 4 does not pursue the historical price pattern which both show some tendencies of cycles as well as a clear decreasing trend (c.f. Fig. 1).

Pulpwood price cycles are mainly due to cycles in the forest products demand, which in turn, correlates highly with the general economic growth. In the present study, a fixed annual economic growth rate was assumed, implying that no attempt was done to forecast possible business cycles. An important factor regarding the decreasing price trend historically is that imported fiber (mainly from Russia and the Baltic countries) to an increasing extent has substituted for domestic wood. After the substantial drop from 1993 to 1994, however, there is hardly any trend visible for spruce pulpwood prices for the period 1994

to 2002. The “base” model projection exhibits no clear trend for the average spruce pulpwood price to 2010, and the share of imported wood used in the Norwegian pulp and paper industry is projected to remain approximately at the same level as it has been the most recent years. On the one hand, the assumed annual capacity growth and the economic growth drive pulpwood demand and would, *ceteris paribus*, imply a rising pulpwood price trend. On the other hand, accumulation of standing timber stock domestically shifts supply outwards, and increased timber import will suppress the impact on domestic prices of increasing domestic timber demand. With the assumptions made for the base scenario, the shifts in demand and supply are of the same relative magnitude, and prices are projected to remain more or less unchanged to 2010.

The reduction in prices under the close-down considered exceeds the price increase from the possible capacity increase examined. According to the model, a large share of the increased timber demand from the new machine will be met by imported roundwood, while Norwegian pulpwood export currently has a limited potential due to a generally high price levels in Norway, at least for spruce. The generality of this asymmetry is further assessed in section 3.3 “Asymmetric price responses”.

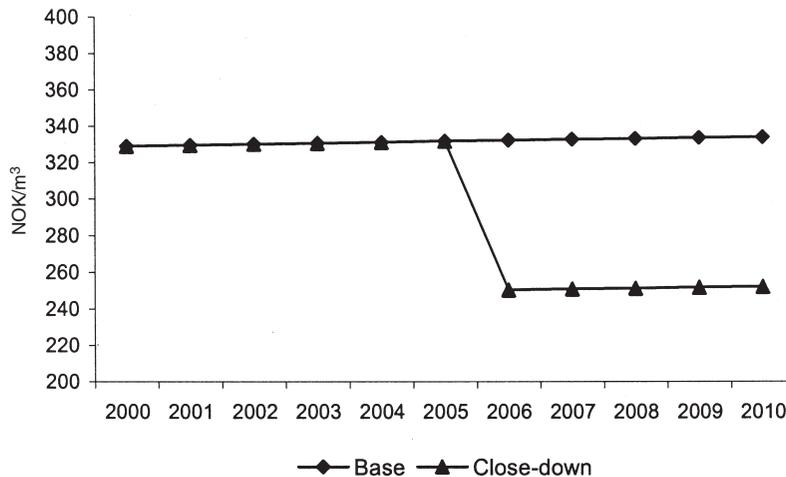


Fig. 5. Projected spruce pulpwood prices (NOK/m³) in Telemark, for the “Base” and “Close-down” scenarios.

3.2 Regional Aspects

In empirical forest sector modeling there is always a trade off between details with respect to size of regions on the one hand and generality and link to broader regions on the other hand. Comparing Fig. 4 with Fig. 5 (the latter show spruce pulpwood prices in Telemark, where Norske Skog Union is situated) for the “base” and the “close-down” scenario illustrates that regional aspects may be neglected when assessing regional shifts in supply or demand at a national or international level. The equilibrium price projection in the local region reduces by approximately 25 percent if the mill stops producing, while the average equilibrium price projection nationwide reduces by less than 5 percent.

The price reduction projected for various counties around Norske Skog Union, given close-down, is shown in Table 3. The most dramatic change will according to the model solution take place in Telemark where the mill is situated. The magnitude of the price decrease depends in general on the transport distance (i.e. transport cost) to the specific mill and the cost of transport to alternative buyers, in addition to the price sensitivities in supply and demand of pulpwood. This point is illustrated by comparing the price projections for the counties Buskerud and Aust-Agder. Both

Buskerud (situated north-east of Telemark) and Aust-Agder (situated south-west of Telemark) share borders with Telemark (Fig. 3). The pulpwood price in Buskerud is unaffected of the close-down since two large mills within the county imply that spruce pulpwood is not exported from Buskerud. In Aust-Agder, however, prices reduce substantially since there exists limited alternative demand for pulpwood.

When assessing the price changes shown in Table 3, one should keep in mind that the model assumes one price for all owners within a county. Thus, the price levels for the various regions represent the price received for a timber delivery in the middle of the region. In a perfect market, forest owners near industry would receive higher

Table 3. Changes of spruce pulpwood prices in regions around Norske Skog Union in the “Close-down” scenario.

Region	Price change from 2005 to 2006 (%)
Telemark	-24.5
Aust-Agder	-13.9
Vestfold	-10.3
Vest-Agder	-5.1
Buskerud	≈ 0

prices, while owners in industry-remote areas would receive lower prices than these average prices. Currently, however, regional forest owner associations do to some extent subsidize deliveries having long transport distances to the industry. These subsidies may level out the effect described above intra-regionally, but may also imply differences between the optimal transport quantities calculated by the model and the actual ones inter-regionally. Despite these uncertainties, it seems clear that relatively detailed models with respect to regions are necessary to analyze the impacts of demand shocks of the magnitude described above at a sufficiently detailed level.

3.3 Asymmetric Price Responses

One interesting finding from the case studies presented above is the asymmetric response of prices to decreasing versus increasing capacities. One intuitive explanation to the asymmetric price response is differences in price sensitivities and benchmark points of the timber supply. As seen from Table 2, however, the numbers for the two specific regions do in this case not differ very much.

To test the robustness of this finding an experiment imposing equal (symmetric) increases and decreases in forest industry capacity in various

Table 4. Price change (%) from base scenario assuming closures and doubled production capacities in various regions.

Region	Capacity of corner-stone mill (10 ³ ton)	Price response to closure of corner-stone mill	Price response to doubling of capacity
Østfold	550	-4.5%	+0.5%
Buskerud	384	-4.1%	+1.8%
Telemark	240	-24.4%	+1.5%
Nord-Trøndelag	532	-23.5%	+0.5%

regions having mills producing newsprint/and or printing and writing paper was conducted. In all cases, the new technologies (input-output coefficients) were assumed equal to the existing ones. The results of this experiment confirm the findings of asymmetric price responses reported in the case studies (Table 4).

This effect is intuitively surprising, but would often apply to demand shocks in importing regions in perfectly functioning spatial markets. The mechanism of asymmetric price responses can be illustrated by considering Fig. 6. In this illustration, the market is simplified to consist of two markets – a local one and the rest of the world. The local market has limited wood resources but supply some quantity at relatively low prices due

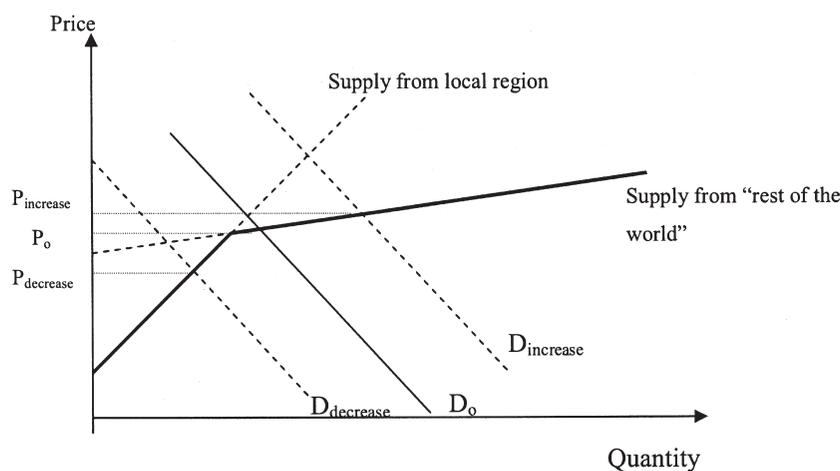


Fig. 6. Price response to positive and negative demand shock in a spatial market with a limited local market and import from “rest of the world”. D = timber demand.

to low transport costs. The “rest of the world” region have vast timber resources, but due to higher transport costs, the prices delivered in the “local” region must reach a certain level before timber is imported from “rest of the world”.

Typically, supply from the international market is more price responsive in terms of absolute quantities than supply from the local market (or in other words timber supply from the international market is regarded as more elastic than the local timber supply). As seen from Fig. 6, this market structure may lead to asymmetric timber price responses.

The projected price decrease from closures differs between regions (Table 4) – the price reductions are substantially higher for two of the regions (Telemark and Nord-Trøndelag) than for the other two. Typically, the price reduction is expected (modeled) to be higher in regions having limited alternative demand (Telemark and Nord-Trøndelag). Although generalization of the findings in this study should be done with care, the quantitative results may well apply to similar cases in regions with similar supply and demand structure. Furthermore, the sensitivity analyses on the transport costs and import price elasticity (see section 3.4) provide insight that can be utilized in areas with other conditions for imported wood than those defined in the base scenario.

3.4 Sensitivity Analyses

Outcomes from model analyses are burdened with uncertainty. With respect to the problem analyzed here the price/transport cost of imported wood and the import price elasticity were regarded as two of the most important parameters. The impacts of these parameters on the model outcome were therefore further assessed. Fig. 7 shows spruce pulpwood prices in Nord-Trøndelag (where Norske Skog Skogn is situated) for the “new machine” scenario, assuming three different levels of transport costs for imported wood. The “new machine” projection is based on the assumptions described above. In “medium transport cost” and “high transport cost”, the transport costs for imported roundwood were increased by 30 NOK/m³ and 60 NOK/m³, respectively, compared to “new machine”.

The equilibrium prices increase by approximately 10 percent when the transport cost increase by 30 NOK/m³ (“medium transport cost”), compared to the originally assumed cost. Like for the “new machine” scenario, increased capacity has limited impact on pulpwood prices in the “medium transport cost” alternative. For the “high transport cost” alternative, however, the price shifts significantly when the new machine is assumed running. The model projects no fiber

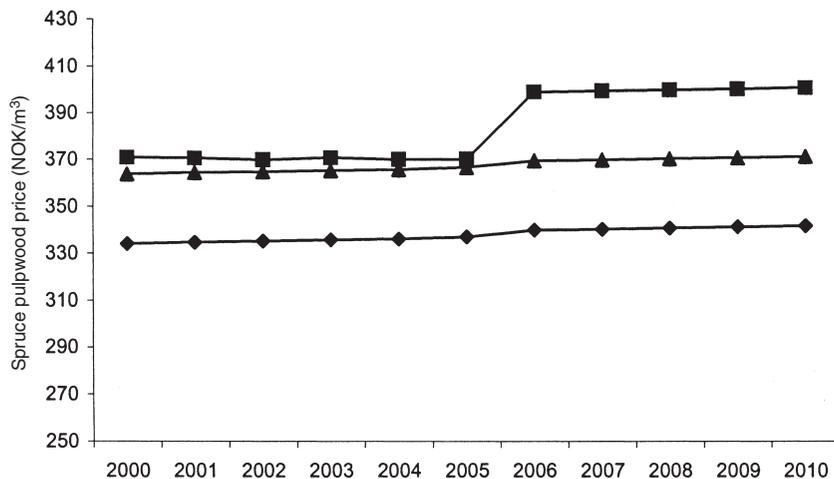


Fig. 7. Projected spruce pulpwood prices (NOK/m³) in Nord Trøndelag assuming new investment, under different assumptions on prices for imported wood.

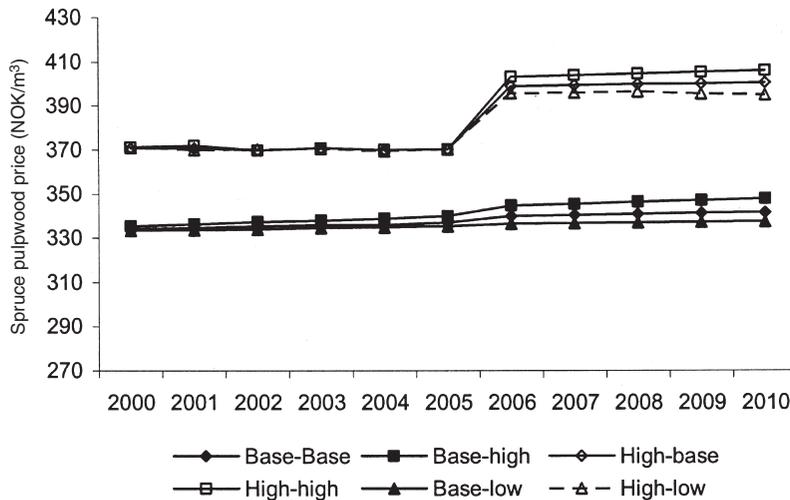


Fig. 8. Projected spruce pulpwood prices in (NOK/m³) with varying import price elasticity and transport cost for imported wood.

import in the “high transport cost” alternative, implying that the demand in Nord-Trøndelag (and counties around Nord-Trøndelag) increases dramatically. The “high cost” alternative does not seem to reflect the real world very well since a relatively large share of the wood fiber used at Skogn actually is imported. Among the three alternatives in Fig. 7, the “new machine” alternative has best fit with observed pulpwood prices and import quantities.

There is a lack of empirical research on import price elasticities, at least in Norway. In this study, the import price elasticity was set to 0.8, but we did also run the “new machine” scenario when increasing it to 1.3, and decreasing it to 0.5 (Fig. 8).

In Fig. 8, “base-base” is the base scenario (the original) transport cost and the base scenario (or the original) import price elasticity (0.8). The scenario “high-high” represents high transport costs, as defined for “high transport cost” in Fig. 7, and the import price elasticity is increased to 1.3, while in “high-low” it is assumed high transport costs and an import price elasticity of 0.5. The remaining alternatives are named accordingly. The overall conclusion from Fig. 8 is that the import price elasticity parameter, when varied within realistic intervals, does not affect the results much. One assumption that may

affect the projections more, however, is the one regarding other capacity changes in the forest industries. As described above, we assumed a general annual capacity improvement of 0.5 percent, while no new capacity investments (except the mill in Skogn which is included only in the “new machine” scenario) were allowed for. This constraint should in particular be stressed for the “close-down” scenario, since reduced pulpwood prices make the area more attractive for new investments, not least in bioenergy. The exogenously determined GDP growth, income and price elasticities for final product demand, and technologies and price levels abroad are other important parameters with respect to the model outcome.

3.5 Methodological Issues

The two capacity changes analyzed in this paper are high on the agenda within the Norwegian forest sector, and as such there is obviously some probability that they will actually take place. None of the events are, however, recognized by the model when modeling investments endogenously – i.e. assuming that investments takes place when product prices cover the per unit variable costs and capital costs. In many cases,

exogenous factors that cannot be recognized by quite simple investments models, determine investment strategies. In the current examples, the alternative value of the mill site (Union) and the economic framework for building a gas power plant (Skogn) are factors that heavily affect the decision. In general, modeling capacity changes seems to be burdened with substantial uncertainty, implying that describing investment strategies represent a major challenge in forest sector modeling. Expert knowledge has recently been incorporated in addition to historical data when projecting future newsprint consumption (Hetemäki and Obersteiner 2001 and Bolkesjø et al. 2003) and timber prices (Leskinen and Kangas 2001). At least for regional analyses like the one presented in this study, existing knowledge on investment or close-down plans forms a useful alternative, or maybe a valuable supplement to the common approach. Ronnila (1995) forms an early example of forest sector modeling work utilizing existing knowledge on investments plans. Also, empirical studies like Lundmark (2001), Lundmark and Nilsson (2001), Bergman and Johansson (2002) and Lundmark (2003) provide improved insight on investment behavior in the forest industries that potentially could form a contribution in improving the capacity change forecast accuracy of forest sector models. An alternative approach when assessing impacts on pulpwood prices of capacity changes would be to conduct econometric studies to test for shifts in prices caused by capacity changes that have taken place historically (*ex post*). Such an approach would be useful for assessing the accuracy of the results of an *ex ante* type of analysis like the one presented here.

The roundwood supply sub-model in NTM II does not include roundwood price expectations. In real life, suppliers would be informed in advance when capacity (and thus demand) shifts, and rational forest owners will adapt the current supply to the expected changes in demand. Therefore, the actual price patterns would probably be smoother around the price shift than the projections shown in figs. 4, 5, 7 and 8. Although the adoption to a new equilibrium might take more than one year, the magnitude of the total price change is consistently handled by the model. Another methodological issue that should be mentioned

regarding the roundwood supply is that there is no direct connection (for example cross-price elasticities) between sawlogs supply and pulpwood supply in the model⁵). It is commonly argued that sawlog prices affect pulpwood supply and vice versa. The most recent empirical examples from Sweden (Nilsson 2002) and Norway (Baardsen 1998), however, report insignificant cross-price elasticities in the supply of spruce pulpwood. In Finland, Toppinen (1997) concludes that sawlog stumpage prices significantly Granger-caused pulpwood prices in the period 1960–1994, but the effect did diminish towards present time. No evidence of Granger-causality is available in the Norwegian market.

4 Conclusion

The capacity changes assessed in this study have quite moderate impacts on pulpwood prices at a national level, but they are likely to have substantial impact at a regional level. The significant difference between a regional and a national point of view illustrates the importance of the aggregation level of data and/or model when assessing implications of changes in spatial markets.

The capacity increase analysed in the present study has less impact on pulpwood prices than the close-down considered, since increased fiber consumption mainly will be imported, while export of wood from Norway seems unlikely due to generally high roundwood price levels domestically. Sensitivity analyses confirm that asymmetric pulpwood price responses often will apply in regions that are importing wood from places having lower stumpage prices delivered at roadside. The effect is stronger in regions having limited alternative demand within reasonable distances.

The rather minor price change projected for the investment case indicates that decision making in forestry can be done without paying too much attention to the possible investment. The quite substantial price drop projected for the close-down case, however, implies that the probability of this possible shock is an important aspect for forest owners' short and medium term harvesting strategy as well as for policy makers and possible

forest industrial investors within the region.

Assumptions regarding the transport cost for imported wood affect the model outcome substantially in terms of levels, but the relative differences between the different scenarios does not vary much, at least not within realistic magnitudes of the transport cost data.

Acknowledgments

The Norwegian Research Council supported this article through the project “Changes in the forest sector markets and the forest policy framework: Effects on the Norwegian forest sector” (NFR-127248/111). The author wishes to thank Professor Birger Solberg, Dr. Alexander Moiseyev and Dr. Maarit Kallio for valuable discussions and contributions on the modelling approach, and Jon Bingen Sande and Anders Qvale Nyrud for useful comments on an earlier draft. Useful comments from the two anonymous reviewers were also highly appreciated. The usual disclaimer applies.

Notes

- 1) Also, sawlog prices have decreased, but not that much, relatively, compared to pulpwood prices.
- 2) Prices of labor, energy, capital, saw dust, recycled paper and other variable costs are exogenously given.
- 3) The structure of NTM II is described more in detail in Bolkesjø (2004).
- 4) Other strategies regarding Norske Skog Skogn have also been discussed, for example to close down the oldest existing machine when building a new one, or just to upgrade the existing machines. Neither of these possibilities were further analysed in this study.
- 5) There is, however, a constraint which controls the sawlogs/pulpwood ratio.

References

- Allen, P.G. & Fildes, R. 2001. Econometric forecasting. In: Armstrong, J.S. (ed.). Principles of forecasting: a handbook for researchers and practitioners. Kluwer Academic Publishers, Norwell, USA.
- Baardsen, S. 1998. Econometric analyses of roundwood markets and sawmilling in Norway. Ph.D. Thesis 1998:29. Agricultural University of Norway. 224 p.
- Bergman, M.A. & Johansson, P. 2002. Large investments in the pulp and paper industry: a count data regression analysis. *Journal of Forest Economics* 8: 29–52.
- Bolkesjø, T.F. 2004. Modeling supply, demand and trade in the Norwegian forest sector. Ph.D. Thesis 2004:10. Agricultural University of Norway.
- & Baardsen, S. 2002. Roundwood supply in Norway: micro-level analysis of self-employed forest owners. *Forest Policy and Economics* 4(1): 55–64.
- & Solberg, B. 2003. A panel data analysis of non-industrial private roundwood supply with emphasis on the price elasticity. *Forest Science* 49(4): 530–538.
- , Obersteiner, M. & Solberg, B. 2003. Information technology and the newsprint demand in Western Europe: a Bayesian approach. *Canadian Journal of Forest Research* 33(9): 1644–1652.
- Chas-Amil, M. & Buongiorno, J. 2000. The demand for paper and paperboard: econometric models for the European Union. *Applied Economics* 32: 987–999.
- Hetemäki, L. & Obersteiner, M. 2001. US Newsprint demand forecasts to 2020. Interim Report IR-01-070. International Institute for Applied Systems Analysis. Laxenburg, Austria. 48 p.
- Kallio, A.M.I., Moiseyev, A. & Solberg, B. 2004. The global forest sector model EFI-GTM – the model structure. European Forest Institute, Technical Report 15.
- Kallio, M. & Ronnila, M. 1992. Competitive versus non-competitive market hypothesis. In: Forest sector, trade and environmental impact models: theory and application. Proceedings from an international symposium, April 30–May 1. CINTRA-FOR, Seattle. p. 212–218.
- , Dykstra, D.P. & Binkley, C.S. 1987. The global forest sector: an analytical perspective. John Wiley & Sons, New York, USA. 703 p.

- Leskinen, P. & Kangas, J. 2001. Modeling future timber price development by using expert judgments and time series analysis. *Silva Fennica* 35(1): 93–102.
- Lundmark, R. 2001. Choice of location for investments in the European paper industry. *Resources, Conservation and Recycling* 33(3): 167–180.
- 2003. Investment behaviour in the European pulp and paper industry. *Scandinavian Journal of Forest Research* 18: 184–192.
- & Nilsson, M. 2001. Increasing rates of paper recycling and the location behaviour of newsprint producing facilities in Europe. *Journal of Forest Economics* 7: 245–262.
- Nilsson, M. 2002. An inquiry into the changing pattern of pulpwood harvest in Sweden. *Forestry* 75(3): 245–255.
- Ronnala, M. 1995. Medium-term scenarios for the Finnish pulp and paper industry. Working paper WP-95-38. International Institute for Applied Systems Analysis. Laxenburg, Austria. 100 p.
- Rørstad, P. K. & Solberg, B. 1992. A tobit analysis of the non-industrial private timber supply behaviour in Norway. *Scandinavian Forest Economics* 33: 352–371.
- Samuelson, P. A. 1952. Spatial price equilibrium and linear programming. *American Economic Review* 42: 283–303.
- Simangunsong, B. C. H. & Buongiorno, J. 2001. International demand equations for forest products: a comparison of methods. *Scandinavian Journal of Forest Research* 16: 155–172.
- Solberg, B., Moiseyev, A. & Kallio, A.M.I. 2003. Economic impacts of accelerating forest growth in Europe. *Forest Policy and Economics* 5(2): 157–171.
- Statistics Norway. 2001a. External trade 2000. Statistics Norway. Oslo, Norway. 150 p.
- 2001b. Forestry statistics 2000. Statistics Norway. Oslo, Norway. 71 p.
- The Norwegian Sawmilling Industries Association. 2001. Nøkkeltallsanalysen 2000. The Norwegian Sawmilling Industries Association. Oslo, Norway. [In Norwegian].
- Tomter, S. 2000. Skog 2000. Norwegian Institute of Land Inventory. Ås. 84 p. [In Norwegian].
- Toppinen, A. 1997. Testing for Granger-causality in the Finnish roundwood market. *Silva Fennica* 31(2): 225–232.
- Trømborg, E. & Solberg, B. 1995. Beskrivelse av en partiell likevektsmodell anvendt i prosjektet “Modellanalyse av norsk skogsektor”. Research paper of Skogforsk 14/95. Department of Forest Sciences, Agricultural University of Norway. Ås. 34 p. [In Norwegian].
- , Buongiorno, J. & Solberg, B. 2000. The global timber market: implications of changes in economic growth, timber supply, and technological trends. *Forest Policy and Economics* 1(1): 53–69.
- Zhu, S., Tomberlin, D. & Buongiorno, J. 1999. Global forest products consumption, production, trade and prices: global forest products projections to 2010. Working paper GFPOS/WP/01. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

Total of 30 references