PROJECTING FUTURE DEVELOPMENT OF THE RUSSIAN FOREST SECTOR USING FOREST SECTOR MODEL

A. Moiseyev[1]

ABSTRACT.--The Russian forest sector is currently under pressure of an economic crisis. Average annual production of the roundwood has decreased about 3 times since 1989. Limited domestic demand for forest products restricts production growth and the development of the technology in forest industries. At the same time forest resources are not fully utilized. However, this situation may change in the future. The key factor affecting the future of the forest sector is annual GDP growth. The PELPS III model is utilized for projecting the future of the Russian forest sector. Preliminary results show that it will take a long time to restore past production levels in the forest industries. The paper also outlines the future development of a forest sector model using a partial equilibrium framework for forest industries and forestry sector.

INTRODUCTION

Russia is a huge country with great forest resources and high potential for the forest sector within the national economy. However, the Russian economy is experiencing very heavy and long crises. Production of the forest sector decreased from 2 to 3 times. Potential of the Russian forest is utilized only on 1/3. Russian federal program of forest sector development (ROSLESPROM 1995) is planning to increase production of the forest industries more than 2 times to 2005. However, there is not any scientific analysis behind this program. It looks nice, but maybe not realistic. Nevertheless, even that will not put the Russian forest sector in the position where Russia was before 1990.

MAIN RUSSIAN FOREST SECTOR CHARACTERISTICS

Forestry Characteristics

Russian total forest land area is 1,110,481.6 thousands ha, from which 705,789.2 thousands ha (73,028 million m^3) are forested lands, including 507,708.2 thousand ha of coniferous forests. Average annual growth is 822 million m^3. Only 351,095.9 thousands ha (43,467 millions m^3) of forests are exploitable. Distribution of exploitable forested lands among European and Asian parts of Russia is shown in the Table 1. Most of forested lands are in Asian part. However most of the non-exploitable forests are in Asian part as well. European forests present the most productive forests (annual increment is almost twice higher than in Asian part of Russia).

TABLE 1.--Distribution of exploitable forested lands in Russia, 1993.

Region	Total Forested Lands, %	Exploitable Forested Lands, %	Ratio of Exploitable to Total Forested Lands, %	Annual increment, CUM/ha
Russia	100.00	100.00	61.80	1.34
European Russia	20.90	30.10	88.90	2.00
Asian Russia	70.10	67.90	54.60	1.10

[1]A. Moiseyev is researcher, European Forest Institute, Torikatu 34, FIN-80100, Joensuu, Finland, Phone: +358 +13 252 020, e-mail: moiseyev@efi.joensuu.fi.

Annual allowable cut (AAC) is 529,407 thousands m^3 in 1993. However, it was utilized only for 1/3 in 1993. Table 2 gives historical retrospective for actual use of AAC in Russia in different time periods. There were periods in the past when coniferous forests were over-cut. For coniferous forests in European Russia utilization of AAC was 59.2 % in 1993. There are some regions in European Russia where this percentage is about 100 % even now.

TABLE 2.--Annual allowable cut in millions cubic meters and it actual use.

Annual Allowable Cut by years		Russia		European Russia		Asian Russia	
Years		Total	Conifer.	Total	Conifer.	Total	Conifer.
1972	AAC	600.9	383.8	236.9	133.7	364.0	250.1
	Actual Use, %	55.5	67.5	88.5	110.4	34.0	44.2
1987	AAC	615.0	389.8	229.0	124.9	386.0	264.9
	Actual Use, %	52.0	59.5	79.0	90.9	35.9	44.7
199Î	AAC	602.4	381.6	220.4	121.1	382.0	260.5
	Actual Use, %	47.0	53.5	71.5	79.5	32.9	41.5
1993	AAC	529.4	319.1	197.8	99.6	331.6	219.5
	Actual Use, %	32.9	37.7	51.4	59.2	21.9	28.0

Forest Industry Characteristics

Forest industries in Russia were experiencing long crisis since 1990. Total removals, roundwood and sawlogs decreased almost 3 times from 1989 to 1995. However, in the pulp and paper industry, the decrease is only 2 times (Table 3).

TABLE 3.--Production of roundwood and forest industry products in Russia from 1985 to 1995.

Product		1985	1989	1990	1994	1995
Total removals	10^6 m^3	337.3	338.4	303.8	118.9	114.6
Roundwood	10^6 m^3	237.7	247.3	221.4	79.8	80.8
Sawlogs	10^6 m^3	142.2	144.9	129.2	52.7	47.5
Pulpwood	10^6 m^3	51.5	53.1	48.6	20.2	26
Sawnwood	10^6 m^3	79.6	81.9	75	30.7	26.7
Plywood	10^6 m^3	1.6	1.7	1.6	0.89	0.93
Particle board	10^6 m^3	4.67	5.65	5.57	2.63	2.21
Pulp	10^6 ton	7.95	8.11	7.53	3.31	4.12
Paper	10^6 ton	5.03	5.34	5.24	2.22	2.77
Newsprint	10^6 ton	1.57	1.72	1.72	1.04	1.46

Despite of the heavy crisis on the domestic forest products markets, export of roundwood, pulp and paper increased in 1995 in comparison with 1985 (Table 4). However, Russia is losing external markets for sawnwood.

TABLE 4.--Export of roundwood and forest products from Russia.

Product		1980	1985	1990	1994	1995

Roundwood	10^6 m^3	16.93	15.43	15.00	13.50	18.00
Sawnwood	10^6 m^3	7.13	7.63	7.10	5.40	4.20
Plywood	10^6 m^3	0.31	0.41	0.32	0.59	0.66
Particle board	10^6 m^3	0.33	0.30	0.12	0.02	0.02
Pulp	10^6 m^3	0.82	0.97	0.39	0.94	1.30
Paper and board	10^6 m^3	1.02	1.10	0.89	1.05	1.45

Most of Russian Forest Industry enterprises were privatized during 1991-1993. Majority of enterprises are joint-stock companies now. However, it does not make any real sense. The main problem for companies is very limited domestic demand for forest products due to crisis of the Russian economy. Most of forest companies are unprofitable. Nevertheless, situation is different for different forest industry brunches. The best situation is in the Pulp and Paper Industry (Table 5). Domestic prices for paper are on the same level with international markets prices. Pulp and Paper Companies are rather big and they act like monopolies on local wood markets. They dictate low prices for roundwood. As a result, harvesting is unprofitable. The sawmill industry is not too monopolized. That is why it has very moderate profit.

There is one exclusion in all tables for profitability. That is Far East region. Apart from all others regions, Pulp and Paper Industry and Woodworking Industry are unprofitable in Far East due to high production costs for everything. Nevertheless the highest prices for sawlogs on Japanese market make sawlog export profitable. Almost all sawlogs are exported from Far East to Japan and others Pacific Rim Markets. Any forest industry company excluding those dealing with roundwood export is unprofitable and are not working now in Far East.

TABLE 5. Prices and production costs for some forest products in Russia in 1995

Region	Newsprint		Sawnwood coniferous		Sawlogs coniferous	
	Price in US$/CUM	Production costs in US$/CUM	Price in US$/CUM	Production costs in US$/CUM	Price in US$/CUM	Production costs in US$/CUM
North region	532.0	336.0	76.0	73.4	17.1	18.6
North-West			43.8	37.1	18.3	18.1
Central			42.1	36.1	15.6	16.3
Volga-Vyatka	455.0	318.0	48.9	39.1	16.9	17.6
Central-Chernozem			50.0	46.4		
Middle Volga			44.3	42.3	20.0	19.6
Norht Caucasus			68.7	65.7		
Ural	551.0	361.0	40.7	36.3	14.8	15.9
West-Siberian			42.1	42.6	12.4	15.3
East-Siberian	445.0	284.0	77.8	70.4	17.4	19.5
Far East	569.0	647.0	66.4	71.2	48.0	41.4

DEMAND AND SUPPLY ANALYSIS FOR THE RUSSIAN FOREST SECTOR

Demand/Supply of Roundwood

Traditionally, wood supply forecast is produced by special state forest management organization (Lesproekt) for local forest management unit (Leshoz) once per 10 years providing forest inventory and forest management plan with enormous details including volume of intermediate and final cuts and allocation of all of this cutting activity as well as silviculture and thinning activity. Nevertheless, there is not any analysis as the basis of this type of forest

management planning. It is based on the personal experience of a forester. No one is doing forest management planning on larger scale and on the national level. There are not any forest management models applied for wood supply forecast at the national level. However, there are a number of approaches developed in the former Soviet Union for long term forest management planing dealing with wood supply. One of them (Komkov and Moiseev 1987) is focusing on maximizing sustainable cutting level. This model was applied to several regions in Russia in the late 1980s. Most of the models being developed in former Soviet Union times were optimization models. There is not any econometric model applied to wood supply in Russia.

Demand/Supply Analysis of Forest Industry Products

Econometrics models are not used for demand/supply studies. Expert estimations were used for long and middle term forecast in the forest sector on the country level. Nevertheless there are some forest sector models applied on the regional level in the former USSR. One of them was developed in VNIPIEILesprom. This model is not partial equilibrium forest sector model. The model is minimizing total production and investment costs in the forest sector of KOMI Republic starting from harvesting and finishing in various forest industries enterprises existing and planning. The model is dealing with very high level of technical details, various timber products assortments. Demand for certain forest products is exogenous in the model. However, there are some studies carried out by international organization.

IIASA Russian Forest Sector Studies

Charles Backman (1995) presented information about forest resources, forest product production, consumption and export in Russia and four Russian regions. Basically this report is just a description of the current Russian forest sector state. There is no any kind of model used in the analysis.

Nevertheless, CINTRAFOR Global Trade Model (CGTM) (Perez-Garcia and Backman 1995) was applied for scenario analysis of the Russian Forest Sector regarding harvesting capital constrain effect on developing of roundwood consumption. There are only two region in the model (Russian West and Russian East). There is an assumption behind the modeling, that harvesting capital will be decreasing 5% per year for a long time due to low demand. As a result, after 2000 harvesting capital constrain will become the most important factor affecting further forest industries development. Prices for roundwood and forest products are considered as relatively low in comparison with international prices for the entire modeling period (difference is slightly decreasing to 2010, but still very significant). That was evident during 1996 already, that Russia increased very fast domestic prices for most of forest products, and relatively low prices for roundwood on the locals wood markets are only due to very monopolized forest industries, keeping high prices for final products and low prices for input wood products. So, price forecast is not reasonable in the model. Low prices are not constraints for the Russian forest sector.

International studies

First world forest sector study was carried out by IIASA using Global Trade Model (GTM) (Kallio, Dykstra, Binkley (editors) 1987). USSR was one of the regions in the world forest sector study. However most of numbers were not taken from real USSR forest sector (only quantities of forest products manufactured in the base period seem to be correct, but not prices and production costs).

Recent world forest sector study has been carried by FAO (1997) using PELPS-based forest sector model. It is difficult to say how reasonable are figures and forecasts for Russia in this study, because the most critical input information is not shown in the FAO report (i.e. prices and production costs).

EFI's Russian Forest Sector Study

EFI is carrying Russian forest sector study using PELPS III (Zhang, Buongiorno, and Ince 1993) forest sector model. Base data are for 1995. Quantity manufactured are presented for 10 final products, 3 intermediate (pulp grades), 4 different kinds of roundwood and chips, 3 production and 3 domestic demand region (European part of Russia, Siberia, Far East). Model incorporates also 3 demand region outside of Russia for modeling of forest product export. Export regions are West Europe (all European countries, excluding Italy, Greece, Spain, which are included to the next export region), South (countries which are exporting Russian forest products through Black Sea), Pacific Rim (Japan, South Korea, China and other importers of Russian forest products in South-East Asia). Model utilizes information about domestic prices, production costs and production capacities delivered by VNIPIEILesprom from Russian official statistics. Critical factor for the study is annual GDP growth. Depending from GDP growth used model project future Russian forest sector development. However price and income elasticities were not estimated statistically in the study. They were used from FAO 1996 provisional forest product outlook (FAO 1997) due to lack of reliable historical price data in Russia.

Four scenarios depending upon annual GDP growth are used for projecting future development of the Russian forest sector. First scenario is “Low” scenario with 2% of annual GDP growth, second - “Medium” scenario with 3% GDP growth, third - “High” scenario with 5% GDP growth and fourth - “Very high” scenario with 7% GDP growth. However, for all scenarios GDP growth for 1st and 2nd years is -10% because of ongoing decline in production of most of products in forest sector and other sectors of Russian economy in 1996 and possibly 1997. 0% GDP grouth is considered for 1998 year. Starting from the 1999 GDP growth is increasing 1% per each year until it reach upper level for particular scenario. Base period for all scenarios is 1995. Results of the model runs for different scenarios are shown in the table.

TABLE 6. --Projection for the future newsprint consumption, export and production (thousands tons).

Scenario		1995	1996	1997	1998	1999	2000	2005	2010	2015	2020
Low	Consumption	775	705	627	635	637	642	678	749	823	876
Medium		775	705	627	635	637	642	719	806	939	1046
High		775	705	627	635	637	642	762	953	1169	1515
Very High		775	705	627	635	637	642	790	1048	1527	2015
Low	Export	948	977	981	995	1012	1017	1077	1151	1258	1328
Medium		948	977	981	995	1012	1017	1158	1307	1517	1662
High		948	977	981	995	1012	1017	1215	1515	1879	2345
Very High		948	977	981	995	1012	1017	1243	1617	2228	2864
Low	Production	1722	1681	1608	1630	1648	1658	1755	1901	2081	2205
Medium		1722	1681	1608	1630	1648	1658	1878	2113	2457	2709
High		1722	1681	1608	1630	1648	1658	1977	2467	3048	3860
VeryHigh		1722	1681	1608	1630	1648	1658	2033	2664	3756	4881

Figures for others paper and pulp products show similar tendency. In case of high scenario production will be restored to the level of 1989 in 2020 and very high scenario in 2015. So, production of most pulp and paper products failed twice during 5-6 years, and it will take 20-25 years to restore past production level in case of high Russian economy growth. Export of newsprint is growing similar to Russian domestic consumption. 2% GDP growth was used for export demand regions. In case of low scenario, low level of domestic demand limits export of newsprint because of capacity limitation. Low domestic demand does not stimulate rapid capacity expansion. AAC is an upper limit for roundwood supply in the model. Only in the case of high and very high scenario AAC starts to limit pulpwood supply near 2015-2020 in the European part of Russia, although there is no limit for sawlogs that time. In this case part of sawlogs supply could be used for producing pulp.

PROSPECTS FOR THE FUTURE FOREST SECTOR MODEL DEVELOPMENT

Several types of optimization models were applied in modeling the national and international forest sector. A dynamic linear programming (DLP) optimization model for the Finish forest sector (Kallio, Propoi, and Seppälä, 1986) covers all branches at the aggregated level including forestry and forest dynamics. Model optimizes a discounted over time sum of net income from forestry and forest industries. Prices for final products are given as exogenous. This is not an equilibrium model. The DLP model is pure optimization model. In the TSM model Sedjo and Lyon (1990) applied optimal control theory for projecting world timber demand and supply for roundwood products. Forest industries are taken to account through demand for roundwood, and prices for roundwood are endogenous. So this is an equilibrium model applied to forestry sector. There are not any other models for forestry dealing with equilibrium prices. Most of them are optimization models with maximizing discounted net present value. For time periods more longer than 10 years this is something like a theoretical exercise because with a real interest rate all profit in the far future is essentially valueless. Simulation models in forestry may provide more valuable information, but forestry optimization models linked to the final products from wood may be also used for analyzing and modeling real forest sector problems.

There are a few partial equilibrium optimization models for the forest sector. Among them are PELPS III based NAPAP (Ince, Zhang, Jacques, and Buongiorno 1993) and GTM model. PELPS III and GTM models use mainly optimization techniques and partly simulation techniques. Optimization part is used to maximize consumers and producers surplus for finding equilibrium prices for final forest products like sawnwood, plywood, different type of pulp, paper and panel products. Simulation techniques are used for updating production capacities, changes in demand and supply curves, etc. So only current time periods have to be optimized. The dynamics of the forest sector is treating by simulating changes between time periods.

Partial equilibrium models like GTM and PELPS III represent the most advanced approach in studying the international and national forest sector for today. Demand for final forest products and wood supply from forest is taken into account together with model for manufacturing intermediate and final products and model for transportation of forest products between international and domestic regions. There are some differences between GTM and PELPS III model in modeling capacity expansion and changes of wood supply depending on the growth of forests. Wood supply in GTM model is shifted from t time period to t+1 through internal simple forest growth model. In PELPS III model it may be done manually through predefined changes in wood supply before actual model run or using external forest growth model linked to the PELPS III model (It was done using this way in the NAPAP PELPS-based model linked to ATLAS (Mills and Kincaid 1992) and TAMM model (Adams and Haynes 1995) for projecting future development of the North American forest sector). However there are no any options for modeling different forest management regimes in the GTM model. In PELP III - based model this may be provided by adequate forestry model. At present time wood supply in partial equilibrium models is modeled as black box with quantity of wood supplied as dependent variable and price as a main independent variable. For demand side this only a way to model particular demand as black box. Production process may be modeled as black box as well (it was done in TAMM model), but in PELPS-based models production of forest products is considered as simple input-output model using so-called activity analyses model. However supply of wood from the forest is considered as black box using econometric equation for wood supply depending on price and 3 possible shifters. Activity analysis may be also expanded to wood supply from the forest like it was done in TSM model. In this case criteria of the optimization problem is the following:

(1) $$Max \leftarrow Z = Z_d - Z_m - Z_c - Z_t - Z_h$$

where:

Z_d is an area under demand curves,
Z_m is a sum of a net manufacturing costs,
Z_c is a sum of a investment costs,
Z_t is a sum of a net transportation costs,
Z_h is a sum of a net harvesting and regeneration costs.

In a typical forest management planning model, Z_m, Z_c, Z_t are not used and Z_d is considered as revenue from sale of roundwood from the forest with constant prices. This may be true for a particular forest owner or a firm, but it is not true for a large-scale forest management plan on the national or regional level. This is because prices depend from quantity of roundwood have been sold. In the DLP forest sector model similar optimization criteria may be applied but again with constant prices. However equilibrium prices were applied by Kallio and Soismaa (1986) in Stackelberg game using nonlinear optimization software for steady state analysis of the Finnish forest sector. The nonlinear optimization techniques limit the size of the studying object. In the TSM model consumer and producer surpluses are the maximization criteria consisting of Z_d and Z_h.

In the case of competitive market:

(2) $$Z_d = \int_0^{D^*} P(D)dD ,$$

where:

P(D) is price as function of forest product quantity consumed;
D^* is an equilibrium quantity.

In the case of monopoly:

(3) $$Z_d = P(D) \times D .$$

Because of the Z_d, the optimization problem is nonlinear. However PELP III model uses stepwise linear approximation for Demand Curves. It allows more effective linear programming optimization techniques. There is another problem in the forestry sector modeling. In the case of using Z_h as a sum of harvesting and silviculture costs it is necessary to specify constraints for sustainable (non-decreasing) wood harvest. Otherwise, model may simulate that most of wood would be consumed in the initial state. Model would not produce any regeneration after final harvesting if not to apply some constraints for doing this with relation to harvesting activity. In most cases like the Finnish forest sector DLP model, constraints for the final forest state are applied in order to insure certain result of the model run. The final state is usually considered as an optimal steady state. For the forest this state is very close to the so-called "normal" forest. For forest industries it means equilibrium prices and no production capacity expansion. Of course, this is a bit artificial state, and it used to be a theoretical assumption. From the steady state point of view, we have to create optimal future forest sector state and than optimize movement of the system from current state to this future final state through a number of steps using one or another optimization criteria. However, determination of optimal final state is rather difficult question because of very high uncertainty of the future, especially from economy point of view. For the forest industries sector time period like 10-15 years would be more than enough. More long period for projection would be insufficient because of high future uncertainty. However this time period is not enough for forestry to ensure certain future forest state. On the satisfactory level that may be done using age distribution of the forest lands in the initial state. The model for optimizing harvesting at the current time with taking into account sustainable wood harvesting in the future and different system of silviculture activity was described by Komkov and Moiseev (1987) and Moiseyev (1989). Within this framework for forestry sub sector, it becomes possible to combine partial equilibrium model for the forest industries like PELPS III with the forestry model. The LP model is used for maximizing allowable cut level subject to age classes distribution and within silviculture activity system or minimizing silviculture and harvesting expenses subject to certain volume of harvest and sustainability constraints. In the last case forestry model can be easily integrated with partial equilibrium forest industries model.

Below is short description of this approach. Harvesting and regeneration costs from equation (1) is the following:

(4) $$Z_h = \sum_k \sum_l c_{kl} \times x_{kl} ,$$

Subject to:

(5) $$\sum_{l} x_{kl} \leq \frac{1}{m+1} \sum_{m=0}^{M} \sum_{l} S_{km}, M = 0,1,2,..., M^{*}; k = 1,2,..., K$$

where:

x_{kl} is the area harvested that is going to be regenerated using system *l* of silviculture activity on forest lands of type *k*;

c_{kl} is the corresponding harvesting and regeneration costs;

S_{km} is the area under forest land of type *k*, age class *m*;

M=0 is the mature age class; M=1 is the age class prior to the mature age class; M=M* is the youngest age class (this class includes area after clear cutting that will be afforested using system *l* of silviculture activity.

Every x_{kl} represents particular system of silviculture activity in the forest lands of type k. This is equivalent to different production technologies in forest industries sector. Constraint (5) represents requirements for the future sustainable harvesting. In the integrated forest industries and forestry activity analysis model one more type of constraint should be presented linking demand for certain type of wood by the industry side to supply of this wood from the forestry side.

CONCLUSION

The main idea for further model development would be determination of the most important factors affecting demand and supply of forest products. The weak point of existing forest sector models is the very aggregated forestry sub model. There are usually no any options for modeling different forest management regimes. In most European countries forest management should be considered an important factor affecting to timber supply. On the other side, many forestry models can model different forest management regimes at a very detailed level. They can provide detail analyses for supply of wood . But they assume constant prices for wood in the current moment as well as in the future, and demand for wood is not taken into account. It is evidently that there are certain interdependencies between demand for forest products and supply of wood from forests. Both demand and supply should be modeled at once on an acceptable level of detail.

REFERENCES

Adams, D., Haynes, R., 1995. The 1993 timber assessment market model: structure, projections and policy simulations. USDA Forest Service. (In press).

Backman C. 1995. The Russian Forest Sector: An Analysis by Four Regions. IIASA Working Paper, WP-95-44, Laxenburg, Austria.

FAO. 1997. FAO provisional outlook for global forest products consumption, production and trade to 2010. FAO, Forestry Policy and Planning Division, Forestry Department., Rome.

Ince, P.J., D. Zhang, R. Jacques, and J. Buongiorno. 1993. The North American Pulp and Paper (NAPAP) Model. USDA Forest Service. U.S. Forest Products Laboratory., Madison.

Kallio, M., D. Dykstra, and C. Binkley (editors). 1987. The global forest sector: an analytical perspective. John Wiley & Sons, Chichester.

Kallio, M., A. Propoi, and R. Seppälä. 1986. A model for the forest sector. pp. 89-112 In: System analysis in forestry and forest industries. Studies in the management sciences. vol. 21 (Machol, R., et al., eds.) Elsevier Science Publishers B.V., Amsterdam.

Kallio, M. and M. Soismaa. 1986. Steady State Analysis of the Finish Forest Sector. pp. 187-212 In: System analysis in forestry and forest industries. Studies in the management sciences. vol. 21 (Machol, R., eds.) Elsevier Science Publishers B.V., Amsterdam.

Komkov, V and N. Moiseev. 1987. Optimization of the forest resources reproduction. (In Russian). "Forest industries" publisher., Moscow.

Mills, R.and J. Kincaid. 1992. The Aggregate Timberland Assessment System - ATLAS: A Comprehensive Timber Projection Model. General Technical Report PNW-GTR-281. USDA Forest Service.

Moiseyev, A. 1989. Economic basing of long-term programs for utilizing and reproduction of wood. (The case of Ust-Ilimsk Forest Industries Complex). Ph. D. Thesis. Moscow forest-technical institute., Moscow.

Perez-Garcia J.and C. Backma.. 1995. The Former USSR Forest Sector and Capital Constraints. IIASA Collaborative Paper, CP-95-1, Laxenburg, Austria.

ROSLESPROM. 1995. Federal Programme of the Russian Forest Sector Development. ROSLESPROM, Moscow.

Sedjo, R.and K. Lyon. 1990. The long-term Adequacy of World Timber Supply. Resources for the Future., Washington.

Zhang, D., J. Buongiorno, and P. Ince,. 1993. PELPS III: A microcomputer price endogenous linear programming system for economic modeling. Res. Paper FPL-526. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory., Madison.