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The Pan Siberian Forest Industry Model (PSFIM): A theoretical concept for forest industry analysis

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Foreword

IIASA, the Russian Academy of Sciences, and the Russian Federal Forest Service, in agreement with the Russian Ministry of the Environment and Natural Resources, signed agreements in 1992 and 1994 to carry out a large-scale study on the Siberian forest sector. The overall objective of the study is to focus on policy options that would encourage sustainable development of the sector. The goals are to assess Siberia's forest resources, forest industries, and infrastructure; to examine the forests' economic, social, and biospheric functions; with these functions in mind, to identify possible pathways for their sustainable development; and to translate these pathways into policy options for Russian and international agencies.

The first phase of the study concentrated on the generation of extensive and consistent databases for the total forest sector of Siberia and Russia.

In its second phase, the study has encompassed assessment studies of the greenhouse gas balances, forest resources and forest utilization, biodiversity and landscapes, non-wood products and functions, environmental status, transportation infrastructure, forest industry and markets, and socioeconomics.

This work, carried out by Dr. Michael Obersteiner at the International Institute for Advanced Studies, Vienna and IIASA deals with the development of the sawmilling industry in Siberia.

Acknowledgment

It is a pleasure to express my appreciation to those who have influenced this work. Most influential in shaping my ideas was the close collaboration with IIASA and there I would like to add my name to the list of scientists who have thanked Sten Nilsson for his contribution to their work and education. I truly want to thank Sten Nilsson for his persistent questioning and encouragement which strongly influenced my entire career during the last four years.

This work is the result of the configuration of knowledge, effort and information spread over mainly four institutes. All started with a conversation with Wolfgang Schopfhauser who inspired me to start as a Young Summer Scientist at the International Institute for Applied Systems Analysis (IIASA). There I should go through a brisk conversion from a convinced eco-physiologist to an industrial economist for the Russian forest sector. This dissertation was heavily improved by the help of Charles Backman, Kai Blauberg, Cynthia Festin, Anatoly Shvidenko, Sergej Venevski and all the others who contributed to the Forest Resources Project at IIASA.

It was clear to me that without the knowledge of the Russian language and lifestyle I would not be able to do a decent job in this new area. As a research fellow at the Institute for Industrial Engineering and Organization of the Siberian branch of the Russian Academy of Sciences, I had the great pleasure to collaborate with Yuri Sh. Blam, Gagik M. Mrktchan, Luda and Olga Mashkina. I would like to thank them and the many other friends I met in Russia for their great hospitality and deep and thoughtful conversations.

Returning from the amiable climate of Siberia I entered the painstaking Program in Economics at the Institute for Advanced Studies (IHS) in Vienna. Before I thank my teachers I would like to express great thanks to my fellow scholars who shared the suffering in some of the courses we had to go through. The discussions with my fellow scholars broadened my views on economics and economic model building. The most influential teachers significantly shaping this work were Ingmar Prucha from the University of Maryland, Jerome Swinckles from North-Western University, and Wolfgang Pollasek from the University of Basel. In addition, I would like to thank Andreas Wörgötter, Sergej Nagaev and Peter Huber for the collaboration on several projects on industrial restructuring in Russian regions.

Special thanks also go Professor Peter Schwarzbauer, my first supervisor at the University of Bodenkultur, Vienna, Austria, and to Professor Peter Glück who served as my second supervisor. This work has benefited at several stages from the careful reading of the many reviewers including Giuseppe Collangelo, University of Milano and IHS; Peter Glück, University of Bodenkultur; Peter Huber, IHS; Wojtek Michalowski, Charleton University and IIASA; Sten Nilsson, IIASA; Arno Riedl, IHS; Peter Schwarzbauer, University of Bodenkultur.

I owe my greatest debt to Anne Mégier, to my daughter Maya Louise Incana, my parents Hertha and Heinrich, and my sister Astrid.

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Chapter 1

Development of the analytical model

1.1 Introduction

Siberia's forest sector is a topic which recently has gained considerable international interest. IIASA (International Institute for Applied Systems Analysis), the Russian Academy of Sciences, and the Russian Federal Forest Service, in agreement with the Russian Ministry of the Environment and Natural Resources, signed agreements in 1992 and 1994 to carry out a large-scale study on the Siberian forest sector. The overall objective of the study is to focus on policy options that would encourage sustainable development of the sector. The goals are to assess Siberia's forest resources, forest industries, and infrastructure; to examine the forests' economic, social, and biospheric functions; with these in mind, to identify possible pathways for their sustainable development; and to translate these pathways into policy options for Russian and international agencies.
The first phase of the study concentrated on the generation of extensive and consistent databases of the total forest sector of Siberia and Russia.
The study has moved into its second phase, which will encompass assessment studies of the greenhouse gas balance, forest resources and forest utilization, biodiversity and landscapes, non-wood products and functions, environmental status, transportation infrastructure, forest industry and markets, and socio-economics.
The objective of this dissertation is to device a strategic modeling tool which could help to develop comprehensive strategic plans for economic development of the forest sector as a possible leading cluster of the Russian economy. Different modeling approaches will enable detailed analysis of possible evolutions of the forest sector, based on which sensible policy measures can be derived. The currently existing economic modeling tools seem to be insufficient to adequately analyze the Siberian forest sector.
In particular I will try to construct a consistent analytic framework to give quantitative answers to the following economic questions:

- What explains industrial output decline in the forest industry?
- What can be assumed to be realistic market scenarios?
- How may the geographic pattern of production evolve in the forest industry?
- What is the most likely future rate of employment?
- What happens with the production rate if product, production and transportation prices change?

- What can governmental policy interventions achieve?

It has to be noted, however, that the focus of this dissertation is to develop just an analytic tool. It is not my intention to carry out the analysis as such. The scenarios featuring the lumber industry [1] presented in section 4.1 only try to illustrate the sensitivity of the model to changes in the model parameters and do by no means try to project any possible real pattern of industry evolution. The application of this model can only be carried out in a more integrative manner involving more knowledge and data from other researchers.

This dissertation has been divided into five chapters. The first chapter gives a brief overview of the current status of the Siberian forest sector (section 1.2), the main problems of the sector are identified and formulated (section 1.3, and a modeling strategy is developed to give answers to the main policy questions (section 1.4). In section 1.4 I first review and give a critique of the existing modeling strategies currently being applied in economic forest sector analysis (subsection 1.4.2) and in addition I give reasons why a pure optimization strategy is not suitable in the context of the Siberian forest sector (subsection 1.4.1). Finally, in subsection 1.4.3 I shortly describe the PSFIM and try to put it into the framework of all other existing forest sector models and shortly review the auction theoretic background which is done in subsections 1.4.4 and 1.4.5. The last section in chapter 1, 1.5, is devoted to a non-technical and intuitive description of the modeling approach. In chapter 2 I use simple mathematics to describe the structure of the model. Here I distinguish between a static phase and a dynamic phase. The static phase describes the auction mechanism, which is applied for each period, leading to a partial market clearing depending on the producer and price constraints. In the dynamic phase, product prices adjust, producers invest or depreciate capital, contract partners revise contract policies and, finally, prices change according to the overall economic development. In chapter 3 I describe two additional modules that are attached to the core model described in chapter 2. The first module, described in section 3.1, ultimately defines production and cost functions for harvesting and saw-milling operations. The second section in chapter 3 first gives a methodological background for a Bayesian panel data estimator [2] and in a second step demand functions are estimated for all export markets relevant for the Siberian forest industry. In addition levels of domestic consumption are discussed. Finally, chapter 4 gives a quantitative overview of the results of the modeling exercise. I distinguish three different scenarios of agent behavior. The result of Scenario I is illustrated on a GIS map. In chapter 5 I summarize the results and give some concluding remarks.

1.2 Background

Since the collapse of the socialist system in 1991 Russia has committed itself to pro-market reforms. The country is undergoing a transition period which is characterized by the elimination of most state subsidies, decentralization of decision making, privatization and the abolition of price and wage controls. The former tradition of soft budgets, which guaranteed employment and low inflation, is abandoned.

[1] The model per se was constructed to analyze the entire forest industrial sector. The scenarios presented in this dissertation, however, only illustrate the results gained for the lumber industry.

[2] This econometric method has never been developed before in the economic literature.

Transition means at the enterprise level the elimination of non-competitive products and radical changes in the ownership structure. This, combined with the collapse of the COMECON and the Soviet Union markets, have caused a deep economic recession in all of Russia and in the remote Siberian regions especially. The entire economy and the forest sector have faced an unprecedented economic decline no country in modern history had to experience. The decline started in 1989 - 1990 and still continues with the exceptions for some export oriented enterprises or product lines. Some 50 % of industrial output in real measures have been lost throughout the transition period (until 1993) in Russia.

The official rate of unemployment is rather low, but is in reality much higher. Hidden unemployment will soon become apparent. Especially workers over forty are most effected by the transition. Pensioners barely survive due to empty pension funds. The economic down-turn has affected the most remote areas where most of the logging towns are located. Visits to such towns give testimony to a very sad picture of the Russian psychological, social and economic state.

Decline in real incomes and construction activities adversely affect the consumption of forest products. Consumption will most likely be at a lower level at the turning of the century than ten years ago. In this light most local expert opinions on future consumption and production levels seem overestimated and remind us of the old five-year and five hundred-days plans. Adoption of a new economic culture securing an efficient functioning of markets will probably take generations. Well established Mafia networks and unrealistic profit and rent seeking by most managers feature the concerns of slow adaptation. Economic problems are in Russia also connected with high political risks which in the worst case may erupt in civil unrest due to the somewhat unfairly layered social structure of society or the unrest may be connected with nationality conflicts. Such unforeseeable events would of course destroy all scenario exercises.

The level and geographic distribution of forest sector output will mainly depend on two factors. The first being the competitiveness of domestic wood working industries and the second being the trade pattern. After the deep economic slump there are few enterprises which are still competitive on domestic and international markets. Those who inherited a decent working capital from the Soviet system are on the way to recover as recent production figures show. For example pulp production in Ust-Illmsk has increased to an production level, which is reaches 80% of capacity [3], which is unusually high for Russian standards. However, a lot of other producers had to close down already and many more will do so in the near future. To this latter group belong mainly producers which produce low quality lumber and round-wood in remote areas.

Trade links with former Soviet satellite countries like Bulgaria, Hungary, East Germany, and the Baltic countries have dried up. There is risk that forest products from Russia will be absent in these markets for a long time. Future delivery of especially round-wood from remote Siberian areas to European Russia will heavily depend on the future of transportation costs. However, there are promising perspectives for timber and timber products trade with some Former Soviet republics and countries with wood deficits in the Pacific basin.

[3] The success of this particular producer can in part be explained by the fact that it belongs to a local Mafia organization that has established an international network of sales offices.

1.3 Problem formulation

Before we decide upon the type of analysis of industrial pattern formation we should make clear,

- Whom are we going to address?
- What kind of questions can and should we answer given the current political and economic conditions and the current state of information?

It is the aim of this research effort to develop a decision support tool for policy makers, administrators of Russian and international governmental and non-governmental organizations. Parts of the model should also be of interest to entrepreneurs being or potentially being involved in the Forest sector of Siberia. It should be possible to conduct sensitivity analysis with regards to different policy and business options.

Due to the effects of transition the Siberian forest industry has undergone an unprecedented production decline and suffered from financial and social hardship. Also ecological problems were to a large extend ignored. At present it is entirely unclear how the entire sector will evolve. Both industry and governmental organizations nationally and internationally have a vital interest in the well-being of the Siberian forests and its forest industry. A number of development scenarios are possible at the moment. Although we cannot anticipate future developments exactly it should be the aim of this research work to develop a tool to visualize possible future scenarios depending on the different policy options taken. This tool should allow the user to learn from the possible future. It is of great importance to disseminate realistic from unrealistic scenarios for both demand and supply. It should be possible to ask questions like *"What is likely to happen to the distribution of roundwood production and its factor demands if markets under certain producer conditions change"*.
There are multiple criteria which the producers in the forest industry should fulfill. This is the main reason why we resort to simulation rather to optimization in our analysis. Optimization would mean that the analyst beforehand gives qualitative assessments to the utility of certain functions, which in most cases can not be expressed by any kind of agreeable market price. The prime function, most of the Siberian producers are dedicated to, is to satisfy internal demand for the respective timber product grades. Certainly, also social benefits such as employment, infrastructure maintenance, and revenue accumulation should be guaranteed by production. This is especially important in remote settlements where other employment is hardly existing. Another criterium is that, forest ecosystems should be managed on a sustainable basis and logging operations should be carried out with minimal long-term ecological impacts. However, in the present situation of rather chaotic economic conditions managers of lespromhozes and timber mills put high priority on their personal goals rather to expose themselves to the entire spectrum of responsibilities they should in principle dedicate themselves.
Hence the most basic questions that need to be answered in one way or the other are the following:

- What is the forest sector's demand level for the factors

    1. labor

2. forest land (timber)
3. capital
4. energy

- What are the effects of changes in the factor prices?
- What happens if technology changes?
- What are the effects of changes in transportation costs?
- What are the competitive prices at different markets?
- What can governmental policy interventions do and what is the outcome of market liberalization?
- What happens if demand changes?
- What are the most likely demand scenarios?
- How long will it take to reach a certain production level?
- What are the possible effects of different systems of forest management and environmental regulations?

1.4 Modeling strategy

After having determined the set of questions to be answered we are now in the situation to develop a tailored model. The model should help to visualize in a simplified way, the possible future geographic pattern of production. The level of aggregation will be the enterprises. Geographical information systems allow to see the effects of changes in the producer system on the entire collection of enterprises without having to aggregate and by this loosing some of the transparency of the analysis. The visual representation of the results will give an indication of the geographic pattern of harvest, social hardship and possible prosperity. The user will immediately be able to see how exogenous shocks determine the geographic pattern of production. The results will indicate production sites which will have to be abandoned whereas other regions will see new entry in the future.
The model developed is a strategic decision support system. It is fast to calculate and simple in its logical structure. It is open in its design i.e. submodules can easily be removed or added. The model is also flexible in the sense that the level of detail can always be adjusted to the current state of knowledge and information and can eventually be transformed into whatever optimization procedure if desired.
The users of the model should be able to conduct experiments. By observing the behavior of the model during the experiments, the analyst is able to make inferences about the possible behavior of the real world system. The restriction of the model to the optimal outcome would have lead to a biased image of the real world system given the current state of information.

1.4.1 Simulation versus optimization

The strength of descriptive simulation [4] models in economics lies in the extent to which they capture certain fundamental relationships apparent in market behavior without putting too much structure *a priory* on the system at hand. Most of the pure economic models adopt a neo-classical framework and assume well-functioning markets i.e. perfect information, perfect competitive markets, profit maximization, zero transaction costs, no externalities, no major policy distortions. Not a single criterium out of this list of assumptions would be fair to apply to the current Russian situation. Moreover, we are more after the question of how the possible future states of producers look like rather than trying to tackle the question of optimal allocation and efficiency of theoretical welfare outcomes.

First of all it is not even clear whether it would be fair to assume profit maximization. Even if it were profit maximization, at the present moment it would be hard to tell whether we face monopolists, oligopolists or agents under perfect competition which maximize their profits. It seems for example to be more reasonable to adopt Baumol's view of maximizing market shares under zero profit conditions in the long run as the behavioral paradigm of agents in transition economies. As we know from duality theory under certain conditions cost minimization is identical to profit maximization. It is believed that these certain conditions again are violated and that this rigid framework has to be loosened up a bit. Nevertheless, a cost limiting behavior as a behavioral goal of any industrial manager should to some extend be build into our simulation model. This can be justified by the fact that some enterprises are either subordinated units of a larger integrated structure which would force the enterprise to run under minimum costs or a free enterprise which needs to minimize its costs to stay in the market in order to fulfill its particular goals and constraints whatever they are. The question is just to which extent cost minimization takes place and how we should integrate this behavioral pattern in our model. We did so by allowing the cost to fluctuate randomly in well defined boundaries. On the other side of the market place also buyers will tend to minimize their costs. Buyers will be willing to establish contracts with cheaper suppliers given similar quality. In this sense we should use optimization and descriptive models together.
Secondly, taking into account the overall uncertain environment of the Russian economy and more so the uncertain development of the roundwood market of Siberia it would be difficult to justify a neo-classical equilibrium approach. An equilibrium solution would fully describe the economy under the optimal allocation. Simulation models will only yield certain indicators that describe some pattern of the economy. The solution of the simulation outcome is not optimal, however, in our case be in a certain neighborhood of the optimal state of the economy.

Another advantage of the simulation approach is that the simulation model which was developed for the Siberian timber products market is easily comprehensible and is relatively open to further extensions and can easily be adapted to integrate results of other modeling results or analysis. In order to understand the core of what the model does it is not a prerequisite to have an in depth knowledge in economic theory and there are no black boxes which make a time constraint reader uncertain about the real functioning of

[4] Throughout the text I will use the word simulation synonymously for descriptive simulation in order to stress the differences to optimization routines.

the model and its implicit pitfalls. The model can also be extended to any detail depending on the data available.
The model is also designed in a way that it could potentially be used as a sub system of a larger system. In our case the larger system would be a model of the entire economy. There is a danger that conceptualizing systems in too small of a framework can result in problems of sub-optimization. Sub-optimization refers to decisions that optimize the behavior of a subsystem but are less than optimal for the system as a whole. For example, an efficient allocation in roundwood model under its isolated demand scenarios can be quite inappropriate given changes in demand patterns due to changes in the upstream industry structure.
Another very important factor that lead to the use of a simulation tool rather than to the use of an optimization tool is the fact that simulations do not force the analyst to put values on functions of the system. This is especially important in situations where explicit values do not exists or are hard to agree upon. In our approach we are more confronted with multiple target values and certain regulations. The optimal strategy or optimal state can only be approximated via more or less extensive sensitivity analysis of individual users which by nature have different values and utility functions. By intelligent and systematic investigation one should be able to learn under what conditions the system performs most efficiently and effectively. This indirect use of optimization purposes is shown by a simulation's ability to answer "what if" questions.

The simulation approach makes best use of the available information. By assimilating the existing knowledge and hard data in the most efficient way one makes use of the giant database and the GIS system that was built during the years of the IIASA Forest Resources Project.

1.4.2 Review of existing models

In this section I will shortly review the currently existing paradigm to analyze large scale forest industry models. Afterwards, I will try to justify the modeling approach taken and simultaneously try to categorize the model within the currently existing approaches. This will be done using the same structure as used by Nabuurs and Pắivinen, 1996.
Let me start the critique of the existing paradigm with the words of Michael Prowse, columnist for the *Financial Times*:"I need hardly underline the contrast between this red-blooded characterization of capitalism and the insipid general-equilibrium model so beloved by mainstream theorists". It is exactly this general equilibrium model that is applied in most attempts of the forest industrial economist to model future developments in the sector. More ironical even is that the profession even dares to give policy recommendations based on their questionable methodological base with no discussion about its relevance or limitations for the objective of the study or analysis carried out. It is still a miracle to me that such work can still be published in journal article or book form. More recent experience, however, has shown that such work better enters the recycling process rather than be read by a broader audience. It is no secret anymore that industry professionals for the most case put much pressure on "forest industry theorist's" by measuring their performance by the match between their results and reality.
During the last few years, there has been increasing criticism by high profile economists about the general equilibrium. I will limit myself to mentioning only a few of the criticisms. Stiglitz states, "General equilibrium theory is widely regarded as a splendid intel-

lectual curiosity rather as a model of reality. The models are fundamentally wrong in that they assume perfect information, perfect competition, and no technical change. Anybody looking at theses models would say they can't provide a good description of the modern world." Soros continues, "the theory is that free and competitive markets bring supply and demand into equilibrium and therefore ensure the best allocation of resources. But when we examine the assumptions for the theory closely, we find that they do not apply to the real world. The condition that supply and demand are independently given cannot be reconciled with reality. The assumption of perfect knowledge has proven unsustainable, so it was replaced by an ingenious device. The world is dominated by imperfect understanding. In reality there is no theoretical equilibrium, the contention that free markets lead to the optimum allocation of resources loses its justification. " And lastly, William Vickery states, "These models have little to do with improving welfare."

Let me now closer examine the structure of the general equilibrium model. The general equilibrium model assumes that when there were many economic agents each might reasonably be assumed to take market prices as outside of their control. Given these exogenous prices, each agent could determine his or her demands and supplies for the good in question. At the price adjusted to clear the market, as such the equilibrium price, no agent would desire to change his or her actions.

In the case were we describe a single market story we speak of a partial equilibrium in that all prices other than the price of the good being studied are assumed to remain fixed. In the general equilibrium model all prices are variable and the equilibrium requires that *all* markets clear. Thus, general equilibrium theory takes account of all of the interactions between markets, as well as the functioning of the individual markets. One of the main assumptions in a general equilibrium is that markets are competitive. Suppose now that there are $i = 1, \ldots, n$ consumers and $j = 1, \ldots, m$ firms. Each consumer i has a quasi-linear utility function $u_i(x_i) + y_i$ and each firm j has a cost function $c_j(x_j)$.

An allocation in this context will describe how much each consumer consumes of the x-good and the y-good, (x_i, y_i), for $i = 1, \ldots, n$ and how much each firm produces of the x-good, z_j, for $j = 1, \ldots, m$. Since we know the cost function of each firm, the amount of the y-good used by each firm j is simply $c_j(z_j)$. The initial endowment of each consumer is taken to be some given amount of the y-good, ω_i, and 0 of the x-good.

A reasonable candidate for a welfare maximum in this case is an allocation that maximizes the sum of utilities , subject the constraint that the amount produced be feasible. The sum of utilities is

$$\sum_{i=1}^{n} u_i(x_i) + \sum_{i=1}^{n} y_i \tag{1.1}$$

The total amount of the y-good is the sum of the initial endowments, minus the amount used up in production:

$$\sum_{i=1}^{n} y_i = \sum_{i=1}^{n} \omega_i - \sum_{i=1}^{n} c_j(z_j). \tag{1.2}$$

Substituting this into the objective function and recognizing the feasibility constraint that the total amount of the x-good produced must equal the total amount consumed we have the maximization problem

$$max_{x_i, z_i} \sum_{i=1}^{n} u_i(x_i) = \sum_{i=1}^{n} \omega_i - \sum_{i=1}^{n} c_j(z_j)$$
$$s.t.$$

$$\sum_{i=1}^{n} x_i = \sum_{j=1}^{n} z_j. \tag{1.3}$$

Letting λ be the Lagrange multiplier on the constraint, the answer to this maximization problem must satisfy

$$\begin{aligned} u_i'(x_i^*) &= \lambda \\ c_i'(z_j^*) &= \lambda \end{aligned} \tag{1.4}$$

along with the feasibility constraint.
But note that these are precisely the conditions that must be satisfied by an equilibrium price $p^* = \lambda$. Such an equilibrium price makes marginal utility equal to marginal cost and simultaneously makes demand equal to supply. Hence, the market equilibrium necessarily maximizes welfare, at least as measured by the sum of the utilities.
In the same spirit, PELPS III by Zhang et al. 1996, calculate a spatial equilibrium in competitive markets by maximizing the sum of producer and consumer surplus subject to material balance and capacity constraints for the forest industry. The optimization finds the production, consumption and trade that maximizes the total value of consumption minus the total cost of production for all products in all countries, in a given year. The objective function for a particular year looks then as follows:

$$maxZ = \sum_i \sum_k \int_0^{D_{ik}} P_{ik}(D_{ik}) dD_{ik} - \sum_i \sum_k \int_0^{S_{ik}} P_{ik}(S_{ik}) dS_{ik} - \sum_i \sum_k Y_{ik} m_{ik} \tag{1.5}$$

where:

$i, k = 1$	country, commodity
$P =$	price in US dollars
$D =$	final product demand
$S =$	raw material supply
$Y =$	quantity manufactured
$m =$	cost of manufacture

Without going into all the technical problems (see for more details Nilsson 1997) of this approach let me give again a few comment to illustrate why such a general equilibrium approach has be ruled out for any reasonable forest industry modeling efforts, not only for the Russian case.

- Assumptions on perfect competition [5] and perfect information
- Identical agents (believes and strategies) and identical technology
- Frictionless markets and no externalities
- Economies of scale
- No policy distortions

There are many more assumptions and each would deserve an entire monograph to be reviewed. Let me end here by simply saying that forest economists for the most part will have to reconsider their profession similar to what macro-economists have to go through

[5] This assumption has been loosened by Ronnilla (1995) for the Finnish pulp and paper industry. The Cournot solution, however, ends finally in a game of perfect competition.

at the moment [6] It is high noon to think about new paradigms in the profession otherwise the entire profession will soon be out-competed by other professions which are more capable to meet the criteria of reality. It becomes increasingly insufficient for academics, who work in the field of forestry and forest industry, to do nothing more than solving a problem of a particular set of linear equations like in the case of the the general equilibrium model.

Let me, however, now return to the question why I choose to develop a new model from scratch using some ideas from auction theory rather than adopting a ready made theoretical framework with easy to use prefabricated commercial computer programs - the black-box doing the miracle for the researcher. To make it clear at this point that the model developed was created on the bases of some ideas from auction theory, but does not built on the theory of auction theory *per se*. The reason for this is that I simulate a multilateral auction where I allow for heterogeneity among buyers and sellers. This is what we find in reality if we want to simulate exchange by auctions in our market setting [7]. Auction theory, is not advanced enough that one could analyze these type of auctions with the help of a sound and clean theoretic basis. Thus, if one would ask the question of what is new in my approach, I would have to answer *"Everything is new! I invented a new economic framework for industry analysis."*. It is also rather difficult to give an answer to the question to which scientific field the model building approach belongs to. I would answer this question by saying that it belongs to operations research and economics. A categorization within the sectoral models on the other hand can more easily be made. In terms of Nabuurs and Paeivinen (1996), my dissertation model belongs to the category of large scale forest sector models. In order to make this point I want to stick to the same methodological structure as presented in Nabuurs and Păivinen (1996) to put my model into the framework of large scale forest sector models.

1.4.3 The PSFIM as a large scale forest sector model

Full name: Pan Siberian Forest Industry Model

SHORT DESCRIPTION OF THE MODEL
The PSFIM was originally designed to model allocation pattern of production in the Siberian forest sector during its transition from a command economy to an economy based on market principles. Due to the implausibility of assumptions built in standard economic models combined with the possibility to link to an extensive resource data base, the modeling strategy was to build an easy-to-understand and easy-to-compute economic model which makes sense and takes maximum use of existing data and expert knowledge. The model is based on Vickery's Nobel Prize Winning auction theory in order to simulate the possible future formation of Russia's forest industrial sector. In the model I distinguish between a static phase and a dynamic one. The static phase describes the auction mechanism, which is applied for each period, leading to a partial market clearing depending on the producer and price constraints. In the dynamic phase, product prices

[6] Many macro-economists, famous names like Paul Romer, start nowadays a PhD course with the words "forget everything you heard so far in your economics classes....".

[7] The word auction can equally be substituted by the term negotiation where the auction setting is used to simulate negotiation behavior reflecting the negotiation power of the agents taking part.

adjust, producers invest or depreciate capital, contract partners revise contract policies and, finally, prices change according to the overall economic development. The model can be used as a decision making tool for policy analysis of various scenarios and levels of detail and is capable to model the entire economic system on the basis of the behavior of individual firms.

METHODOLOGY

Modules of the model

The core of the PSFIM consists of two parts: the static or allocation phase,and the dynamic phase where investment, demand, price and uncertainty levels are determined. There are two additional modules which calculate costs for individual firms and demand for various regions. The model is hirachical in the sense that submodules for the different branches (products) of final consumption are calculated first and the different raw-material suppliers deliver to the wood working mills in a second stage[8]. Due to the simple structure it is possible to simulate individual enterprises that either do trading within the region or do export to other regions. Aggregations can simply be calculated by taking the sum over individual producers.

Input data

Enormous amounts of data [9] from different sources and expert knowledge has been involved in the development of the model. The model is designed that upon the arrival of new knowledge or hard data these information can rapidly be included. In the current version a cost module calculates costs as a function of a number of variables starting from forest inventory information, forest management rules, to harvesting and processing technology. Market information has been taken from Russian and International sources. For example for the analysis of major international markets, FAO data were used [10]. Depending on the study's objective, scenarios will require time series data for the estimation of demand functions. However, different demand scenarios can also be explored if there are no data available by simple guesses or other types of analysis. In addition, the user can specify different types of economic agents. In respect to their behavior agents can differ in regards to their market power and negotiation skills, and in regard to their ability to stick to the terms of the contract negotiated. For a review of all variables and parameters of the model (see section 4.1).

Level of calculation

Calculations are carried out at an individual mill and product level for the respective geographic area analyzed. The geographic area can vary form a small economic region up to the global scale. Likewise, the product definition can be refined to any level depending on the input data quality and the respective questions asked. In this thesis only results for the lumber industry are shown.

[8] In the simulation presented in this thesis illustrating the lumber industry, sawmills are modeled as autarc production units, which means that roundwood is produced by the lumber producer himself i.e. the lumber producer does not need to purchase any roundwood from other producers.

[9] To make this point let me refer to the example that the transportation matrix of the roundwood cost module has a size of 8 MB.

[10] The WWW-page reference is as follows: $http://apps.fao.org/lim500/Agri-db.pl$.

Simulation method [11]

There are no industry wide (regional wide) cost functions. Costs are calculated for individual producers delivering to all possible markets**. Multiple technologies are possible or simply a vector of production costs of individual producers*.
Exchange is simulated not by a very specific class of trade game (i.e. maximization of consumer and producer rent or any other one-sided optimization) but negotiations or auctions are simulated using multiple decision criteria with different negotiation capabilities and market power of individual agents **. Optimization of any kind can be treated and implemented as special cases. In addition to heterogeneity in the cost structure, agents are heterogenous in terms of strategies and reliability**.
Prices and investments adapt as a function of inter alia current and past profits, installed capacities and expected demand *.
Input and output data are linked to a GIS.

Control variables in decision making

See section 4.1.

Method for finding the final solution

Depending on the market or negotiation power of the buyers or sellers the algorithm either allows the buyers purchase at a low price or the sellers sell at a high price. Either the producers or the buyers gain relatively more from the transaction. An increasing price auction with a reserve price is iteratively conducted until either producer or buyer constraints are violated. Due to the nature of the auction set up it is impossible (also theoretically) for the individual agents to compute their optimal strategy in the auction nor is it possible to compute the optimal strategy [12] over periods using an inter-temporal optimization procedure. Nonetheless, the agents behavior tends towards a quasi-optimal state in a distant future period.

RESULTS

Timescale and period length

The model was developed to simulate over an unlimited horizon of projection years. It seems, however, more sensible to limit the simulation to a restricted period of time since we tend to accumulate errors over time with undesirably large prediction errors. Currently the model runs for projections over 10 years in one year time steps.

Output unit

Typically, output is given at an individual enterprise level of the final product. Trade flows between individual agents, prices negotiated by individual bargain, supply slacks, capital formation, profits, investment and many other details can be reported on an individual mill level or be aggregated to regions or macro-regions.

[11] Ideas and solution concepts that are basically new compared to other methods used by the profession are marked by * to ** depending on the degree of "newness"

[12] Please, note that for example short-term profit maximizing behavior of any agent is clearly not compatible with long-term profit maximization. This is true for the model and, as it seems to me, also true in reality.

EXAMPLES AND FUTURE PLANS

The model was until recently under construction and some calibration runs have been carried out to model the forest sector of Siberia. Future plans are to model the global pulp and paper industry, the Russian forest sector and probably analyze some Scandinavian regions. After publishing this dissertation parts of the model will be published in economic and operations research journals. In addition experiments will have to be carried out in order to pin down negotiation behavior across different cultures.

MODEL TECHNICALITIES

Flexibility for dealing with varying levels of decision making and varying geographic scales

The model is based on the behavior and characteristics of individual enterprises. Thus aggregations can be made at any time. At the same time individual units can also be replaced by an aggregate. It will, however, be indispensable to use information on the industrial structure of the aggregates analyzed [13].

Method for linking to the biological subsystem

The model was designed in such a way that it would use the Korovin (1996) model as a sub-module which would predict annual allowable harvest levels and inventory data for individual forest management units. Unfortunately, the Korovin model, in its current version is not capable to 'collaborate' with my model. This is due to some technical incapabilities, unnecessary rigidities and computational constraints of the Korovin model. It is planned to adapt the Korovin model such that it becomes more open and can be integrated into a larger model.

In principle, however, the model can easily integrate any biological model. There is of course a strong preference to integrate a model with a biological sub-module which would model forest ecosystems of the size that would realistically match the level of detail of operations of an individual enterprise.

Method for dealing with international trade

The model analyzes *inter alia* international trade flows. Here factors like transportation costs, loading and reloading costs, tariffs and quotas are included in the analysis. In addition, the model is capable to model differences in the business approaches of different cultures.

Method for dealing with transportation and processing costs

As mentioned before, the transportation system can most realistically be computed. The transportation system, enters the model as an exogenous infrastructure to be used. A GIS system computes the cheapest transportation variant for each individual producer delivering potentially to all markets. The best solution enters the model as the 'used' transportation solution for the individual producer. As means of transportation from the mill, lorries, ships and railways can be used. Transportation to the mill is exclusively modeled by truck transport. Currently there is hardly any timber floated in Russia.

Timber harvesting costs are calculated for individual operations depending on the physical and economic parameters governing harvest operations of the individual enterprise.

[13] This is in principle also true for the currently existing model approaches, however, is largely ignored by the researchers.

Wood processing costs are also calculated on an individual mill level. Processing costs will largely depend on the quality and cost structure of inputs (dimension, species, and cost of roundwood and factor costs) and the capability to exploit economies of scale of the individual enterprises.

Ability for dealing with wood processing capacity and allocation
Processing capacity can be simulated in great detail in the PSFIM. First of all, the model allows for different kinds of technology. There is a possibility to introduce technology choice as a function of the requirements demanded at target market. Let me make this point by referring to the example of a Siberian lumber mill delivering to the European market. The mill will have to use more eco-save and high quality production technology in this case opposed to technology for the production of deliveries to Central Asia. Capacity additions are calculated in such a way that the entire industry composed of individual producers has the tendency to converge to a quasi-optimal solution**. Investments and inherited capacities age through time and if production is allocated in a less competitive environment it may finally close down. Aggregate investment levels have to be supplied exogenously but can also be endogenized. Aggregated investments are then partitioned among perspective producers each period. Partitioning is calculated proportional to the specific investment attractiveness of individual producers.

Ability to take into account environmental effects of wood processing
Environmental effects as such would have to be added by a special module creating a function where pollutant or other adverse environmental effects are modeled in dependence of production output and the technology used [14]. Indirectly, environmental action plans can be included in the cost functions of different technologies. Many environmental problems in the forest sector are of local nature. PSFIM was designed in such a way that such local environmental effects can be included in the analysis.

User friendliness
The current version of the model is programmed in GAUSS 3.0 (1996). There is no user friendly interface implemented.

TECHNICAL REQUIREMENTS
GAUSS 3.0 can either be installed on a PC or on an UNIX machine. It is highly recommended to implement the model on an UNIX system if the seller/buyer matrix exceeds a dimension of 100×100.

1.4.4 Auction theory

The latest Nobel prize in economics was awarded to the honorable economist William Vickery for his findings in auction theory. During the privatization process little attention has so far been given to auction theory in transition economics in almost all transition countries . In this dissertation I use ideas and theories of auctions in order to simulate possible future pattern formation of the forest industrial sector in Siberia. I will not tackle the problem of privatization of former state enterprises with auction theoretic approaches,

[14]Currently such functions are developed by the Author for the Austrian Pulp and Paper industry.

however, more so use these tools to approximate an efficient geographic distribution of the industrial production. In this dissertation I will mainly discuss the analytical structure and concentrate less on numerical results.
Auctions are one of the oldest forms to determine transaction prices. One of the earliest reports on an auction is attributed to the Greek historian Herodotus. He described the sale of women to men willing to get married in Babylonia around the fifth century B.C.. Historical sources tell us about various auctions taking place in Greece, the Roman Empire, China, and Japan. Not only history is witness of this economic institution, but also nowadays auctions are used in a remarkable range of situations. There are auctions for livestock, flowers, antiques, artwork, stamps, wine, real estate, publishing rights, timber rights, used cars, contracts and land, and for equipment and supplies of bankrupt firms and farms, etc.. Auctions are of special interest to economists because they are explicit mechanisms, which describe how prices are formed.
The continuing popularity of auctions makes one wonder about the reasons for this. One explanation is that auctions often yield outcomes that are efficient and stable. Or to say it more formally, in a static deterministic model, the set of perfect equilibrium trading outcomes obtained in an auction game (as the minimum bid is varied) coincides with the set of core allocations.
A second explanation might be that a seller in a relatively weak bargaining position, consider the case where the seller is the owner of a nearly bankrupt firm, can do as well as a strong bargainer by conducting an auction. However, the seller then can not use strategic policies like imposing a reserve price or charging entry fees. Even a seller in a strong bargaining position may decide to sell via auction, if it is optimal in relation to other exchange possibilities. These three partly complementary explanations provide a cogent set of reasons for a seller to use an auction when selling an indivisible object.

The four most common auction forms are the first and second price sealed-bid, the English, and the Dutch auction [15]. Depending on what kind of good is to be sold we talk about private or common values auctions. The private value assumption is mostly satisfied for nondurable goods. This is due to the fact that we can say that the consumption of such a good is a personal matter. In contrast, if we consider durable goods the private value assumption is not fulfilled anylonger. There is the possibility of resale and therefore there is a market price.

Usually the seller and the bidders are assumed to be risk-neutral. Nevertheless there are papers dealing with risk-averse bidders. The same is true for symmetry. Symmetry or asymmetry among bidders means that we have to take into consideration whether the buyers draw their signals from a symmetric or an asymmetric probability distribution. The former implies that all bidders are homogeneous, whereas the latter allows heterogeneity among them.

1.4.5 Description of various auction forms

First and Second-Price Sealed Bid Auction The first-price auction is a sealed bid auction in which the buyer with the highest bid obtains the object and pays the amount

[15] For a closer description on auctions the reader is referred to the following readings of Boeheim and Zulehner 1997, Bulow and Klemperer 1994, Capen, Clapp, and Campbell 1971, Cassady 1967, Davis and Holt 1993, Fudenberg and Tirol, Hendricks and Paarsch 1993, Kagel 1995, McAfee and McMillan 1987, Milgram 1987, Myerson 1981, Paarsch 1991, Wilson 1992 [55].

bid. Whereas in the second-price auction the item still goes to the bidder with the highest bid, but the bidder pays only the amount of the second highest bid. This arrangement does not necessarily mean a loss of revenue for the seller, as in this auction form the buyers will generally bid higher than in the first-price auction. The second-price auction is also known as the "Vickrey" auction.

Dutch Auction The Dutch auction, also called descending auction, is conducted by an auctioneer who initially calls for a very high price and then continuously lowers the price until some bidder stops the auction and claims the good for that price. This kind of auction is frequently used in the agricultural sector.

English Auction There is more than one variant of the English auction. In some the bidders themselves are calling the bids and when nobody is willing to raise the bid anymore the auction ends. Another possibility is that the auctioneer calls the bids and the bidders indicate their assents by a slight gesture. Yet there is another form of the English auction, where the price is posted using an electronic display and is raised continuously. A bidder who is active at the current price presses a button. In the moment the bidder releases the button she has withdrawn from the auction. This variant is in particular used in Japan. These are three quite different forms of the English auction with three quite different corresponding games.

Tender auction Under a tender auction, as referred in the following text we understand an auction where the auctioneer calls a price and sellers announce their quantities they are willing to deliver at that price. It is possible to have a fixed or increasing price tender auction. A combination of the two is also possible where the price increases at first and level off at the end. By this the auctioneer risks to fail the target quantity originally set out for the tender. The auctioneer will of course stop auctioning if the target value is reached.

1.5 Intuitive description of the PSFIM

Siberia is a large piece of land where producers are sparsely scattered. Many times producers are far away from markets of their products. In addition, the entire economic environment has considerably changed after the collapse of the command economy. The problem centers now around the question of how the allocation of production will change during the transition to market economy. Today, economic agents in Siberia act according to different economic paradigms as they were used to under the previous regime. Different decision rules guide economic activities given a framework of changed constraints. Finally, Russia has opened its borders which allows more freedom of capital and trade flows. It is the purpose of the modeling effort presented in this paper to describe the effects of these changes in the Siberian Forest sector.

The first economic activity of business partners in the Forest Industry of Siberia is to establish trade contracts. Imagine now for simplicity a fictitious market hall at a trading point in Russia [16]. A trading point in this sense is located either at one of the Siberian borders for export trade or located at the border to a wood working mill or by some

[16]This image can equally be treated as a traveling sales or purchase agent of the respective organization.

final consumer of finished products. All producers, who due to their competitive position and their available capacities, and who are potentially willing to sell their products are invited to this market hall. In the market hall buyers and sellers meet. Buyers learn about prices and quality of the products producers try to sell. As a side effect of this discussion both buyers and sellers get a grasp of the reliability of their respective possible contract partners [17]. In addition, buyers get to know the geographic location of producers and their productive capacities. By this buyers can make inference on the total cost of delivery for each producer. Generally buyers believe, to some degree, that:

- Reliability and quality of services increase with the profit margin for each producer.
- Buying from a high profit producer today will guarantee cheaper contracts in the future when competition might become stiffer and prices adjust.
- Buyers have the tendency to contract with large (small) firms.
- At a generally low price level producers are more likely to be uncertain contract partner whereas the reliability of buyers increases.
- Only producers who can profitably deliver their products can be reliable contact partners.

Consequently, producers with a relatively high potential profit share and comparative marketing advantages will get larger contracts at a given price.
The second argument following the listing is that if a buyer 'helps' a producer with a relatively high potential profit margin (i.e. low cost producer) to stay in business, this particular enterprise might increase its capacity and will be more likely to be able to decrease product prices in the periods to come if prices generally fall due to changes in market conditions and the bargaining power of buyers increases. This latter point clearly describes a strategic behavior of buyers to decrease expected future costs.
After all of this information is exchanged buyers decide where to buy and give out their orders at the base price. Due to the fact that not all producers are willing to sell off their goods at the base price it is likely that only a portion of the total demanded volume is actually contracted out. Depending on the bargaining power of buyers against sellers, quantities that are given out for tendering in each auction are set exogenously. This is considered to be common knowledge and is taken into account by the buyers when making their offers. After buyers revealed their preferences to the individual producers, depending on their own bargaining power and the producer structure, producers decide to accept, modify or reject proposed offers. Producers, of course, will screen all proposals and will select among them. Most profitable proposals are accepted immediately whereas others will be postponed with the hope to come back to a similar offer when tender prices increased. Some relatively unprofitable proposals will never be accepted.
In the Russian business environment, ordered products might get lost or to some extend

[17] In the model setup it could be agreed that certain consumers would buy timber products from sustainable managed forests whereas others would not change their preferences in dependence of the forest management regime. Thus, certain producers would be required to manage their forests according to certain forest management rules. Sound forest management rules will ultimately result in higher roundwood production costs. In the current version of the model sustainable management of the forest resources is modeled by decreasing productivity from the base productivity, which assumes clear cutting. Productivity is decreased by varying the number of trees removed per hectar. Additionally, world class harvesting equipment is assumed to be used that would guarantee the least ecological impact.

be of bad quality so that not the entire contract volume as originally negotiated is realized. Strategically, producers have the tendency to deliver bad quality if prices are low. Buyers on the other had will postpone payment or complain about delivered quality of the product with increasing prices.

It follows that after the first round of negotiation buyers and sellers have to meet again. Some weeks later the same auction procedure starts over again, however, with increased product prices and different tender volumes. If there are still volumes to be tendered in subsequent auctions product prices rise continuously until either producers run out of capacity or buyers have satisfied their total demand. Any price increase leads to an increasing number of competitors entering the market.

At the end, when no more auctions are conducted, all agents involved analyze past market processes, update their information and develop new strategies for investments, price and contract policies for the next period to come. Policy setting of each individual agent involves analysis of the past as well as expected future market developments including prices, competition, total demand, overall investment climate and uncertainty. Strategies, if feasible in the light of the financial and natural resource conditions, are implemented by each producer. Trading according to the tender mechanism starts again in the following period.

Chapter 2

Mathematical formulation

In the model description I distinguish between a static phase and a dynamic phase. The static phase describes the auction mechanism, which is applied each period, leading to partial market clearing depending on producer and price constraints. In the dynamic phase product prices adjust, producers invest or depreciate capital, contract partners revise contract policies and finally input prices change according to the overall economic development.

2.1 The static phase

In this section I will develop the core of the simulation model, i.e. the auction mechanism. In the auction procedure, buyers start to give out orders to the individual enterprises. The behavior of buyers is described by an allocation rule and an array of constraints. Sellers after receiving offers from different buyers screen all offers and decide which offers they will take, modify or reject.

2.1.1 The buyers' problem

The equation system 2.1 describes the behavioral rule with which buyers determine purchasing proposals to the individual producers [1].
The analytical formula looks as follows [2],

[1]Please note that the index for the product or product group l was dropped for the reason of convenience, however, appears later at some points were we have to differentiate between different product groups.

[2]The following indexes are used:

$e = 1, \dots, E$	Number of eco-regions where enterprises are located
$i = 1, \dots, N$	Total number of enterprises at products market l. (Note that the index sets of i, j, k are again vectors of the dimension $1xL$ for $l = 1, \dots, L$ indexing the number of markets in product space.)
$j = 1, \dots, M$	Number of markets in geographic space
$k = 1, \dots, K$	Number of tender auctions in period t
$t = 1, \dots, T^s$	Number of simulated periods

$$
\begin{aligned}
Y_{ijtk} &= \left(\frac{S_{ijkt}\Omega_{ijt}}{\sum_j(S_{ijkt}\Omega_{ijt})}U^S_{ijtk_Q}\right)(D_{jt}A_{jtk}U^B_{ijtk_Q})\\
&\textit{where}\\
Y_{ijtk} &> 0 \quad \text{if} \quad \begin{cases} Y_{ijtk} & \geq \; Y^{min}_{ij} \\ \sum_k\sum_j Y_{ijtk} & \leq \; \bar{Y}_{it} \\ \sum_k\sum_i Y_{ijtk} & \leq \; D_{jt} \\ C_{ijt} & \leq \; \bar{P}_{jtk}U^B_{ijtk_P} \\ \sum_k\sum_i\sum_j Y_{ijetk} & \leq \; \bar{R}_{et} \end{cases}\\
Y_{ijtk} &= 0 \quad \text{if} \quad else.
\end{aligned} \tag{2.1}
$$

Y_{ijtk}	...Output of producer i which is delivered to market j at time t in k^{th} tender
S_{ijkt}	...Service coefficient of producer i at market j in k^{th} tender at time t (see equation 2.2)
Ω_{ijt}	...Coefficient of comparative non-technological scale effects of producer i at market j at time t (see equation 2.5)
$U^S_{ijtk_Q}$	... Contract uncertainty of seller. Random number drawn from a uniform distribution for market j with $E(U^S_{ijtk_Q}) = \xi^{QS}_{jt}$ and $VAR(U^S_{ijtk_Q}) = \sigma_{\xi^{QS}_{jt}}$ at time t. (see section 2.2.4)
D_{jt}	...Total tender volume at market j at time t
A_{jtk}	...Parameter determining the size of tender volumes for the k^{th} auction at market j at time t. $A_{jtk}\epsilon]0,1]$
$U^B_{ijtk_Q}$	... Contract uncertainty of buyer. Random number drawn from a uniform distribution for market j with $E(U^B_{ijtk_Q}) = \theta^{QB}_{jt}$ and $VAR(U^B_{ijtk_Q}) = \sigma_{\theta^{QB}_{jt}}$ at time t (see equation 2.3 and section 2.2.4).
$\bar{Y}_{it}$	... Production capacity of producer i at time t.
Y^{min}_{ij}	...Minimum contract size. $Y^{min}_{ij}\epsilon\Re^+$
C_{ijt}	...Unit production cost (CIF) of producer i at time t to market j
$\bar{P}_{jtk}$	...Vector of maximum total cost at market j where transaction is allowed at time t in k^{th} iteration
R_{et}	...Biological resource constraint (AAC [3]) in ecoregion e at time t

The allocation rule,[4] the first line in equation 2.1, consists of four main driving forces. They are the ability to provide additional services, demand, market position and contract uncertainty.

Let me start with the ability to provide additional services. Services can only be provided by producers which can actually afford to do so. In this respect the ability to provide additional services is a direct function of the profit per unit output of the respective seller who would sign a contract to deliver to a certain market as described in equation 2.2.

$$
\begin{aligned}
S_{ijkt} &= \pi^{\eta_{jt}}_{ijkt}\\
&= (\bar{P}_{jtk}U^B_{ijtk_P} - C^P_{it}U^C_{it} - C^T_{ijt})^{\eta_{jt}}
\end{aligned} \tag{2.2}
$$

[4]The allocation rule in its current formulation is provisional. First the elements are obviously highly collinear and should be premultiplied by the variance-covariance matrix in order to yield an eucledian space. The weights will have to be adjusted accordingly. We are currently testing various risk metric approaches. Contracts should then be tendered according to risk/benefit ratings of individual companies.

π_{ijkt} ... Profit per unit output for producer i delivering to market j at time t in the kth auction.

$U^B_{ijtk_P}$ ... Price uncertainty of buyer. Random number drawn from a uniform distribution for market j with $E(U^B_{ijtk_P}) = \theta^P_{jt}$ and $VAR(U^B_{ijtk_P}) = \sigma_{\theta^P_{jt}}$ at time t.

C^P_{it} ... Production cost per unit output of producer i at time t

U^C_{it} ... Random variable drawn form a truncated normal distribution with $E(U^C_{it}) = \gamma_t \leq 1$ and $VAR(U^C_{it}) = \sigma^C_t$ at time t

C^T_{ijt} ... Transportation cost per unit for producer i to market j at time t

η_{jt} ... Degree of profit maximization at market j at time t with $\eta_{jt} \epsilon \Re^+$

Including profits per unit of output, π_{ijkt}, in the service equation help to describe a type of 'cost minimizing' behavior of buyers. Although in the model buyers are purchasing the product at the current tender price, $\bar{P}_{jtk}$, costs are minimized in the sense that (1) additional services are provided free of charge, (2) a least cost seller is more reliable in keeping the terms of the contract, and (3) that expected future price for a product of a low cost producer might adjust to the competitive price (i. e. $E_t(\bar{P}_{jTk^*} = C)$) if the business environment becomes more price competitive. The probability, if we were to see the problem in a probabilistic context [5], that an enterprise will deliver its products to a particular market increases exponentially, η_{jt}, with the profit per unit output of the individual enterprises to be earned on this market. The production costs *per se* are allowed to vary additionally to the variation according to the calculations described in section 3.1. This additional variation follows the law of a normal truncated distribution, $U^C_{it} = N^t r(\gamma_t, \sigma^C_t)$ and should reflect differences among producers in production costs due to *inter alia* unobserved variables such as management skills and efficiency of the work force employed. In addition, buyers can only marginally deviate from the 'official' tender price and make special offers to individual producers. This is achieved by adding some random noise, $U^B_{ijtk_P}$, to the current tender price $\bar{P}_{jtk}$.

The second variable to be discussed concerning the allocation rule is demand. In the model, demand is a $1 \times K$ vector, with K being the number of markets. This vector sets the upper limit of volumes to be traded at a particular trading point. Thus demand can be interpreted as the maximum export volume at a particular export trading point or maximum domestic consumption at one of the domestic trading points. The elements of the vector are either estimated with the help of econometric models as discussed in section 3.2 or are simply estimated by per capita consumption growth and population growth assumptions. The probability that a producer delivers to a certain market is linear to the size of the market [6]. In the first tender, $k = 1$, a portion, $D_{jt1}A_{j1}$, of demand is given out to be tendered. In the second tender, $k = 2$, another portion of the remaining

[5] In principle there are several other options available to obtain an equilibrium at the k^{th} auction. One could either take a general equilibrium approach were producer and consumer surplus are maximized or one could either maximize for the buyer or the seller as shortly discussed in the following paragraph on optimal behavior. The beauty of the probabilistic approach is, however, that multiple criteria can be optimized.

[6] If we loosen up the linearity assumption, this would mean that a collection of producers or even all producers like particular markets better than others. This market behavior can be implemented by either increasing the demand of the preferred market in the allocation rule while keeping the demand in the constraint set to the original value. This would mean that producers actually over- respectively underestimate the true size of the market. The other way to introduce differences in the preferences of a subset of producers would be to introduce a preference matrix adjusting for the differences. A deviation from the linearity assumption could be motivated by the existence of stake effects - a well known result in empirical economics.

demand, $D_{jt2}A_{j2}$ for $D_{jt2} = D_{jt1} - \sum_i Y_{ijt1}$, is given out. In the following periods tender volumes at particular markets are calculated likewise. Remaining demand in period t is calculated by $D_{jtk} = D_{jtk-1} - \sum_i \sum_1^{k-1} Y_{ijtk}$.
Further, the model allows to mimic market power. If A_{j1} is close to unity, low cost producers are 'forced' by the model to sell off their products earlier in the auction. By this a powerful buyer is able to purchase a product at a relatively low price. The effect of A_{jk} can, however, also be interpreted from the sellers point of view. If A_{j1} is relatively high, low cost producers are willed to sell their products earlier in the auction. They might fear to have too many additional bidders in the next rounds, $k+1, k+2, \ldots$, which would decrease their market share and might also lower the overall profit of the individual producer. Being in the position of owning a large market share has some utility. If the utility of having a high market share is larger than the utility of producing at maximum profits at time t, A_{j1} becomes also a measure of an inter temporal rate of substitution with the implication that a rational acting agent would set off lower profits today with expected higher profits in the future, due to the producer's market position, if the accumulated discounted profit stream is maximized given the producer's information set at time t. Following this line of arguments we find that high market power (i.e. $A_{j1} \rightarrow 1$) on the buyers side can equivalently be treated as a fierce competitive environment among producers. Due to heterogeneity among producers a more competitive environment i.e. high bargaining power on the buyers side, will eventually lead to a concentrated producer structure by the model. A weak market position of buyers would contrarily allow producers with relatively higher costs stay longer in a particular market. As a result, weak market power will lead to higher variance in prices and a less concentrated, but inefficient, producer structure. A_{jk} has to be set exogenously and has to be determined according to the ability of a particular buyer to purchase products on the international market.
In each tender the calculated potential contract volume is multiplied by two random numbers $(U^S_{ijtk_Q}, U^B_{ijtk_Q})$ drawn from two uniform distributions. The parameters θ_{jt} and ξ_{jt} determine the lower (*Low*) and upper (*Up*) bound of the uniform distribution. The description of how the parameters adjust has to be postponed at this stage and is described in detail in section 2.2.3. This is due to the fact that the change in contract uncertainty is dependent on the current market price, which we did not discuss yet. The strategies concerning contract reliability are different for buyers and sellers. Buyers will be more interested in acting according to the contract if the price level is relatively low. Sellers on the other hand will try to be more reliable if prices are high. In the current version of the model contract reliability from the sellers side only affects the size of the contracts. This is to say that the volumes, that would have been traded based on the assumptions we made on all other variables in the allocation rule, are multiplied by a number drawn from the uniform distribution determined by ξ_{jt}. This essentially reflects the sellers doubts that the potential buyer is able to pay the price agreed upon or the unwillingness to accept other items in the contract. Contract uncertainty from the buyers' side can influence both the size of the contract proper by changing θ^C_{jt}, or change the price which the buyer might suggest to the individual seller by changing θ^P_{jt}. Thus the contract uncertainty from the buyer's side also influences the profitability of producers. The interpretation is such that if a buyer judges that a certain producer is reliable the buyer will give him/her a higher price and a larger contract volume. Thus the buyer charges a risk premium or gives it to the seller depending on the judgment. In this case the influence on price and size go together with the buyers judgment of the sellers reliability. The dependence between

these two types of contract uncertainty is expressed in equation 2.3

$$\theta^P_{jt} = \vartheta\theta^C_{jt} \qquad \text{for } \vartheta\epsilon\Re^+. \tag{2.3}$$

The market success of each individual producer is now dependent on the marketing strategy and the reliability of both partners involved in the trading procedure. By introducing uncertainty this modeling approach allows, for example, that a producer despite the fact of an inefficient and expensive production scheme is successfully marketing its products. This is in fact what we see in many markets not only in Russia.

Economic elements which are not directly related to technology like market dominance or formal or informal producer networks also play an important role in the dynamics of the Russian Forest Industry of today. These effects are subsumed in the term 'non-technological scale effects'(Ω_{ijt}). There are mainly three reasons to speak of 'non-technological' scale effects:

1. Scale effects in marketing and trading activities [7]
2. Market power of producers increases with size.
3. Large enterprises tend to produce higher quality.

Ω_{ijt} within the model is formulated as follows,

$$\Omega_{ijt} = \left(1 + \frac{\bar{Y}_{itx}^{\alpha_{jx}}}{\sum_j \bar{Y}_{it}^{\alpha_{jx}}}\omega_{jt}\right) \tag{2.5}$$

$\bar{Y}_{itx}$ ... Production capacity of producer i at time t of technology x.
α_{jx} ...Degree of non-technological scale effects for technology x. $\alpha_{jx}\epsilon\Re$
ω_{jt} ...Coefficient non-technological scale effects at market j at time t. $\omega_{jt}\epsilon\Re^+$

The degree of scale effects within the set of eligible producers delivering to a certain market is modeled by changing the parameter α. The scale effect $Scale_i$ is,

$$Scale_i = \begin{cases} \text{decreasing} & \text{if } \alpha < 0 \\ \text{constant} & \text{if } \alpha = 0 \\ \text{increasing} & \text{if } \alpha > 0. \end{cases}$$

The overall effect of 'non-technological scale effects' on product allocation, i.e. relative change of volumes allocated due to the 'non-technological scale effects' is determined by the coefficient ω_{jt}. One could call ω_{jt} the elasticity of 'non-technological scale effects' in this sense.

The initial endowment of productive capacities is given and defined by the production

[7] In the current version of the model the existence of Financial Industrial Groups (FIGs) is ignored. Currently there is not sufficient information available on membership of individual enterprises belonging to a FIG. If this information would be available we would include this information as follows:

$$\omega_{jt} = \omega_{i^*jt} = \omega_{jt}I^{FIG} \tag{2.4}$$

I^{FIG} is an information matrix creating the sum to the respective FIG. In our case $I^{FIG} = e_i * e_j$ suggesting that there are no FIG existing.

output in 1989. In subsequent periods when producers are allowed to expand capacities, production capacity $\bar{Y}_{itx}$ is made up of two parts as discussed in section 2.2. I differentiate between capacities from old technology ($\bar{Y}_{itx}^{O}$) which is essentially the capacities inherited from the past and newly added capacity ($\bar{Y}_{itx}^{N}$) via investment [8]. As we are to model non-technological scale effects as discussed above we put a stronger weight on new technology i.e. in terms of market success of products produced by new technology, on a relative basis, are more competitive than products produced by old technology. Thus we can write the composite of old and new technology as $\bar{Y}_{itx} = \nu_{jt}\bar{Y}_{itx}^{N} + (1-\nu_{jt})\bar{Y}_{itx}^{O}$ for $\nu_{jt}\epsilon]0.5, 1]$.

The allocation rule is subject to a number of constraints. These constraints are the size constraint of contracts, capacity constraint, demand constraint, constraint on the profit level and a natural resource constraint for logging operations.
Contracts calculated by the allocation rule have to be over a minimum size Y_{ij}^{min}. In the model the minimum size will be treated as a multiple of a rail container volume.
The second line in the constraint set of equation 2.1 describes the capacity constraint. This is that the sum of accumulated production dedicated to all markets of an individual enterprise is not allowed to exceed its capacity. The capacity of each individual enterprise was, for simplicity, set equal to the production output in 1989 as already mentioned. This might, in fact, be a rather weak assumption, however, reflects the current state of information. Additionally, it is widely accepted among local and international experts (pers. comm. Nilsson, Backman, Blam 1997) that this is the best currently available indicator for capacity levels of individual enterprises. In this respect an information update on the physical capacities should be performed to make better predictions. A time series on capacity evolution would also be of great importance to improve the quality of the model calibration exercise [9]. In cases where $\sum_k \sum_j Y_{ijtk} \geq \bar{Y}_{it}$ with $\sum_k \sum_j Y_{ijtk-1} \leq \bar{Y}_{it}$ contract volume was set to $Y_{ijtk} = \sum_k Y_{ijtk-1} + (\bar{Y}_{it} - \sum_k \sum_j Y_{ijtk-1}) Ind$. Ind is an indicator matrix for the direction of trade.
The third line in the constraint set describes the demand constraint. This is basically saying that the sum of accumulated realized production of all enterprises dedicated to a certain market can not exceed demand at this particular market.
The fourth line opens up the possibility to simulate supply side market imperfections via price settings. In essence this constraint forces all producers to be under a certain price benchmark in each iteration, k, in order to be able to compete at a certain market. From a supplier point of view this constraint tries to mimic the profit level where producers are still willing to market her/his product on a given market. If the total costs exceeds the price level, $\bar{P}_{jtk}$, it is too unprofitable to deliver to the respective markets. In the current

[8] Note that in terms of technology and finally costs per unit output the two technologies are identical. This is due to the fact that currently it is virtually impossible to obtain sensible productivity and cost functions for Russian technology. We know, however, that Russians are somewhat indifferent in their technological choices suggesting that cost functions are similar. This assumption might, however, be rather strong and needs to be scrutinized for further modeling efforts. From a model building point of view it would not be difficult to model sets of different technologies producing the same good. In addition, the question arises which assumption should be made on technological choice for future production. In the case of logging operations, however, it will be necessary to introduce different technologies for different ecological and terrain conditions. Existing engineering models could be used for this particular task in combination with preference functions of Russian entrepreneurs.

[9] In the case of round wood production this is especially important in the light of the ever increasing use of the Wachter system in logging operations. The Russian expression Wachter system can be understood as temporary logging champs. In addition the lifespan of logging equipment is rather short in Russia.

setting it would also be possible for producers to enter the market with dumping prices. This, however, was not included in our simulation runs. Prices are initially set according to the available statistics.
The fifth line in the constraint set constrains the total output of all producers to be less or equal to the Annual Allowable Cut (AAC). Let us call this constraint for now the sustainability condition.

2.1.2 The sellers' problem

After buyers revealed their offers to their potential set of sellers each individual seller decides which offer he/she will accept, modify or reject. The seller will accept the offer if it comes from the buyer which guarantees the highest returns, will modify, i.e. decrease the contract size, if it comes from a buyer which would result in lower marginal profits and will reject if the offer would yield marginal profits that would not justify delivery. In the latter case the seller believes that she/he would be able to sell again with higher yield in a tender to come [10] [11].

$$Y_{ijkt} = \begin{cases} Y_{ijkt} & \text{if } \pi'_{ijkt} = \pi'^{*}_{ijkt} \\ Y_{ijkt}(\frac{\pi'_{ijkt}}{\pi'^{*}_{ijkt}})r_l & \text{if } \pi'_{ijkt} \leq \pi'^{*}_{ijkt} \text{ and } Y_{ijtk}(\frac{\pi'_{ijkt}}{\pi'^{*}_{ijkt}})r_l \geq Y_{ij}^{min} \\ 0 & \text{if } \pi'_{ijkt} < \pi'^{*}_{ijkt} \text{ and } Y_{ijtk}(\frac{\pi'_{ijkt}}{\pi'^{*}_{ijkt}})r_l \leq Y_{ij}^{min} \end{cases}$$

2.1.3 Optimal behavior

From a theoretical point of view the numerical calculation would converge to an optimal solution of the allocation pattern of production for the buyer if the buying / selling uncertainties, $(\sigma_{\xi^{QS}_{jt}}, \sigma^{(\cdot)}_{\theta}, \sigma^{C}_{t}) \to 0$, would converge to zero, the coefficient of profit maximization, $\eta \to \infty$, approach infinity and, all of the volume would be given out for tendering in the first tender (i.e. $A = 1$ equal unity), the price increase be infinitely small but still be positive (i.e. $\Delta \bar{P}_{jtk} \leq \varepsilon$), and the number of auctions within a period, $K \to \infty$ be allowed to be allowed to be infinitely large such that all potential capacity could be used.
For the calculation of the quasi-optimal state as illustrated in equation 2.14 I have set the coefficients and parameters according to this reasoning.
Producers are allowed to optimize only within an individual tender. They are not able to optimize within the framework of all tenders within a period and are further not able to optimize in time across periods.
Given the present uncertain economic environment and given the rather poor enterprise information the parameter values of the model will not be in a close neighborhood of the optimal values, however, will converge slowly towards an optimum. This type of model was constructed to allow agents to act according to an optimizing behavior, but only to a certain extend. The optimizing behavior *per se* is not scrutinized, but the degree

[10] Here we make the assumption that sellers are not able to compute their optimal strategy to maximize profits for the entire auction procedure. Sellers are not able to foresee quantities that will be offered to them in the next round(s) and periods.

[11] The prime in π'_{ijkt} indicates that the seller selects offers from feasible contract partners only. Feasibility is defined by the constraint set 2.1. π'^{*}_{ijkt} indicates the maximum marginal profit out of the feasible set of contracts.

of optimization or optimizing behavior of the agents. This is probably the most distinguishing feature of the used approach in relation to standard models used in economics and operations research. Thus, this is the beauty but also the weakness of the modeling approach taken. The quality and the usefulness of the results hinge on the calibration of the model. We are truly opening Panthoras box allowing for a lot of arbitrary inputs. The trick is to open Panthoras box in a controlled manner.

2.2 The dynamic phase

In the dynamic phase we calculate changes in capacity following different investment regimes, prices are allowed to adapt according to expected demand and supply scenarios, maximum potential demand is forecasted and costs change according to input price and technology scenarios. Not all of the variables mentioned are fully endogenized. There are two main reasons for this. First, by endogenizing one buys also a lot of assumptions that have to be made. Second, by endogenizing one looses to some extend control over what the variable does in the model and finally some variables are by nature truly exogenous. Demand is probably the most important variable that was not fully endogenized. The difficulty that arises if we were to endogenize demand is for example that we would have to estimate cross-price elasticities with competing goods to assess changes in market shares. Such an exercise would demand mass data of the target market if we were to analyze a market economy with the standard econometric tools. In the case of a formerly command oriented economy the analyst might have to resort to other estimation methods. Just imagine given reasonable and defendable answers to the question of how much the market share on the Chinese import lumber market would change if the import price of Russian lumber price were 10% lower than that of its competitors. Such considerations and many others have left me convinced that the role of demand should be analyzed by scenario analysis and not be pinned down by clever reasoning using complicated response functions based on probably weak and hardly defendable assumptions and few data.
The art of making the static model dynamic is determined by transition conditions for the endogenized variables and finding the appropriate scenarios for the exogenous variables. For the latter it is also important to take the interdependence of the variables into account. We decided not to use a Markow switching model, in the narrow sense, to describe the formation of new capacity. In our particular context, a Markov switching model in a narrow sense could briefly be described in the way that variables after the static phase are adjusted by a transition matrix determining the evolution of the respective variable over time. Each element in the transition matrix has a statistical distribution. If we were to apply transition matrices of that sort we would to some extent loose control over the model. Moreover, we need to consider the fact that we already used uncertainty in the static model. Another reason, which is more connected with investment is that the possible user should implicitly model investment uncertainty by playing with the parameters driving investments. One can argue that contract uncertainty, modeled by $(\sigma_{\xi^{QS}_{jt}}, \sigma^{(.)}_{\theta}, \sigma^{C}_{t})$, is a one-to-one correspondence to investment uncertainty. Intuitively this is to say that if a contractor or a contractee is unreliable in a trading procedure as described in the static phase he/she will be an unreliable investment partner resulting in project failures. Following this line of interpretation we face a Markov switching model in a wider sense, where the project failure rate is modeled implicitly by the set-up of the contract procedure of product delivery.

2.2.1 Investment and capacity changes

The first element to be discussed in greater detail is investments. Investment and divestment bring about an adaptation of the allocation pattern of productive capacities due to changes in the economic conditions. Investment should reflect the current and expected economic situation. Mainly two questions are of interest when discussing investment. "Where and when should one invest?"is to be answered. In the model approach these questions are related to a number of variables. Investment is related to the current allocation of capacity, the current supply pattern, current and expected profitability, strategic capital targeted to particular markets, and a number of behavioral patterns like the willingness of producers to reinvest in the same activities. In the model transition conditions for capacity changes from t to $t+1$ are described by[12],

$$\bar{Y}_{it+1} = \bar{Y}_{it} + \Delta\bar{Y}^{i}_{it} - \Delta\bar{Y}^{d}_{it}. \tag{2.6}$$

In the current version of the model three separate investment cycles have to be taken into account. There are two independent investment cycles and divestment. Capacity that will be available to each producer in the up-coming period, $\bar{Y}_{it+1}$, is made up of the sum of already existing capacities, $\bar{Y}_{it}$, plus capital additions determined in the dynamic phase,$\Delta\bar{Y}^{i}_{it}$, minus capital assets $\Delta\bar{Y}^{d}_{it}$ that are depreciating due to over capacity of a particular producer. Capacity additions or investment cycles are again the sum of two parts. The first being capital generated by own profits, as described in equation 2.7. Equation 2.7 shows the potential investment generated by own resources. However, the potential set by investment from the 'cash flow' has to be adjusted by a constraint set as described in equation 2.10.

$$\begin{aligned} i^{\pi}_{it} &= \sum_{1}^{t}\beta_t(\sum_{j}(\pi_{ijt}\varrho_t) - \sum_{1}^{t-1} i^{\pi}_{it}) = \\ &= \sum_{1}^{t}\beta_t(\sum_{j}(\sum_{k}\varrho_t(Y_{ijtk}(\bar{P}_{jtk} - (C_{P_{ijt}} + C_{T_{ijt}}))) - \sum_{1}^{t-1} i^{\pi}_{it}) \end{aligned} \tag{2.7}$$

Equation 2.7 says that the potential set of capital addition, i^{π}_{it}, that stems from own resources is calculated by the discounted difference of total accumulated profits dedicated to the product,$\sum_1^t(\sum_j \pi_{ijt}\varrho_t)$, and past production related capital investment expenditures $\sum_1^t i^{\pi}_{it}$. The discount factor, i.e. interest rate, is denoted as β_t. Total accumulated profits, $\sum_1^t(\sum_j \pi_{ijt}\varrho_t)$, are calculated by the assumption that a portion ϱ_t of profits generated each year is not reinvested in new productive assets, but in other projects [13]. ϱ_t is allowed to vary over time as indicated by the subscript. Initial profits ($\sum_j \pi_{ijt=0}$) and initial investments ($i^{\pi}_{it=0}$) were set equal to zero in the model.
The second component of investments is foreign (extra-enterprise) venture capital. This foreign investment is distributed among enterprises that still have a future market potential, measured as their market position at the stage T (see equation 2.14), at a given market. Total foreign investment capital, I^{f}_{jt}, targeted to market j in period t is distributed

[12] Notational remark: If one of the subscripts is dropped this means that the sum in reference to the dropped subscript is calculated i.e. ,$\bar{Y}_{iT} = \sum_j \bar{Y}_{ijT}$.

[13] At various visits to enterprises of the forest industry of Russia it was observed that large portions of capital generated evaded the country or were invested in leisure projects or other non-product related investments.

among the i competitors for foreign investment capital according to their relative difference in the market potential $((Y_{iT} - \bar{Y}_{it}))$. In this set up, for example, a currently small producer close to Vladivostok is more likely to receive venture capital additions than a currently larger producer in Yakutia [14].

$$
\begin{aligned}
i^f_{ijt} &= \frac{(Y_{ijT} - \bar{Y}_{ijt})}{\sum_i (Y_{ijT} - \bar{Y}_{ijt})} I^f_{jt} \\
&\text{where we define} \\
\bar{Y}_{ijt} &= \frac{Y_{ijt}}{\sum_j Y_{ijt}} \bar{Y}_{it}
\end{aligned}
\tag{2.8}
$$

In order to calculate the difference between the future market position evaluated at time t, Y_{ijT}, and the current capacity, $\bar{Y}_{it}$, for each individual market, capacities were distributed according to their current supply scheme as shown in the second line of equation 2.8.
The two investment components, i^{π}_{it}, i^f_{ijt} , are still in monetary units and need to be converted into physical capital units. This is shown in equation 2.9 where the monetary units are divided by the unit cost of productive capacity, C^{cap}_{jlt}, of product l and market j at time t.

$$
\Delta\bar{Y}^i_{it} = \sum_j \Delta\bar{Y}^i_{ijt} = \sum_j \frac{(i^{\pi}_{ijt} + \sum_j i^f_{ijt)}}{C^{cap}_{jlt}} \tag{2.9}
$$

The constraints for investment, as shown below 2.10, require that out of the set of potential investment projects, i.e. the collection of all $\Delta\bar{Y}^i_{it}$, only projects of sufficient size are allowed [15]. Further it is demanded that projects must be prospective in the sense that supply at the 'optimal' allocation (Y_{iT}) is larger than todays capacity $(\bar{Y}_{it})$.

$$
\Delta\bar{Y}^i_{it} > 0 \leftrightarrow \pi_j + i_j > 0 \leftrightarrow \begin{cases} \Delta\bar{Y}^i_{it} & \geq \Delta Y^{min} \\ (Y_{iT} - \bar{Y}_{it}) & > 0 \end{cases} \tag{2.10}
$$

In cases where the capital addition is greater than the difference to the optimal supply allocation, i.e. $\Delta\bar{Y}^i_{it} \geq (Y_{iT} - \bar{Y}_{it})$, I set the investment volume equal to the difference between the capacity of today and supply at the 'optimal' state at time T plus an additional allowable volume for overshooting. We will denote this latter circumstance by $\Delta\bar{Y}^i_{it} = (Y_{iT} - \bar{Y}_{it}) + \Delta Y^o$ where ΔY^o denotes the allowable volume for overshooting.
$\Delta\bar{Y}^d_{it}$ defines the lost capital stock due to excess capacity and depreciation of Soviet type technology, $\bar{Y}^O_{it}$, of producer i. Excess capacity occurs if capacity that was inherited or built over time is not employed due to the economic supply and demand scheme as calculated by equation 2.1. Physical excess capacity depreciates at rate δ_t where $\delta_t < 1$. Due to the fact that the old Soviet type technology, $\bar{Y}^O_{it}$, is in most cases worn out and can not be maintained even if used already, these old capacities 'naturally' depreciate at a rate of $\delta^*_t \leq 1$.

$$
\Delta\bar{Y}^d_{it} = (\bar{Y}_{it} - \sum_j Y_{ijt})\delta_t + \bar{Y}^O_{it}\delta^*_t \tag{2.11}
$$

Investment and loss of physical assets mutually exclude each other. This I try to illustrate in 2.12. Here I simply state that if depreciation is larger than zero, investment activities

[14]This of course is only true if α^T_t is sufficiently small at time t which will be the case in all scenarios.
[15]For ΔY^{min} is demanded that $\Delta Y^{min} \geq 1$

are canceled for this particular year and if the enterprise actively is allowed to invest no depreciation according to our definition can take place.

$$\begin{aligned} \Delta\bar{Y}^d_{it} > 0 \leftrightarrow \pi_j + i_j = 0 \leftrightarrow \Delta\bar{Y}^i_{it} = 0 \\ \text{this implies that} \\ \Delta\bar{Y}^i_{it} > 0 \leftrightarrow \Delta\bar{Y}^d_{it} = 0 \end{aligned} \tag{2.12}$$

The final constraint for capacities is that they are bounded from below as depicted in 2.13. This is motivated by the believe that an enterprise needs to be of a certain minimum size, $\bar{Y}^{min}$, in order to stay in business. The criteria for the selection of the proper $\bar{Y}^{min}$ can be based on either technological or economic reasoning. Another strategy for the appropriate selection of $\bar{Y}^{min}$ would be to consult existing data.

$$\bar{Y}^{min} \geq \bar{Y}_{it+1} \tag{2.13}$$

2.2.2 The 'quasi-optimal' supply pattern at time T

The calculation of the quasi-optimal state, in equation 2.14, follows exactly the same procedure as discussed in the static phase. Parameters are adjusted such that the quasi-optimal state, at time T, are set according to the considerations discussed in the paragraph of optimal behavior in section 2.1. The quasi-optimal state is permanently updated as the exogenous variable cost, determining costs at time T, is a function of costs at time t i.e. $C_{P_{iT}} + C_{T_{ijT}} = f^{cp}(C_{P_{it}}) + f^{ct}(C_{T_{ijt}})$.Further, Ω_{ijT} changes in each period since current capacities change from one period to the other. This causes some inertia in the evolution pattern of capacity building and is motivated by the fact that producers can base their decisions on information that is available at time t. Thus the effects of technological / price shocks and changes in the competitive position of enterprises can not be anticipated by the agents. The optimal solution for the buyer is computed as follows,

$$\begin{aligned} Y_{ijTk} &= \left(\frac{\pi^{\eta_{jT}}_{ijkT}\Omega_{ijT}}{\sum_j(\pi^{\eta_{jT}}_{ijkT}\Omega_{ijT})}U^S_{ijT_Q}\right)(D_{jT}A_{jTk}U^B_{ijTk_Q}) = \\ &= \left(\frac{(\bar{P}_{jTk}U^B_{ijTk_P} - C^P_{iT}U^C_{iT} - C^T_{ijT})^{\eta_{jT}}(1 + \frac{\bar{Y}^{\alpha_j}_{it}}{\sum_j \bar{Y}^{\alpha_j}_{it}}\omega_{jT})}{\sum_j((\bar{P}_{jTk}U^B_{ijTk_P} - C^P_{iT}U^C_{iT} - C^T_{ijT})^{\eta_{jT}}(1 + \frac{\bar{Y}^{\alpha_j}_{iT}}{\sum_j \bar{Y}^{\alpha_j}_{iT}}\omega_{jT}))}U^S_{ijTk_Q}\right)(D_{jT}A_{jTk}U^B_{ijTk_Q}) \end{aligned}$$

where

$$\begin{aligned} Y_{ijtk} &> 0 \quad \text{if} \quad \begin{cases} Y_{ijtk} & \geq \; Y^{min}_{ij} \\ \sum_k\sum_j Y_{ijTk} & \leq \; \bar{Y}_{iT} \\ \sum_k\sum_i Y_{ijTk} & \leq \; D_{jTk} \\ C_{P_{iT}} + C_{T_{ijT}} & \leq \; \bar{P}_{jTk}U^B_{ijTk_P} \\ \sum_k\sum_i\sum_j Y_{ijeTk} & \leq \; \bar{R}_{eT} \end{cases} \\ Y_{ijTk} &= 0 \quad \text{if} \quad else. \end{aligned} \tag{2.14}$$

Y_{ijTk} ... Output of producer i which is delivered to market j in the quasi-optimal state T in k^{th} tender

π_{ijkT} ... Unit profit of producer i at market j in k^{th} tender at the quasi-optimal state T

Ω_{ijT} ... Coefficient of comparative non-technological scale effects of producer i at market j at the quasi-optimal state T

C_{iT}^{P} ... Unit production cost of producer i at the quasi-optimal state T

U_{iT}^{C} ... Random variable drawn form a truncated normal distribution with $E(U_{iT}^{C}) = \gamma_t \leq 1$ and $VAR(U_{iT}^{C}) = \sigma_T^C$ at time T

C_{ijT}^{T} ... Transportation cost per unit for producer i to market j at time T

η_{jT} ... Degree of profit maximization at market j at time T. $\eta_{jT} \epsilon \Re^+$

ω_{jT} ... Coefficient non-technological scale effects at market j at time T. $\omega_{jT} \epsilon \Re^+$

A_{jTk} ... Parameter determining the size of tender volumes for the k^{th} auction at market j at time T. $A_{jTk} \epsilon]0, 1]$

$U_{ijTk_P}^{B}$ ... Price uncertainty. Random number drawn from a uniform distribution for market j with $E(U_{ijTk_P}^{B}) = \theta_{jT}^{P}$ and $VAR(U_{ijTk_P}^{B}) = \sigma_{\theta_{jT}^{P}}$ at time T.

$U_{ijTk_Q}^{B}$ ... Contract uncertainty of buyer. Random number drawn from a uniform distribution for market j with $E(U_{ijTk_Q}^{B}) = \theta_{jT}^{QB}$ and $VAR(U_{ijTk_Q}^{B}) = \sigma_{\theta_{jT}^{QB}}$ at time T.

$U_{ijTk_Q}^{S}$ ... Contract uncertainty of seller. Random number drawn from a uniform distribution for market j with $E(U_{ijTk_Q}^{S}) = \xi_{jT}^{QS}$ and $VAR(U_{ijTk_Q}^{S}) = \sigma_{\xi_{jT}^{QS}}$ at time T.

D_{jT} ... Total tender volume at market j at time T

$\bar{Y}_{iT}$ ... Production capacity of producer i at time T of technology l.

α_j ... Degree of non-technological scale effects. $\alpha_j \epsilon \Re$

Y_{ij}^{min} ... Minimum contract size. $Y_{ij}^{min} \epsilon \Re^+$

$\bar{P}_{jTk}$ ... Vector of maximum total cost at market j where transaction is allowed at time T in k^{th} iteration

R_{eT} ... Biological resource constraint (AAC) in eco-region e at time T

Overall, the set-up of dynamics of the model is very similar to a standard inter temporal stochastic optimization procedure solving time-continuous stochastic optimization problems. The distinguishing feature of equation array 2.12 is that we do not necessarily arrive at an optimal solution in T, however, there is a persisting tendency to converge to this state. Perfect congruence with the optimal state, as approximated by equation array 2.14, is not obtained due to either insufficient resources, *inter alia* natural resources, investment capital, lack of demand, or due to the stochastic behavior of contract building. Secondly, the optimal state is a moving target making it difficult to converge to.

2.2.3 Price determination

It is generally accepted among economists that prices need to adapt according to the interaction of demand and supply. In fact, most mainstream economists believe that price rigidities explain departures from trend growth and equilibrium states (Burda and Wyplosz 1993) [33]. In the Russian case, prices are rather rigid due to fixed minimum

export prices and information lags. This is especially true for the export oriented forest industry where minimum export prices are regularly fixed by governmental organizations. The model tries to account for some of these imperfections.
In principal the model allows two approaches to introduce the role of prices in the allocation pattern of productive capacity. First prices can be determined by an exogenous model, i.e. the price path can be estimated by an independent modeling effort and enter then the tender model as an exogenous variable. Price development should then be modeled with econometric methods. There again we can take two different routes. The first would be to resort to time-series regression models. However, this class of models like AR(ρ), ARMA, ARIMA, ARCH, GARCH and many others are only sensible to apply if the analyst has a large quantity of data at hand. This would be the fact if one were to analyze a time-series of daily stock market prices over a couple of years. However, such data are not available to us for the markets analyzed. Moreover, such models show predictive power only for short-term predictions.
The second approach to be taken is to endogenize price changes. The price changes are then directly determined by the model variables given some assumptions on the process of price determination. This is from a computational and a model building point of view not a trivial task since the price change depends essential on all other variables and coefficients of the model. Hence, it becomes difficult to make a correct and fast diagnosis of price fluctuations predicted by the model.
In the model price changes, as can be seen in equation 2.15, become a function of the expected supply slack, the expected total investments, and the current profitability level of the industry at distinct markets.

$$\begin{aligned}\Delta P_{jt} &= f^*(\frac{E_t(ss^{net}_{t+t'})/t' + \sum_i(C_{ijt}Y_{ijt})}{\sum_i\sum_k(P_{ijkt}Y_{ijkt})}) \\ &= f^*(\frac{[E_t(ss_{jt+t'}) - E_t(I_{jt+t'}(I^f, I^\pi, I^d))]/t' + \sum_i(C_{ijt}Y_{ijt})}{\sum_i\sum_k(P_{ijkt}Y_{ijkt})}) \qquad (2.15)\end{aligned}$$

where

	ΔP_{ijt}	...Change of price of product l which is delivered to market j at time t
	$E(ss^{net})$	...Expected net supply slack of product l which is dedicated to market j at time t i
where	$E(ss_{ijlt})$	...Expected supply slack of product l which is dedicated to market j at time t
	$E(I_{ijlt}(I^f, I^\pi, I^d))$	...Expected total net investment to market j at time t
	$\sum_i \pi_{ijlt}$	...Total current profits gained at market j with product l.

$E(ss^{net})$, the expected net supply slack, can be seen as the expected supply slack, see equation 2.16, corrected for the total expected capacity investments targeted to market j. The calculation in equation 2.15 follows the logic that prices change according to the ratio of total capital requirements to total revenue as calculated at time t. Thus, prices adapt in such a way that there is a tendency to market clearing. If total predicted capital requirements for the upcoming period, with prediction period of t' years, is larger than todays total revenue than prices increase and vice versa. This would also mean that there is a tendency that on the aggregate firms will earn zero expected profits.
The expected supply slack of a given product at a given market is given by,

$$E(ss_{jlt}) = E_t(D_{j,t+t'}) - \sum_i \bar{Y}ijt \qquad (2.16)$$

where $\begin{array}{lll} E(ss_{ijt}) \leq 0 & \text{if} E_t(D_{j,t+t'}) \geq \sum_i \bar{Y}ijt & \ldots\text{under supply} \\ E(ss_{ijt}) \geq 0 & \text{if} E_t(D_{j,t+t'}) \leq \sum_i \bar{Y}ijt & \ldots\text{oversupply.} \end{array}$

In other words the expected supply slack is the difference between the current supply, which is the installed capacity, and the expected demand at time t of the product concerned at market j in period $t + t'$. In our case the latter is the predicted demand. In the simulation runs presented t' was set 2 years. In other words this difference expresses the supply gap that would arises if the economic supply would not change and demand would grow or fall in the upcoming two periods. t' is hypothesized to be the economic planning horizon of the relevant agents determining price formation at market j.

The total net expected investments are made up of three components. The first being foreign or outside investments I^f and the second being investments financed out of the company profits, I^π, dedicating capacities to market j. The third component is depreciation capital. The sum of all three components is expressed in equation 2.17.

$$\begin{aligned} E(I_j(I^f, I^\pi, I^d)|Inf_t^f) &= E_t(I^f_{jt+t'}|Inf_t^f) + E_t(\sum_i I^\pi_{ijt+t'}|Inf_t^\pi) - E_t(\sum_i I^d_{ijt+t'}) \\ I^f, I^\pi, I^d &. \geq 0 \\ E_t(\sum_i I^\pi_{ijt+t'}|Inf_t^\pi) &= (\sum_{t-t^*}^{t} \sum_i \pi_{ijt} + (t'-1)\sum_i \pi_{ijt})|Inf_t^\pi \\ E_t(\sum_i I^d_{ijt+t'}) &= (t'-1)\sum_i (\Delta \bar{Y}^d_{it} \frac{Y_{ijt}}{\sum_i Y_{ijt}}). \end{aligned} \tag{2.17}$$

$E_t(I^f_{jt+t'}|Inf_t^f)$ is the conditional expected foreign or external investment at time $t+1$. The information set Inf_t^f constrains $I^f_{t+t'}$ as discussed in 2.12. $E_t(\sum_i I^\pi_{t+1}|Inf_t^\pi)$ describes the conditional expected investment out of own financial resources made up of contributions of individual enterprises targeting capital to particular markets in the up-coming period given an information set Inf_t^π at time t. This information set contains information on accumulated profits ready for investment with additional information on investment constraints which have been discussed more closely in the investment section. Depreciating capital, which is due to oversupply to certain markets, is originally calculated on the aggregate of an enterprise. By building the ratio $((Y_{ijt})/(\sum_i Y_{ijt})$ one can make inference which markets are over-supplied.

This modeling approach allows to have investment and consequently prices to be determined by the strategies of the agents being active on the concerned markets. That is to say that, e.g. Japanese investments in areas which are targeted or are expected to be targeted to re-import the produced product will directly influence the import / export price for Japanese traders.

$f^*(.)$ is a logistic filter function which either dampens or enhances the effect of the ratio of total expected capital requirement and total revenues on prices calculated on the basis of $E(ss^{net}), \sum_i(C_{ijt}Y_{ijt})$ and $\sum_i \sum_k (P_{ijkt}Y_{ijkt})$. The logistic [16] function 2.18 (see some examples of the function with changing parameters in figure 2.1) allows to introduce price inertia by setting bounds to the price change, ΔP_{ijt}, and additionally allows to 'play' with the elasticities of the calculated ratio. The latter is determined by $c4$.

$$\Delta P_{jt} = c1 - \frac{c2}{c3 - exp(\frac{E(ss^{net} - \sum_i (C_{ijt}Y_{ijt})}{\sum_i \sum_k (P_{ijkt}Y_{ijkt})}) * c4} \tag{2.18}$$

[16] In the field of forestry this function is used to describe growth phenomena of trees and populations.

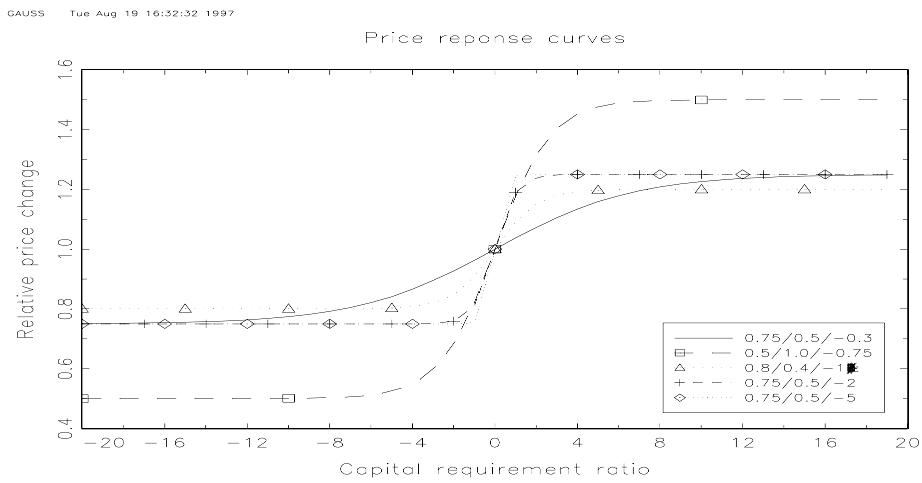

Figure 2.1: Illustration of the logistic filter (Legend refers to the coefficients of equation 2.18: c1/c2/c3).

where
$c1$ ... Sets the position of the inflection point
$c2$ ... Defines the upper bound of price changes
$c3$ ... Defines the lower bound of price changes
$c4$ ... Elasitcity of the capital requirement/revenue ratio determined by the slope of the curve between $c2$ and $c3$.

The price level of the initial auction ($k = 1$), for the up-coming period can now be determined by taking into account that prices are bounded. The boundedness is achieved by implementing the following constraint set,

$$\bar{P}_{jtk=1} = \begin{cases} P_{jt}^{min} & \text{if } \Delta P_{jt}\bar{P}_{jt-1k=1} < P_{jt}^{min} \\ \Delta P_{jt}\bar{P}_{jt-1k=1} & \text{if } P_{jt}^{min} \leq \Delta P_{jt}\bar{P}_{jt-1k=1} \leq P_{jt}^{min} \\ P_{jt}^{max} & \text{if } \Delta P_{jt}\bar{P}_{jt-1k=1} > P_{jt}^{max}. \end{cases}$$

As stated initially in this paragraph, we observe not only price changes in certain bounds each year but also minimum, P_{jt}^{min}, and maximum, P_{jt}^{max}, absolute price levels. In the case of export prices we refer to the officially reported 'recommended minimum price level for products of the Russian forest industry for country j for the 1 quarter of 1995' (Minimalnie recomenduemii uroven zen na Rossiiskuju lesobumaschnuju produkzijy, pastblejaemuju b j [17], na kvartal 1995 god) (ROSLESPROM 20.01.1995) [18]. For internal markets the minimum price level was set to a percentage of the whole sale prices at the Moscow commodity exchange [18] with regional adjustment coefficients. In the simulations it is assumed that the absolute price level constraints resume to be valid.

Setting the initial price level is one component of changing the average price level at the concerned market and is one possibility to model the overall price development. Changing

[17] In this case j stands for the country which can equally be regarded as export market j. If the export market consists of a bundle of different countries with different minimum recommended minimum price levels the weighted average is calculated with the export value of product l as a weight.

[18] Special thanks goes to Dr. Charles A. Backman who donated these data.

the price increase from one tender price to the other is another way how we can equilibrate price and demand via price setting. The mechanism follows the same logic as we applied in the previous equations 2.15,2.16,2.17. The only difference of course is that the parameters of the logistic filter 2.18 will be set differently. Thus we will denote the coefficients differently as can be seen in equation 2.19

$$\Delta^+ P_{jt} = c1^+ - \frac{c2^+}{c3^+ - exp(\frac{E(ss^{net} - \sum_i (C_{ijt} Y_{ijt})}{\sum_i \sum_k (P_{ijkt} Y_{ijkt})}) * c4^+} \tag{2.19}$$

where
$c1^+$ ... Sets the position of the inflection point
$c2^+$ ... Defines the upper bound of the change in price
$c3^+$ ... Defines the lower bound of the change in price
$c4^+$ ... Elasitcity of the capital requirement/revenue ratio determined by the slope of the curve between $c2$ and $c3$.

Note, however, that the increase in prices in the ascending price tender auction depend also on the expected net supply slack. In other words if the initial price falls the price increase is smaller. A slower increasing price affects both the variance and the mean of the prices achieved at the particular market. Both the variance and the mean decrease with slower increasing prices. Prices do increase slower if the expected supply slack becomes smaller, which in turn leads to stronger competition.
Let me denote the price change from one tender to another in a given period as $\Delta P^+_{jt} = \bar{P}_{jtk-1} - \bar{P}_{jtk}$. Then we can write for $k \geq 2$,

$$\bar{P}_{jtk} = \begin{cases} \Delta P^+_{jt} + \bar{P}_{jtk-1} & \text{if } \Delta P^+_{jt} + \bar{P}_{jtk-1} \leq P^{min}_{jt} \\ P^{max}_{jt} & \text{if } \Delta P^+_{jt} + \bar{P}_{jtk-1} > P^{max}_{jt}. \end{cases}$$

2.2.4 Changes in uncertainties

Price uncertainties ($U^B_{ijtk_P}$) and contract uncertainties ($U^B_{ijtk_Q}, U^S_{ijtk_Q}$) are subject to two different processes. The first being an exogenous process of uncertainty and the second an endogenous process which is dependent on the current average product prices. The parameters for modeling contract uncertainties are defined in equation array 2.20

$$\begin{aligned} (Up - Low)^B_{jt} &= \upsilon^B_{jt} (Up - Low)^B_{jt-1} (1 - \frac{\bar{P}_{jtk=1} - \bar{P}_{jt-1k=1}}{\bar{P}^{max} - \bar{P}_{jtk=1}} \iota^B) \\ (Up - Low)^S_{jt} &= \upsilon^S_{jt} (Up - Low)^S_{jt-1} (1 + \frac{\bar{P}_{jtk=1} - \bar{P}_{jt-1k=1}}{\bar{P}^{max} - \bar{P}_{jtk=1}} \iota^S) \end{aligned} \tag{2.20}$$

Up and Low denote the upper and lower bound of the uniform distribution for buyers (B) and sellers (S) which changes over time according to the relative distance of the current base price $\bar{P}_{jtk=1}$ to the maximal possible price. The difference or the distance between Up and Low is the direct measure of uncertainty. Up and Low determine the variance of the different types of uncertainty. From equation 2.20 we can see that uncertainty of buyers is increasing with increasing base prices whereas sellers decrease the uncertainty. In the current version of the model the expected values of the random numbers drawn are $\theta^{QB}_{jt} = \xi^{QS}_{jt} = (Up - Low)^B_{jt}/2 = (Up - Low)^S_{jt}/2 \neq 1$. In this case, uncertainty does decrease or increase the aggregate price level of the products traded. ι determines differences in the speed of adjustment of uncertainty to changing prices by changing the variance of the uniform distribution. The variances are defined in equation 2.21

$$\begin{aligned}\sigma_{\theta^{QB}_{jt}} &= \frac{(\upsilon^B_{jt}(Up-Low)^B_j)^2}{12} \\ \sigma_{\xi^{QS}_{jt}} &= \frac{(\upsilon^S_{jt}(Up-Low)^S_j)^2}{12}\end{aligned} \tag{2.21}$$

In the model υ_{jt} is a value of a function which is a smaller unity and homogeneously decreasing with t and can take different values for sellers (S) and buyers (B). υ_{jt} models the exogenous process of uncertainty. υ_{jt} was introduced to include the effect of learning over time. In the period of economic transition, uncertainty in the business environment is a very important factor determining the success of the forest industry. As soon as the business environment will improve the degree of uncertainty will considerably decrease. The process of adaptation, however, is linked to the overall legal and political infrastructure and socio-economic peculiarities of the concerned markets. The analyst can by simulation explore the changes in the pattern of uncertainty and model the evolutionary path of learning which is in reality and in the model determined exogenously.
There is also a hysteresis effect in the uncertain behavior of the contract partners. The random numbers are drawn not every period but every t^{*r} period. Thus there is a persistancy in the behavior of individual traders over a certain period determined by t^{*r}.

Interaction between contract reliability and total demand and investment
Feedback loops between e.g. contract reliability and the concomitant reduction of the total investment and demand volumes are determined only to a limited extent endogenously in the model.
Let me first discuss how total investments are affected. Investments as we have seen in equation 2.9 consist of two parts. The level of foreign venture capital is not directly influenced by contract uncertainty in the current version of the model. The interaction can only be included by an external functional relationship between the contract uncertainty and foreign investments. This has to be done prior to the model runs since foreign investment has to be determined in the calibration phase. Only if foreign investments equals the supply slack one could develop a response function where investment would decrease with the degree of uncertainty. Own capital resources generated on the other hand are directly decreased by the influence of $U^B_{ijtk_P}$. This is true for two reasons: (1) the expected value of the price uncertainty is smaller or equal unity (i.e. $E(U^B_{ijtk_P} \leq 1)$, (2) not all least cost producers can use their capacity which in the aggregate decreases the profit level and thus future capacities via decreased investments from own resources. Additionally least cost producers might loose unused capacity which has to be rebuilt again.
The model is designed in a way that markets do not necessarily have to be cleared. Supply slacks can occur. The size of the demand slack is also partly influenced by contract uncertainty. There are essentially three ways on how increases in contract and price uncertainties influences the actual supply,

1. Lower aggregate investment due to decreased profitability [19]

[19] Note that the profitability of an individual company decreases whereas expenditures of the buyer increase. Depending on how price development is modeled it could occur that aggregate profits would rise over time due the increased supply slacks which leads to increased prices. This effect, however, is buffered by the calculation referred to in point (3).

2. Decrease of aggregate capacity participating in the tender
3. Prices enter the demand equation

As mentioned earlier potential demand D_{jt} enters the model as an exogenous process. Demand is determined by equation 3.12. GNP enters exogenously whereas prices are determined by the model. This approach, so nice it might look at the surface, lacks an important feature of realism. This is that both prices and aggregate uncertainty have a considerable impact on the market share of geographically dispersed suppliers. In the current version I did not include such a response function.

From a methodological point of view the only sensible way to overcome the problem of proper response functions would be to quantify the relationship of contract uncertainty and affiliated aggregates by empirical experiments with real agents. This, however, would by no means be possible due to financial and time constraints of the study irrespective of the methodological questions and uncertainties related to such an approach.

Chapter 3

Additional modules

This chapter is organized in such a way that I discuss two additional modules that were necessary to be attached to the core model. In principle the core model is designed in such a way that any kind of additional modules can be added. In the case of the Siberian forest industry we are on the one hand faced with a very unreliable database concerning the producers and on the other hand demand equations have to be constructed in order to give reasonable predictions for export potentials and domestic consumption.

3.1 Cost determination by using an engineering approach - The Cost Module

In this dissertation, not the entire forest industry of Siberia is analyzed, but only two product lines, $l = 2$, are dealt with. These are roundwood production and lumber production. Production patterns of pulp, paper, plywood and reconstituted panel products are not directly analyzed. However, positive externalities or let us call it technological synergies like chips produced in a lumber mill that is combined with a e.g. pulp mill are taken care of in the analysis. As previously mentioned data collected from individual producers and in particular cost information is highly unreliable in Russia. This has lead me to not rely on this type of questionable information but rather model costs using an engineering approach. Engineering knowledge has been compiled from various sources located in Russia and internationally.

3.1.1 Harvesting

At this point I will try to develop a straight forward method to derive costs of production by using engineering type productivity functions from the latest literature and use market values for the relevant input factors. Roundwood production costs are calculated assuming harvester / forwarder technology [1]. Subsequent transportation to the lower landing is modeled by a Russian engineering model. This model will be referred to as the Petrov model (Petrov 1995 [38]) named after the responsible author of a project report to IIASA. For the description of the costs of lumber production also an engineering type of model

[1]Find a detailed description of the Russian logging operations in the following Western literature: Blandon 1985, Obersteiner 1995 [34], Strakhov *et al.* 1996[44], Wood Resources International 1996 [56].

was developed.
The developed cost functions are of great importance for the simulation exercise. The variables driving costs i.e. the geography, the forest resource itself and the management scheme do in fact define to a great deal the competitiveness of the upstream industry.
In the current version of cost calculation there is only one technology assumed. This technology is the same for all producers. This assumption can of course be subject to criticism. However, let me already now make some comments on this assumption. In the current state of the Siberian Forest industry, technology is rather homogeneous. This is true for harvesting operations and lumber production. The only exception is that some large wood working combines produce with Western technology. As discussed earlier in this section the positive effects of lumber mills that are combined with other upstream production using wood chips are taken indirectly into account in the analysis.
During transition, however, producers will make different technological choices. In the model I differentiate two different quasi technologies. In the allocation rule as discussed in equation 2.1 we discriminate between products produced form old capacity, i.e., capacity that was inherited through the privatization process and is essentially of Russian standard and products produced by the western technology standards. Again, to make this clear, the costs for the two technologies employed are equal. What changes, however, is the probability to receive a contract due to the difference in ω_{tx} if $x_o \neq x_n$ changes. This leads to the effect that the relative competitiveness of an enterprise changes with the addition of new capacities due to a more favorable ω_{tx} . Moreover, enterprise information that were collected by Russian collaborators to IIASA's Siberian Forest Study, covers cost information only for a small subset of the entire collection of enterprises. If we were now to use this information the question arises of how can one make inference on the costs of all other producers. The prediction of cost would virtually be impossible and by no means reflect reality.
For harvesting operations one should ideally use different technologies for different environmental conditions. In this case a different technology would be employed in e. g. mountainous regions. Substantial work has already been put into answering this question. At this stage is would be too premature to present results given the currently available information [2].
Let me continue with the description of cost determination for harvesting. Harvesting costs per unit of output are calculated every period as a function of the updated total capacity. I distinguish between capital cost, labor costs, and fuel or material costs. Taxes and overhead costs are then taken as a percentage of these three cost items. This is described in equation 3.1.

$$\kappa_t^{tot} = [(\kappa_t^l + \kappa_t^M + \kappa_t^C) * (1 + \tau_t/100) * (1 + O_t/100)]/\bar{Y}_{it} \tag{3.1}$$

κ_t^{tot} ... Total cost per one cubic meter roundwood (\$ / CUM)
κ_t^l ... Total labor cost of roundwood production in period t (\$)
κ_t^M ... Total material cost of roundwood production in period t (\$)
κ_t^C ... Total capital expenditures for roundwood production in period t (\$)
τ_t ... Tax rate at time t calculated on the basis of net costs (%)
O_t ... Over head costs at time t calculated on the basis of net costs (%)
Labor costs per unit output, as defined in equation 3.2, in turn are calculated on the basis

[2] There are certain unsolved problems connected to the available data on terrain condition, road density, relief and others.

of the number of machines employed which are handled by labor given the capacity at time t, unit labor costs at time t, and a labor overhead factor reflecting additional labor necessary for organizational and support duties.

$$\begin{aligned} \kappa_t^l &= (Harv_t * \varsigma^{Harv} + Fwd_t * \varsigma^{Fwd} + Truck_t * \varsigma^{Truck}) \\ &* \quad \kappa_t^{ul} * (1 + O_t^l * 100) \end{aligned} \tag{3.2}$$

$Harv_t$ ...Number of harvesters needed given the output capacity at time t and productivity at time time t (physical units)
Fwd_t ...Number of forwarders needed given the output capacity at time t and productivity at time time t (physical units)
$Truck_t$ ...Number of logging trucks needed given the output capacity at time t and productivity at time time t (physical units)
ς^{Harv} ...Number of working shifts for harvesters
ς^{Fwd} ...Number of working shifts for forwarders
ς^{Truck} ...Number of working shifts for trucks
κ_t^{ul} ...Total cost of one unit of labor in period t
O_t^l ...Labor specific over head costs at time t (%)

Here again we have to define a number of variables somewhat closer. The number of machinery used each period mainly depend on the productivity of the machines employed and how intensive the machinery can be used. The intensity is dependent on the question of how many hours the machinery can be used for its purpose in the respective period. If the period is a calendar year than the number of hours a machine can be used depends on the factor of seasonality, that is the number of days of utilization during the year, and the average number of hours per day or in other words the number of working shifts. Equation 3.3 will define the number of respective harvesters as is due to Brunberg 1995 [46] and was slightly adapted to the Russian circumstances.

$$\begin{aligned} Harv_t &= \frac{\bar{Y}_{it}}{P_t(DV_t, Tr) * d^{Harv} * std^{Harv} * sh^{Harv}} * \Re_t^{Harv} \\ P_t &= \frac{6000 * dt}{(su_t(hg) + 56 * DV + 80 * Tr/100)} \Upsilon \end{aligned} \tag{3.3}$$

$Harv_t$ ...Number of harvesters needed given the output capacity at time t and productivity at time time t (physical units)
P_t ...Productivity of a harvester at time t dependent on average log volume and share problem trees (CUM/h)
dt ...Down time per hour (percent)
DV_t^{WB} ...Average log volume of harvested logs(see 3.4) in cubic meter without bark (WB)
Tr ...Percentage of problem trees (percent)
d^{Harv} ...Number of days when the harvester is operating (days)
sdt^{Harv} ...Number of hours of a working shift in harvester operations (hours)
sh^{Harv} ...Number of shifts in harvest operations
$\Re_t^{Harv}$ ...Productivity factor of Russian operators
$su_t(hg)$ ...Set-up time between trees as a function of the degree of 'High-Grading'(hg)
Υ ...Species specific adjustment factor for productivity.

The average log volume of harvested logs was estimated from the Blam-database [41] where I assumed a logarithmic functional relation ship. The simple intuition behind picking this functional relationship is that the larger the growing stock per hectar the more large volume trees will be found at the site. This leads to the fact that the volume of the single tree increases slower with the average growing stock in a natural forest [3]. The estimated function looks as follows,

$$\begin{aligned} DV^{IB} &= -3.1362 + 0.7197 * GS_{it} \\ DV^{WB} &= 0.92 * DV^{IB} - 0.02\sqrt{DV^{IB}} \end{aligned} \tag{3.4}$$

Note, however, that equation 3.4 describes the relationship [4] between the growing stock per hectar on a given site (GS_{it}) with the average *harvested* volume of timber extracted. Thus, the measure is of economic and not of ecological nature.

Tr describes the percentage of problem trees. The number of problem trees are according to Brunberg 1995 [46] mainly related to trees which need to be cut additional times, trees which are difficult to access and trees which are difficult related to other problems. The functions developed by Brunberg 1995 [46], explaining Tr were developed for Swedish conditions and can therefore not be applied one-to-one to Russian conditions. First of all terrain conditions in Siberia are different and secondly the forest in Siberia that are given out for harvesting operations are mainly natural forest opposed to secondary forests in Sweden. However, as can be seen in equation 3.3 the model allows for adjustments. Furthermore, the Brunberg model is consistent with a model estimated by Guglhoer and Weixler (1995) with German data, if adjusting the model accordingly. This leads to the assumption that the Brunberg model can be used more or less univerily if the calibration is done cautiously.

$su_t(hg)$ is according to Brunberg (1989,1991,1995) [46] [13] [45] dependent on the distance between the logging roads, number of trees per hectar, soil type, the slope of the logging site and acceleration capacity of the harvester itself. In the current version of the model only a limited amount of the factors mentioned above are included in the analysis. This is mainly due to the fact that necessary data are not yet available at an enterprise specific level. However, in the simulation of the costs one can explore the effects of 'high-grading' as a factor influencing productivity and consequently costs. 'High-grading' directly relates to the ratio between the number of tree growing on the site and the number of trees harvested [5]. Especially, in natural forests one tends to encounter a large number of small sized trees. Today only a small number of trees is removed from the site under Siberian management practices. This means that a lot of trees have to be cut first in order to access the harvestable trees. Such forest management schemes drastically reduce the productivity of harvesting operations by changing $su_t(hg)$. In the case that Russian technology is used the effect might not be so large. Russian logging operations use tank-like base machinery with which it is possible to simply drive over trees and shrubs without cutting.

Originally I tried to follow a methodology develped by Bergstrand(1985) [30], Toplitsch (1992) [50] and Rinnhofer (1990) [22] to derive the number of forwarders that should operate together with the harvesters. The functions, especially by Bergstrand(1985) [30], were too detailed and in fact complicated such that I decided to use a simple approach. Also dealers of this type of equipment do rely mostly on expert opinion rather than

[3] This simple reasoning, however, still needs to be tested for natural forests in Siberia.

[4] Statistical note: The residual sum of squares, degree of freedom and F-value in this estimation were: $Rsq = 0.529, DF = 289, F = 205.65$.

[5] In the simulation runs of the entire model I change the landscape factor, ls_i, which indirectly can also be interpreted as a measure for high grading i.e. the more trees are left the more land is used.

methodology when it comes to the question of how many forwarders should be combined with the harvesters operating.

$$Fwd = Harv * coeff^{Fwd} \tag{3.5}$$

Equation 3.5 shows the simple relationship between the number of harvesters and the number of forwarders that co-operate. The forwarder coefficient, $coeff^{Fwd}$, mainly depends on the average driving distance between the upper landing (road-side storage), the harvesting operation, tree volume, and terrain conditions. The driving distance links back to hg. Forest management is thus also related with the productivity of forwarder operations. This fact has to be taken into account when determining $coeff^{Fwd}$. More detailed field experiments concerning the determination of $coeff^{Fwd}$ would be desirable in order to make better assessments of future cost development especially in the light of changing forest management practices.
The third cost component in equation 3.1 is the trucking operation. The estimated equation 3.6 is, as mentioned earlier, derived from data supplied by Petrov (1995). The original data is based on detailed time studies made in Siberian enterprises. The forest roads in Siberia are often in very bad condition and Russian trucks are different from Western types. Western types of trucking models used by SkogKalk (1995) [32] and similar analytical tools developed in Canada and the US (TopM 1996) can not be applied to Russian conditions given the current situation and the time span of simulation. I am personally convinced that the Petrov model describes the current Siberian conditions for trucking at best for the current situation. However, it is believed that in the next few years measures have to be taken to increase the productivity of this particular phase of the roundwood production chain. In the simulation we will have to take this factor into account by adjusting the coefficient in equation 3.6 appropriately.

$$\begin{aligned} Truck_{it} &= \frac{(LT_t + 0.00512 * dist_i + 0.096 * drain_i + 0.112 * relief_i}{\bar{Y}_{it} * d^{Truck} * std^{truck} * sh^{truck}} + \\ &+ \frac{0.117 * R^{cond})}{\bar{Y}_{it} * d^{Truck} * std^{truck} * sh^{truck}} \qquad (3.6) \\ dist &= \sqrt{\frac{\bar{Y}_{it} * 100}{GS_{it} * hg * \pi} \bar{Y}_{it} \Im_i ls} \qquad (3.7) \end{aligned}$$

$Truck_{it}$	...Number of trucks needed given the output capacity at time t and productivity at time time t (physical units)
LT_t	...Total loading and unloading time (hours)
$dist_i$	...Distance from the lower to the upper landing (km)
$drain_i$	...Index for road drainage
$relief_i$	...Index for road drainage
R^{cond}	...Index for road conditions
d^{Truck}	...Number of days when the truck is operating (days)
sdt^{Truck}	...Number of hours of a working shift in trucking operations (hours)
sh^{Truck}	...Number of shifts in hauling operations
$\Im_i$	...Number of years the enterprise is assumed to operte from the center point
ls_i	...Landscape factor for enterprise i

$$drain_i = \begin{cases} 1 & \text{if road is drained} \\ 2 & \text{if road is without drain} \end{cases}$$

$$relief_i = \begin{cases} 1 & \text{if flat terrain} \\ 2 & \text{if hills and mountains} \end{cases}$$

$$R^{cond} = \begin{cases} 1 & \text{if roads with gravel base} \\ 2 & \text{if roads with natural soil base with drainage} \\ 3 & \text{if roads with natural soil base without drainage} \end{cases}$$

The indexes $drain_i, relief_i, R^{cond}$ allow to model differences in the forest road conditions in greater detail. In the current state of the database, however, these two indexes have to be set at average values due to lack of detailed information. It is expected that in the near future these detailed factors can also be taken into account as soon as data are ready. The distance calculation is based on a central gravity approach. This is to say that the lower landing does not change its geographic location for the time period $\Im_i$. $\Im_i$ can be set according to the type of forest leasing, logging enterprises can choose. $\Im_i$ also relates to the assumptions to be made concerning the sustainable management of the forests. In this case $\Im_i$ has to equal the average rotation period of the respective forests. Information concerning this management type is potentially available from the modeling efforts made by Korovin et al.(1996) [16]. Each year it is assumed that the enterprises logs out a small piece of the total pie of forest land leased or allocated to the concerned harvesting enterprises. Thus the average transportation distance does not change over time. In reality this assumption might be violated as logging enterprises do move their operations as close to the market as possible and do not take into account increasing future transportation distances due to their centered extraction activities. This problem may be linked to a number of reasons including the form of ownership, present economic hardship and general management practice.
After having defined in great detail the parts of the engineering model I will now turn back to the cost calculation. The next cost item after having defined labor costs per unit output [6] are material costs as defined in equation 3.11.

$$\begin{aligned} \kappa_t^M &= Harvd^{Harv} std^{Harv} sh^{Harv} U_t^{Harv} + Fwdd^{Fwd} std^{Fwd} sh^{Fwd} U_t^{Fwd} + \\ &+ Truckd^{Truck} std^{Truck} sh^{Truck} U_t^{Truck}. \end{aligned} \tag{3.8}$$

In this equation U_t denotes the unit costs per hour (\$/hour). Material costs in this case comprise cost items like fuel, lubricants and others to run the logging equipment. Repair costs, however, are included in κ^C, as can be seen in equation 3.9, and thus are treated as part of the fixed costs.

$$\begin{aligned} \kappa_t^C &= \frac{Harv\varrho^{Harv} C^{Harv}}{sh^{Harv} \varpi_t^{Harv}} + \frac{Fwd\varrho^{Fwd} C^{Fwd}}{sh^{Fwd} \varpi_t^{Fwd}} + \\ &+ \frac{Truck\varrho^{Truck} C^{Truck}}{sh^{Truck} \varpi_t^{Truck}} + C^{road} \bar{Y}_{it}^{\xi}. \end{aligned} \tag{3.9}$$

$\varrho^{\cdot}$	...Coefficient of repair where $\varrho^{\cdot} > 1$
$C^{\cdot}$	...Market price of one unit of respective machinery including interest (\$)
ϖ_t^{Harv}	...Amortization period of the respective machinery (years)
ξ	...Coefficient to penalize large harvesting operations in repect to fixed road costs

[6] Note that in the current set up of the model once the unit costs are determined total costs are inelastic to the actual supply. That is to say that the variable cost item e.g. labor cost does not change the total unit cost even if the capacity is not fully used.

$\varrho^{Harv}, C^{Harv}, \varpi_t^{Harv}$ are taken from companies selling the respective machinery on the Russian market (TIMBERJACK 1996). ξ was included in order to reflect the fact that with increasing size of a roundwood producer the road maintenance costs increase on a relative basis due to the large ramification of the road network, due to the fact that distant areas can not be maintained like in a smaller enterprise [7]. C^{road} is a constant number and hence the adjustment with $\bar{Y}_{it}^{\xi}$ has to be made to come closer to the real pattern of cost distribution.

3.1.2 Saw milling

In the model results presented in this dissertation it is assumed for simplicity reasons that lumber mills produce all required inputs roundwood themselves. The calculation of roundwood production for lumber mills follow the same methodology as described in equations 3.1 to 3.9. The milling process in terms of cost calculation is calculated analogous to equation 3.1. The milling costs are now denoted with an additional $*$ as can be seen in equation 3.10.

$$\begin{aligned} \kappa_t^{tot*} &= [(\kappa_t^{l*} + \kappa_t^{tot}\bar{Y}_{it}^{*}\varepsilon_{it} + \kappa_t^{C*})\bar{\kappa}_t^{M*} * 100 \\ &* \quad (1 + \tau_t^{*}/100) * (1 + O_t^{*}/100)]/\bar{Y}_{it}^{*} \end{aligned} \tag{3.10}$$

κ_t^{tot*} ... Total cost for the production of one cubic meter lumber ($\$/CUM$)
κ_t^{l*} ... Total labor cost of lumber production in period t($)
κ_t^{tot} ... Sawlog costs per unit in period t($\$/CUM$)(see 3.1)
$\bar{Y}_{it}^{*}$ ... Capacity for lumber production at time t in CUM
ε_{it} ... Technical input/output coefficient ($CUM^{wood}/CUM^{lumber}.\varepsilon_{it} \geq 1$
$\bar{\kappa}_t^{M*}$ ... Coefficient for material cost of lumber production in period t(%)
κ_t^{C*} ... Total capital expenditures for lumber production in period t ($)
τ_t^{*} ... Tax rate at time t calculated on the basis of net costs (%)
O_t^{*} ... Over head costs at time t calculated on the basis of net costs (%)

In comparison to roundwood production there are, of course, some changes to be made in the saw milling module. The first change is the calculation of labor productivity. Physical labor productivity was recalculated based on Hogel (1994) [31] and is [8],

$$P^{*} = -153.3 + 550.83 \ln(\bar{Y}_{it}) \tag{3.11}$$

where in this context P^{*} defines the physical labor productivity in units labor per year at a given output level. Another factor that needs to be taken into account is the coefficient of utilization of roundwood in the milling process. Let me denote this coefficient as ε_{it}. As already discussed earlier, this coefficient changes if the lumber mill happens to be located at a wood working combine that uses the wood chips produced by the lumber mill. This information is captured by the index i in ε_{it}. In the case of integration $\varepsilon_{i^I t}$ can be set to unity if i^I denotes integration. In any case $\varepsilon_{i^I t} < \varepsilon_{it}$ for $i \neq i^I$.
Additionally, material costs in lumber production are not separately calculated but enter as a percentage of the total labor and capital costs as denoted by $\bar{\kappa}_t^{M*}$. The capital costs take scale effects into account. As scale effects enter the model, indirectly scale effects are

[7] Note that this is an untested hypothesis.

[8] In the simulations it became apparent that this function yields implausible results for enterprises with a production smaller than 30.000 CUM.

then also included in the material and general costs since these costs enter as additional shares in the total cost calculation as shown in equation 3.1. The sales tax and the export duty are added later as discussed in section 2.1.

3.2 Demand prediction

In this section I will try to present three things. First, I will try to motivate the use of a functional form of the demand equation and shortly describe the methodology of forecasting. Second, I will present and short describe the econometric techniques that were employed. Here I describe a special panel data technique [9], the two-way error component fixed effects regression model, and a short description of a Bayesian estimation approach which was combined with the panel data estimation [10]. In the final part in section 3.2.3 we show results of the estimations with a short description of the markets.

3.2.1 Functional form of demand functions

As forest industry products satisfy different needs, their consumption is dependent on a number of different indicators. Most frequently forest industry economists estimate total consumption of forest products in dependence of income, prices, the abundance of substitute products and the number of consumers. A number of studies emerged recently discussing these issues for the forest sector and need not be repeated here (Buongiorno 1977 [14], Jaakko Poeyry 1995 [39], Sedjo and Lyon 1995 [40], Baudin and Brooks 1995 [11], Apsey and Reed 1995 [49], Nilsson 1996 [42], Solberg et. al. 1996 [43], Romain 1996 [28], Brooks et al. forthcoming [12]). The consumption path of forest products is mainly linked to the trajectory of GDP. Elasticities change by country groups and products analyzed. There are of course structural differences between developed and less developed countries and between countries exporting forest products, due to their natural endowments and population density, and countries importing them. These differences, ignored by so many analysts, were of course included in the analysis by carefully distinguishing between country groups as is discussed later in section 3.2.4. In the framework of this analysis we will not disaggregate product groups. It is true that there might be differences in the lag structure and differences in elasticities of different grades. For the purposes of our aggregate analysis, however, differentiation between product groups seems to be justifiable and differences in the effects are hypothesized to equal out in the aggregated analysis and should eventually be captured by the stochastic term in our regression. The second fundamental variable determining demand [11] of forest products is prices. The effect of changes in prices captures two phenomena. On the one hand the consumer will react directly to price changes due to changes in the relative purchasing power and on the other hand consumers might want to substitute wood or wood products with other

[9] The two-way error component fixed effects model is described for two reasons. First, the one-way error component model is just a special case of the two-way error component model were $\lambda_i = 0$. Second, due to the nature of data the fixed effects model is almost *a priori* most suited due to the fact that we observe a fixed set of countries over time. There are by definition no random effects by the sampling scheme.

[10] Please, note that for notational convenience the Bayesian estimation is described assuming cross-sectional data.

[11] Demand can be interpreted as either total consumption or export/import demand.

competing products. Elasticities will be changing with the level of GNP [12].
Finally, we have to consider changes in population. Increases in population will, of course, result in increased consumption and trade of forest products. Differences in the propensity to consume of different age and social classes has been ignored for the time being.
In our analysis we will consider forecasts from different econometric models and in the case of non-exiting data we will have to resort to analysis of other researchers. The choice of the model depends on the quality and quantity of data available. The most frequently estimated equation is defined by equation 3.12. Consumption of import is determined by a GLS estimator of the following structure,

$$\begin{aligned} Y_{it} = \alpha + \lambda_t + \mu_i + \beta_{GNP} logGNP_{it} + \beta_P P_{it} + \epsilon_{it} \\ \epsilon_{it} = \rho\epsilon_{it-1} + u_{it}. \end{aligned} \tag{3.12}$$

where

Y_{it}	... Output/Import per capita of country i in time period t
α	... Intercept
λ_t	... Time specific intercept
μ_i	... Country specific intercept
β_{GNP}	... Estimated parameter for GNP elasticity
GNP	... Gross National Product per capita of country i in time period t
β_P	... Estimated parameter for price elasticity
P	... Import price of country i in time period t
ϵ_{it}	... AR(1) disturbance
ρ	... Coefficient of autocorrelation
u_{it}	... White noise with $E(u_{it}) = 0$ and $E(u_{it}^2) = \sigma_u^2$ and $Cov(u_{it}, u_{is}) = 0$ if $t \neq s$

. Equation 3.12 illustrates the relationship between demand, Y, of country i at time t and a time variant effect λ_t, the country specific effect μ_i, the log of GNP of country i at time t, prices of country i at time t, and an error term. In cases where $\rho > 0$ the error term is corrected for autocorrelation of order one (AR(1)). If the latter is the case this transformed model should be referred to as,

$$Y_{it}^* = \beta\prime X_{it}^* + \epsilon_{it}^* \tag{3.13}$$

.

The optimal prediction of future demand, $\hat{Y}_{it+1}^*$, given X_{it+1}^* and X_{it}^*, is then calculated by equation 3.14.

$$\hat{Y}_{it+1}^* = \hat{\beta}\prime X_{it+1}^* \tag{3.14}$$

By disassembling $\hat{Y}_{it+1}^*$ we find

$$\hat{Y}_{it+1} - \rho y_{it} = \hat{\beta}\prime X_{it+1} - \rho\hat{\beta}\prime X_{it} \tag{3.15}$$

Thus, we carry forward a proportion ρ of the estimated disturbance in the preceding period. This can be justified by the reference,

$$E(\epsilon_{t+1} \| \epsilon_t) = \rho\epsilon_t \tag{3.16}$$

[12] The log allows to model decreasing marginal propensities to consume with increasing income.

This effect can be interpreted as contracts which have a duration over a calendar year but also a certain stickiness in the contract building. In this light it seems to be reasonable that higher-order auto-regression play a minor role in contracts since most of the contracts are renewed and newly negotiated every year. However, this argumentation is only partly true. By the correction of autoregressive processes in the residuals one also captures part of the dynamics of the process. By this pseudo-differencing the growth rate today is also dependent on yesterday's growth rate.

It can also be shown that forecasting n periods ahead can be calculated by (Greene 1997 [54]),

$$\hat{Y}_{it+1} - \rho^n y_{it} = \hat{\beta}\prime X_{it+1} - \rho^n \hat{\beta}\prime X_{it} \tag{3.17}$$

3.2.2 The two-way fixed effects error component regression model

In this section I give a description of a single regression model with two-way error components. We consider its basic assumptions as well as the assumptions on the error components, which lead to the fixed and random effects model. To this purpose we heavily draw on Maddala 1993 [19], Prucha [25] and on Baltagi [20].

The basic model and its assumptions

Let us consider now a single regression model and refer to it as the general model:

$$\begin{aligned} y_{ti} &= \alpha_{ti} + x_{ti1}\beta_{ti1} + \ldots + x_{tiK}\beta_{tiK} + \nu_{ti} \\ &= \alpha_{ti} + \sum_{k=1}^{K} x_{tik}\beta_{tik} + \nu_{ti} \qquad \text{with } i = 1, \ldots, N \text{ and } t = 1, \ldots, T \end{aligned} \tag{3.18}$$

where N and T denote the number of units and time-points, respectively, and on the k-th explanatory variable. Further ν_{ti} denotes the (ti)-th disturbance term, α_{ti} and β_{tik} stand for the intercept and slope coefficient. The disturbances μ_{ti} are typically assumed to be *iid* with zero mean and finite variance.

In Equation (3.18) no restrictions are imposed on the coefficients α_{ti} and β_{tik}. In general these restrictions are required for estimations as there are NT observations, but $2NT$ coefficients. There are several possibilities to do this. I concentrate on models, where the intercept varies over units and time and where the slope coefficients are constant.

$$y_{ti} = \alpha_{ti} + \sum_{k=1}^{K} x_{tik}\beta_k + \nu_{ti} \qquad \text{with } i = 1, \ldots, N \text{ and } t = 1, \ldots, T$$

with $\alpha_{ti} = \alpha + \mu_i + \lambda_t$, where α denotes the overall intercept, μ_i and λ_t represent the unobservable unit and time specific effects, respectively. By now, it proves convenient to rewrite the model in matrix notation.

$$y = e_{NT}\alpha + (I_N \otimes e_T)\mu + (e_N \otimes I_T)\lambda + X\beta + \nu \tag{3.19}$$

We assume that following conditions hold:

- The disturbances ν_{ti} are distributed $IID(0, \sigma_\nu^2)$ with $0 < \sigma_\nu^2 < \infty$ and finite fourth moments. In particular, we assume the disturbances to be $N(0, \sigma_\nu^2)$ distributed.
- The elements of the regressor matrix X are non-stochastic and bounded in absolute value, the matrix (e_{NT}, X) has full column rank, and the matrices $M_1 - M_5$ converge to finite nonsingular matrices as both N and T tend to infinity (independent of the path on which N and T tend to infinity).

From above we can conclude that $E\nu = 0$ and $E\nu\nu' = \sigma_\nu^2 I_{NT}$.

The above described models can be further categorized according to whether the variable coefficients are assumed to be *fixed* or *random*. The fixed assumption leads to *dummy variable models* and ordinary least square estimation, whereas the latter assumption yields *error component models* and general least square estimation. However, as we do not use the random effects model a more detailed description is omitted in contrast to the fixed effects model.

The fixed effects model

As we are not able to estimate simultaneously α and $\mu_1, \dots, \mu_N, \lambda_1, \dots, \lambda_T$, we impose following restrictions:

$$\sum_{i=1}^{N} \mu_i = \sum_{t=1}^{T} \lambda_t = 0.$$

Let $Z^\mu = [z^\mu_{.1}, \dots, z^\mu_{.N}] = I_N \otimes e_T$ and $Z^\lambda = [z^\lambda_{1.}, \dots, z^\lambda_{T.}] = e_N \otimes I_T$. Substitution of these restrictions into (3.19) leads to

$$\begin{aligned} y &= W\delta + X\beta + \nu \\ &= Z\gamma + \nu, \end{aligned} \tag{3.20}$$

where $W = [e_{NT}, z^\mu_{.1} - z^\mu_{.N}, \dots, z^\mu_{.N-1} - z^\mu_{.N}, z^\lambda_{1.} - z^\lambda_{T.}, \dots, z^\lambda_{T-1.} - z^\lambda_{T.}]$, $\gamma = [\alpha, \mu_1, \dots, \mu_{N-1}, \lambda_1, \dots, \lambda_{T-1}]'$, $Z = [W, X]$, and $\gamma = [\delta, \beta]$ where Z is a $(p \times q)$ matrix and γ is $(q \times 1)$ vector with $p = TN$ and $q = T + N + K + 1$. Equation (3.20) is now the starting point for the classical estimator and the Bayes estimator. These two estimators and their statistical properties are described in Section 3.2.2 and 3.2.3.

The classical estimator

Premultiplying (3.20) with Q_0, which wipes out the unit and time specific effects, gives

$$Q_0 y = Q_0 X\beta + Q_0\mu, \tag{3.21}$$

as $Q_0 W = 0$. This gives a transformed system, where the dimension of the used matrices is smaller than in (3.20). Solving the normal equations for the OLS estimator we get following estimators

$$\begin{aligned} \hat{\beta} &= [X'Q_0X]^{-1}X'Q_0y \\ \hat{\alpha} &= \overline{y}_{..} - \sum_{k=1}^{K} \overline{x}_{..k}\hat{\beta}_k \end{aligned}$$

$$\hat{\mu}_i = \overline{y}_{.i} - \hat{\alpha} - \sum_{k=1}^{K} \overline{x}_{.ik}\hat{\beta}_k$$
$$\hat{\lambda}_t = \overline{y}_{t.} - \hat{\alpha} - \sum_{k=1}^{K} \overline{x}_{t.k}\hat{\beta}_k$$

where $\overline{y}_{..}, \overline{y}_{.i}$ and $\overline{y}_{t.}$ denote the overall, the unit specific and time specific mean of the dependent variable, respectively. Further $\overline{x}_{..k}, \overline{x}_{.ik}$ and $\overline{x}_{t.k}$ represent the same means for the independent variables.

Statistical properties of the estimator Under the above given assumptions and given the fixed effects model is the true one, the fixed effects estimator $\hat{\beta}$ is BLUE. Additionally, the estimators for α, μ, λ and β are consistent, if N and T tend to infinity. Let $\hat{\nu} = y - e_{NT}\hat{\alpha} - (I_N \otimes e_T)\hat{\mu} - (e_N \otimes I_T)\hat{\lambda} - X\hat{\beta}$, then

$$\hat{\sigma}^2_\nu = \frac{\hat{\nu}'\hat{\nu}}{(N-1)(T-1)-K} = \frac{1}{(N-1)(T-1)-K}\sum_{t=1}^{T}\sum_{i=1}^{N}\hat{\nu}^2_{ti}$$

is an unbiased and consistent estimator for σ^2_ν.

3.2.3 The Bayesian estimator

Bayesian models go back to the Bayesian theorem which says that given two arbitrary events A and B from the sample space S the following holds:

$$Pr(B)Pr(A|B) = Pr(AB) = Pr(A)Pr(B|A) \tag{3.22}$$
$$\tag{3.23}$$

from which follows

$$Pr(A|B) = \frac{Pr(A)}{Pr(B)}Pr(B|A) \tag{3.24}$$

and analogous we can write for data and density functions

$$Pr(\theta|Data) = \frac{Pr(\theta)}{Pr(Data)}Pr(Data|\theta) \tag{3.25}$$

The Normal-Gamma Regression Model In this section I follow Hamilton 1994 [23], Judge et al. 1988 [29] and Zellner 1971 [57] to give a brief introduction in Bayesian estimation of a classical linear regression model with unknown variance. Consider the regression model as it is given by the second line of Equation (3.20). The common Bayesian approach to the estimation of this regression equation is to assume that the joint prior density function of γ and σ^2_ν follows a normal-gamma distribution. In terms of the reciprocal value of the variance of the disturbances - known as the precision - the normal-gamma distribution is given by:

$$f(\gamma, \sigma_\nu^{-2}|Z) = f(\gamma|\sigma_\nu^{-2}, Z) f(\sigma_\nu^{-2}|Z) \tag{3.26}$$

where $f(\gamma|\sigma_\nu^{-2}, Z)$ is defined by the normal distribution $N(\bar{\gamma}, \sigma_\nu^2 \bar{\Omega})$. Further $f(\sigma_\nu^{-2}|Z)$ is defined by the gamma distribution $\Gamma(\bar{a}, \bar{b})$. The vector $\bar{\gamma}$ represents the analysts prior information about the coefficients of the regression model and $\bar{\Omega}$ its confidence in that guess. The parameters $\bar{a}$ and $\bar{b}$ of the gamma distribution describe the prior information about the variance of the disturbances. The sample likelihood $f(y|\gamma, \sigma_\nu^{-2}, Z)$ is defined by the normal distribution $N(Z\gamma, \sigma_\nu^2)$ and hence the joint posterior of γ and σ_ν^{-2} is given by

$$f(\gamma, \sigma_\nu^{-2}|y, Z) = f(\gamma|\sigma_\nu^{-2}, y, Z) f(\sigma_\nu^{-2}|y, Z)$$

where the posterior density of γ conditional on σ_ν^{-2} is $N(\bar{\bar{\gamma}}, \sigma_\nu^2 \bar{\bar{\Omega}})$ and therefore

$$f(\gamma|\sigma_\nu^{-2}, y, Z) = \frac{1}{(2\pi\sigma^2)^{p/2}} \sqrt{|\bar{\bar{\Omega}}|} \exp\left\{[-\frac{1}{2\pi\sigma^2}](\gamma - \bar{\bar{\gamma}})' \bar{\bar{\Omega}}^{-1} (\gamma - \bar{\bar{\gamma}})\right\}$$

with

$$\begin{aligned} \bar{\bar{\gamma}} &= (\bar{\Omega}^{-1} + Z'Z)^{-1}(\bar{\Omega}^{-1}\bar{\gamma} + Z'y) \\ \bar{\bar{\Omega}} &= (\bar{\Omega}^{-1} + Z'Z)^{-1} \end{aligned}$$

The marginal posterior density of σ_ν^{-2} is $\Gamma(\bar{\bar{a}}, \bar{\bar{b}})$:

$$f(\sigma_{nu}^{-2}|y, Z) = \frac{\sigma_\nu^{-2[(\bar{\bar{a}}/2)-1]} (\bar{\bar{b}}/2)^{\bar{\bar{a}}/2}}{\Gamma(\bar{\bar{a}}/2)} \exp\left\{\frac{-\bar{\bar{b}}\sigma_\nu^{-2}}{2}\right\} \tag{3.27}$$

with

$$\begin{aligned} \bar{\bar{a}} &= \bar{a} + q \\ \bar{\bar{b}} &= \bar{b} + (y - Zg)'(y - Zg) + (g - \bar{\gamma})\Omega^{-1}(Z'Z + \Omega^{-1})^{-1} Z'Z(g - \bar{\gamma}) \end{aligned}$$

where $g = (Z'Z)^{-1}Zy$ is the classical OLS estimator for γ. The marginal posterior density function for γ is a q-dimensional t-distribution with q degrees of freedom and given by:

$$f(\gamma|y, Z) = \frac{\Gamma[(q + \bar{\bar{a}})/2]}{(\pi\bar{\bar{a}})^{q/2}\Gamma(\bar{\bar{a}}/2)} \sqrt{|\frac{\bar{\bar{b}}}{\bar{\bar{a}}}\bar{\bar{\Omega}}|} \left\{1 + \frac{1}{\bar{\bar{a}}}(\gamma - \bar{\bar{\gamma}})'(\frac{\bar{\bar{b}}}{\bar{\bar{a}}}\bar{\bar{\Omega}})^{-1}(\gamma - \bar{\bar{\gamma}})\right\}^{-\frac{q+\bar{\bar{a}}}{2}} \tag{3.28}$$

From Equations (3.27) and (3.28) the following Bayesian estimates for the unknown parameters γ and σ_ν^{-2} can easily be derived:

$$\begin{aligned} E(\sigma_\nu^{-2}|y, Z) &= \bar{\bar{b}}/\bar{\bar{a}} \\ E(\gamma|y, Z) &= \bar{\bar{\gamma}} \end{aligned}$$

Note that for diffuse prior information, which is represented as $\bar{a} = \bar{b} = 0$ and $\bar{\Omega}^{-1} = 0$ the above equations reduce to the well known OLS estimates for γ and σ_ν^{-2}.

Testing for Fixed Effects

To check for the existence of fixed unit and/or time specific effects we test the following three hypothesis:

$$
\begin{array}{lll}
H_0^1: & \mu_1 = \ldots = \mu_{N-1} = \lambda_1 = \ldots = \lambda_{T-1} & = 0. \\
H_0^2: & \mu_1 = \ldots = \mu_{N-1} & = 0. \\
H_0^3: & \lambda_1 = \ldots = \lambda_{T-1} & = 0.
\end{array}
$$

In order to do so we simply employ a F-test. Let R be a $(m \times k)$ matrix where R is formed according to the restrictions which are imposed by the three hypothesis above where m is the number of restrictions. Then m equals $N+T-2$ for H_0^1, $N-1$ for H_0^2 and $T-1$ for H_0^3 respectively.

The Classical F-Test In the context of the classical estimator for γ and under the H_0 that $R\gamma = 0$ the test statistic

$$
F_C = \frac{(Rg)'[R(Z'Z)^{-1}R']^{-1}(Rg)/m}{(y-Zg)'(y-Zg)/(p-q)} \tag{3.29}
$$

is $F(m, p-q)$-distributed. Here again, $g = (Z'Z)^{-1}Z'y$ is the classical OLS estimate for γ.

The Bayesian F-Test In contrast to the classical statistican a Bayesian regards $R\gamma$ as a random variable. The probability that $R\gamma = 0$ is related to the probability that an $F(m, \bar{\bar{a}})$ variable would assume the value

$$
F_B = \frac{(R\bar{\bar{\gamma}})'(R\bar{\bar{\Omega}}R')^{-1}(R\bar{\bar{\gamma}})/m}{\bar{\bar{b}}/\bar{\bar{a}}}
$$

Note again that under a diffuse prior the Bayesian F-statistic reduces to the classical one - apart from the correction for degrees of freedom in the numerator of Equation (3.29).

3.2.4 Demand in export markets

In the preceding section I derived the properties of the econometric models. I will now turn to the application of these models. First I will give a short overview of the highlights of the developments on several export markets and then present the results from the estimation efforts.

Japan Japan imports roundwood from various countries which comprises 75% of its total wood supply. However, after a long period of over-cutting in the supplying countries, the forest resources have been degraded and sustainable management of theses forests is being strongly demanded. The forest policy in supplier countries has been moving in the direction of limiting wood harvesting and exports due to concerns for the environment and degradation of forest resources. Exporting countries are now trying to promote domestic timber industries. Thus, imports from these countries to Japan will continue to decrease, and especially imports of logs will be severely limited.

In the eyes of the Japanese forest industry, forest resources of Russia are still abundant and can be readily developed. There is a long history of Russian-Japanese trade in forest products. After World War II imports of Russian wood increased dramatically. In 1973, roundwood imports from the USSR reached 9.2 million cubic meter. Thereafter, however, the price of Soviet wood started to rise rapidly. Soviet logs were soon out-competed by North American logs. Also the quality of Soviet logs declined remarkably, especially from the early 1980s on and onwards. In addition, the composition of species of logs imported from the USSR continued to fluctuate, causing disruption to the market. This is a feature that is of great importance for Japanese timber markets since joinery and home building follow strong traditions.

Although Japanese-Russian wood trade has indicated negative trends in recent years, there has been some progress as a result of negotiations between Japan and Russia (Russian Far East Update 1997 [52]). The accuracy of scaling of logs has improved and prices are now negotiated for each shipment. However, the fundamental problems of Japanese-Russian wood trade have not been resolved. Supply instability and the failure to sort by species and grades continue to present obstacles to increase use of Russian logs in the Japanese market(Kakizawa 1994 [21]). Russian wood is used mainly for construction purposes. In principal Russian wood would be equally preferred to its competitors. However, due to degregation of wood quality, the lack of sorting logs by species and grades in Russia, old-fashioned Russian port facilities, unreliability of Russian traders, and finally the unwillingness of Japanese consumers to change their preconception about quality standards leaves Russian logs largely non-competitive.

It is very likely that the trend of establishing Russian-Japanese joint woodworking plants will continue. Exporting more value-added products will create more jobs in Russia, help the Russian economy and help Japanese importers to minimize the problems identified above. Moreover, it seems that joint companies tend to make more efficient use of the valuable raw material wood. If this trend will persist the Russian market share will increase in all products.

South Korea Korea has been one of the fastest growing economies in the world for the last three decades. Korea due to its cheap and disciplined labor resource has built an export oriented industrial structure. Korea, however, is poorly endowed with natural resources. Nonetheless, Korea was able to build a sizeable forest industry. The dominant pattern of the forest industry in the 1960s to 1970s was importing hardwood logs from South East Asia and exporting mainly to North America mostly in the form of low-value bulky products such as plywood. The forest industry and exports of forest products continued to grow throughout the 1970s. The trend was halted in 1980 by a log export ban in Indonesia, the major supplier of hard wood logs to Korea. Although exports of forest products have sharply declined since 1980, Korea has continued to import large amounts of logs for its growing economy, now mainly for its domestic use. The internalization rate of wood import went up from 43% in 1969 to 97% in 1990 (Kwang Il Tak 1994a [48]). At present, virtually all wood demand is derived from domestic consumption. On the supply side, the limited land base and growing stock in Korea could not meet the soaring wood demand boosted by the economic growth of the country. The average annual share of domestic wood supply between 1968 and 1990 was only 16% of total timber demand.

The average annual growth rate of timber demand for the period from 1968 to 1990 was 6.5%. If this situation continues the self-sufficiency ratio will continue to fall and Korea will have to continue to rely on imports to meet rising domestic demand.
Korea has traditionally imported from few major sources. Hardwoods were mainly imported from Indonesia and Malaysia, and softwood from the United States. When Indonesia banned log exports in 1980 Papua New Guinea, the Solomon Islands, Chile, and New Zealand emerged as new supply sources to Korea for hardwood and softwood respectively. In 1991 and 1993, when harvest operations were significantly reduced at the Pacific Rim of the United States and prices increased dramatically, Chile and New Zealand took over the market share from the United States. Whenever shifts in the market structure took place, the main force behind the change was changes in the relative prices. This observation can also be confirmed by our econometric analysis. The estimated price elasticity shows a steep gradient and is statistically and economically well different from zero. Price increases were driven mainly by short supply, which stems form either environmental concerns or protection of own industries in supplying countries. Price is such a powerful driving force in Korea that the shift of suppliers is not only taking place among suppliers of one kind of comparable species but even between different species. For example, hardwood logs have been gradually replaced by softwood due to relative price changes in the 1980s.
The geographic vicinity of Korea to the Russian forest resource base suggests that now, in times of changed political relations, the Russian Far East in particular could become one of the major timber suppliers to Korea. In the late 1980s, when Korea and the former USSR were paving the way for formal diplomatic ties, the Russian Far East was added to the new supply sources of softwood. Russian logs began to be imported in 1990. Russian imports have increased by more than 10 times since from 1991 to 1994. Russia held already a sizable market share of about 13% in 1994.

Despite the fact that Korea's total wood consumption has increased impressively the wood consumption per capita has almost stagnated for the last 20 years. The growth in population and industrial activity made the total wood consumption grow. This growth pattern is believed to prevail according to Kwang-Il Tak (1994b)[47]. His expected scenario for the position of Russian logs in the Korean market is that Russian log prices maintain their current levels i.e. more expensive than the New Zealand and Chilenian log (pinus radiata), but less expensive than the United States log. In this case, the log imports will largely consist of low grade Russian pulpwood, which supply will be constrained by Russian export taxes. Under this scenario, Russian logs will make up between 15% and 20% of total annual softwood log imports, or between 1.2 and 1.6 million cubic meter. Under the optimistic scenario, that is, if Russian logs would be competitive to U.S. logs only by having over 30% price difference the market share will increase up to 30% to 50% of total softwood log imports by the year 2000. In terms of volume this would mean between 2.4 million and 4 million cubic meters.
The estimated parameters of the one-way fixed effects model for the country group [13] Japan and Korea are shown in table 3.1,and table 3.2

Interestingly, the GNP import coefficient for roundwood, see table 3.1, is even negative. Decreasing roundwood imports with increasing GNP per capita might be due to increased imports of finished or semi-finished timber products since total consumption of all timber

[13]The panel forming this country group comprised time series of China, Hong Kong, Indonesia, Japan, Korea, Malasia, Mongolia, Philipines, Singaure, and Thailand.

Table 3.1: Estimated GNP and price coefficients for the roundwood import equation of Japan and Korea - $\rho = 0.5657$ and $R^2 = 0.95$.

Variable	Coefficient	Standard Error	t-ratio	p-value
ln GNP	-17.219	10.699	-1.609	.11087
Price	-.34544	.54581E-01	-6.329	.00000

Table 3.2: Estimated GNP and price coefficients for the lumber import equation of Japan and Korea - $\rho = 0.4998$ and $R^2 = 0.93$.

Variable	Coefficient	Standard Error	t-ratio	p-value
ln GNP	27.229	1.8807	14.478	.00000
Price	-.12116E-02	.34053E-02	-.356	.72306

products increase. This hypothesis is supported by a rather high elasticity of GNP per capita on lumber imports (see table 3.2), which can be regarded as a semi-finished product. In contrast to roundwood imports, lumber imports by Japan and Korea are rather price inelastic. This suggests that a price shock on the international roundwood market might trigger a demand shock for timber products in these countries. Further investigations would be necessary to clarify this and related questions.
There are still a number of institutional questions to be resolved which are mainly related to trade and investment issues and are to some extend described in Kwang-Il 1994b [47] and Backman 1996 [3]. It is the institutional uncertainty that deters brokers and investors to meet the opportunities on the Russian timber and timber products market.

China China is still under a more or less central planned economy and as it can be foreseen today, this situation will change only gradually. An econometric approach should therefore only partially be applied to make forecasts of import of timber and timber products.
Although China has a rather high self-sufficiency ratio, growing demand will only be covered by imports due to a decline of natural forests and a decline in mature forests. China currently tries to stimulate internal production by establishing plantations with fast growing species. This program is paralleled by efficiency improvement measures increasing the level of comprehensive utilization. In 1983, China imposed the "Regulations for Economical and Rational Application of Wood and Wood substitutes" as a means of limiting demand for timber. Timber is still included in the "Interim Method of Quota Management of Imports of General Products". Timber was considered as a "Class 1 Commodity" of 'strategic' national importance (MOFTEC regulations November 1994)(Waagener et al. 1996 [53]). These measures should avoid strong import dependence of this large economy, where small changes in the per capita consumption pattern might have dramatic effects on the Pacific Rim wood and wood products market. Prices would increase dramatically if China would liberalize its import regulations and thus harm the overall trade balance of the country.
China has historically had preferential tariff structure favoring the import of unprocessed timber with increasingly higher tariff rates for semi-processed and finished products. However, very recently China departed from its rigid position to favor domestic manufacturing of wood raw materials. At the November 1995 meeting of APEC in Osaka; China an-

nounced its intention to greatly reduce tariff rates. The published rates in January 1996 were generally low, the higher rates of processed timber were initially higher and were proposed for reductions which were much more modest. However, exemptions from the general rule are possible in the case of Russia. There are a number of special barter and labor-export agreements with Russia. Government officials indicate that this could be 'resolved' in the case of trade with Russia, although no clear policy appears to exist dealing with such issues.

Besides the obvious trading advantages of China to intensify trade of forest products with Russia there are still serious obstacles to be removed before Russia can be expected to supply significant volumes. Chinese importers feel that Russian trade is not 'trustable' in terms of quality per orders, timely delivery and other details of trade agreements. Timber from Russia is small in size and China prefers large timber. However, this problem is in principal only of technical nature and can be resolved by adequate processing and the technical properties of Russian wood is at least equal to its competitors. The role of finance and credit arrangements is perhaps the most important feature impeding trade.

As noted by Waagener et al. 1996 [53], projected near-term exports from Eastern Russia (East Siberia and Far East) will in all likelihood remain in the range of 5 - 10 million cubic meters, primarily as unprocessed timber. China is not demanding in quality, nor will China pay a premium price paid by other Pacific Rim buyers. Increased trade in lumber and panel products are according to the authors unlikely. However, limited imports of newsprint and cardboard stocks from Russia indicates that such trade is feasible. China is facing severe shortage of both wood-based pulp as well as a broad range of paper and paperboard products. On the other hand, growing consumption within Russia and limited production capacity in Eastern Russia will, however, continue to constrain trade in pulp and paper products.

Central Asian republics and Kazakhstan Historically, the Central Asian republics of the former USSR have relied on Russia to supplement domestic roundwood supplies. Imported roundwood represented up to almost 100% of the commercial roundwood supply in some regions (see table 3.3). In Kazakhstan, due to its own resources, which is to almost 50% deciduous, the import share is not as high.

Table 3.3: Import share of regional consumption of all of Central Asia and Kazakhstan Source: Backman (1996)

	Lumber			Panel Products		
	1989	1992	1993	1989	1992	1993
Central Asia	0.72	0.77	0.81	0.96	0.96	0.96
Kazakhstan	0.24	0.41	0.28	0.47	0.54	0.41

According to Backman 1996 [4] Kazakhstan and the Central Asian republics will continue to be net importers of wood fiber under five different GDP growth assumptions. Roundwood exports have dramatically decreased after 1989. According to data form Backman(pers. comm) exports declined from 1989 in three years to one fifth of its previous level. Central Asian economies have seen a dramatic downturn. Real GNP persisted to decline well after 1995 (Arynovea 1996 [8]). Additionally, wealth is very unevenly distributed in these countries. This suggests that the purchasing power of potential final consumers of timber and timber products decreased even more rapidly. The consumption of lumber is closely correlated with developments in the construction sector. In Kazakhstan, for example, construction of housing continued to decline despite the existence of a powerful construction sector. In 1993, cement output fell by 38.5% and brick output by 18.5%. Housing construction dropped by 24% in 1993. The decline in the construction of hospitals and schools was even steeper. On a net basis lumber exports to Central Asia increased as can be seen in table 3.4 [14].

The central Asian market is and always was dominated by suppliers from Western Siberia

Table 3.4: Export to Central Asian countries from the Russian federation Source: Goskomstat 1996.

	NPT	NPT	Lumber	Lumber
	1994	1995	1994	1995
Kasakhstan	348,1	230,3	18584,3	19718,5
Kirgisia	13,2	8,5	1639,9	2387,0
Tadtschikistan	7,2	14,9	1510,6	3848,0
Turkmentistan	5,4	0,5	2996,0	2650,4
Usbekistan	103,2	43,5	17736,1	17147,3

and the Western part of East Siberia (Voevoda 1985 [26]. The Tomsk region, for example, holds a very high market share in Central Asia. According to data from the local Goskomstat(1996) and federal Goskomstat (1996) [17] and Investitiony pasport (1996) [6] the market share of Tomsk in the roundwood market was 47% in 1994 and 52% in 1995. Also on the lumber market Tomsk was able to increase its market position by a growth rate of 7.7% in 94/95. Large volumes are traded on the bases of tender auction contracts with Ministries or municipalities in these countries. Barter is the prevailing way of trade. Joint ventures were and are about to be established to increase direct sales. Official prices of timber products in Central Asia are 2-4 times higher than the local prices in Siberia. The furniture market seems to be underdeveloped. Italian designed furniture costs 3 to 4 times as much as one would pay in Western Europe.
With increasing wealth the former Central Asian republics will have to cover increasing consumption almost entirely by imports due to the lack of own resources. There are generally few data available and little analytical work done on the projection of future consumption and trade pattern of timber products. In this case, I will just rely on rule of thumb estimations with the support of the modeling exercise by Backman (1996).

Middle Eastern countries Trade of forest products to Middle Eastern countries is a rather new phenomenon and has never really shown up in any international statistics. There is little material available on how successful Russian timber products can be sold

[14]'NPT' stands for Non-processed timber ('000' CUM) and 'Lumber' in ('000' US$).

on these markets. There are already a number of joint ventures implemented. These joint ventures range from simple trade cooperations to joint small-scale sawmilling up to capital investment in leading large-scale sawmills. The Middle Eastern wood products market is paying high prices. As it seems currently, Iranian, Turkish, and other international timber brokers take advantage in these markets due to the limited knowledge of Russian producers and traders. Russian exports are expected to rapidly grow in the short- to medium-term future.

Western and Central Europe Prior to 1991 the Soviet Union was a major supplier of timber products to Eastern and Central European countries. This is especially true for Bulgaria (wood, pulp, newsprint), Hungary (wood, sawnwood, pulp, newsprint), East Germany (wood, sawnwood, pulp) and Poland (pulp, paper) who received substantial amounts from "mother" Russia. Russia was also a major supplier of wood and pulp to the Baltic area (Eronen 1996) [15]. It is unlikely that these countries will source their timber from distant regions in Siberia. However, significant amounts of timber are traded through these countries to the international market. Russia has also delivered substantial amounts of roundwood to Finland, Austria, Sweden, Italy and Germany (see Stakhov et al. 1996 [44]). However, mainly due to dramatically increasing transportation costs, Russia has lost its competitiveness on these markets. According to the Austrian foreign trade statistics (Holzkurier 1995 [7]) roundwood imports form the CIS fell in 1993 by 75%. Imports of lumber and panel products, on the other hand, increased in volume. The volumes imported from Siberia are probably minimal.
The main importer of roundwood is Finland with a share of 39.1% of all Russian exports in 1994. The loss in competitiveness of Russian logs is due to mainly three factors. (1) Most of the wood exported was used as pulpwood where price is the determinate of competitiveness. (2) Especially Scandinavian producers are nowadays hesitant to rely too much on the still cheap Russian wood due to the lack of non-sustainable forestry practices in Russia. The market success on European markets increasingly depends on the implementation of eco-certification. A system of eco-labeling might soon be introduced in Europe where the woodworking industry has to proof that the timber used stems from certified forests according to European standards. Despite somewhat uncoordinated efforts of Russian organizations to create a Russia-made certification program Russian logging methods will not live up to international standards. (3) Uncertain institutional setting in Russia causes additional costs due to day-to-day trouble shooting, and is frequently quoted as the largest impediment in the trade and investment with Russia.
Siberia has a high share of pine forests of high timber value. Timber from these pine forests is valued for its fine textured wood with evenly distributed growth rings and its small, well dispersed and firmly bound up knots. Also, birch is valued for its strength and light color for furniture production. There are still comparable small amounts of sawnwood and unprocessed timber exported from Siberia to Western Europe. Most of it is roughly edged or other processed timber products. The main importer countries for lumber are the UK and Germany.

As we can see from table 3.5 containing data form FAO 1996a,b [9] [51] differences in prices are substantial (46% in 1995) between sawnwood from Canada and Russia. However, there are little differences in the wood quality. However, Russian lumber is badly dried, if at all, and usually the quality delivered, reliablity and additional services do not correspond to Canadian standards. Personal communication with European traders showed that they are impressed by the high quality of Siberian timber, but regret the

Table 3.5: Import prices of sawnwood (coniferous) to the United Kingdom from the Russian Federation and Canada (US$)(Source: FAO 1996a,b)

Year	Russian Federation	Canada
1993	154	228
1994	182	270
1995	196	287

wasteful, inefficient and low quality production scheme.
Recent trade statistics of exports from Russia to European countries show that there is a clear trend of Western Europeans to import more value added products from Russia. However, the fact that the GNP elasticity of roundwood imports (table 3.6) is larger than the elasticity for lumber import (table 3.7) suggests that there is a tendency to increase the value per unit transported.

Table 3.6: Estimated GNP and price coefficients for the roundwood import equation of Western Europe - $\rho = 0.7437$ and $R^2 = 0.82$

Variable	Coefficient	Standard Error	t-ratio	p-value
ln GNP	61.553	20.842	2.953	.0033
Price	-.1213	.5693E-01	-2.130	.0337

Table 3.7: Estimated GNP and price coefficients for the lumber import equation of Western Europe - $\rho = 0.5236$ and $R^2 = 0.93$

Variable	Coefficient	Standard Error	t-ratio	p-value
ln GNP	34.503	3.6453	9.465	.00000
Price	-.46208E-01	.76345E-02	-6.053	.00000

There is hardly any import information available for Eastern European countries. This lead me to resorted to estimate consumption by using the Baysian approach (see table 3.8). As a first step I estimated a two-way error component regression model for roundwood consumption of Western Europe and used the coefficients as priors for the consumption equation estimated for Eastern Europe. Unfortunatly, it is beyond the scope of this study to make estimations of the import demand of this country group. For the model exercise the coefficients for consumption are equally treated as elasticities for import from Siberia which by itself does not seem to be implausible for the Ukrain for expample [15].

3.2.5 Domestic consumption

There is little known on domestic consumption of timber and timber products. Especially, the most recent Russian publications give testimony of this fact (Burdin 1997 [37], and

[15]Future research has to be conducted by modeling world trade in order to give better predicition on import / export flows.

Table 3.8: Estimated GNP and price elasticities for the roundwood consumption equation of Eastern Europe using the elasticities of Western Europe as prior information - Baysian two-way error component random effects model $R^2 = 0.96$

Variable	Coefficient	Standard Error	t-ratio	p-value
ln GNP	87.601	112.73	0.777	.84
Price	-0.221	0.40	-0.547	0.86
constant	588.057	2064.44	0.284	0.87

Rykounina 1997 [27]). The currently most comprehensive studies available are by Backman on fiber flows and physical accessibility. The methodology indirectly refers back to final consumption based on regional disintegrated data of aggregate forest product groups. His expertise is published in Backman 1994 [1], Backman 1995 [2], Backman 1996 [3], and Backman forthcoming [5]. Some regional studies on forest product markets have been conducted by Obersteiner 1996 [35], Obersteiner 1997 [36], Hedeselskabet 1995 [24]. Also the World Bank indicates that the assessment of the internal consumption pattern is one of the most urgently needed studies for the Forest Sector of Russia (The World Bank 1997 [10]). Currently IIASA is conducting a study on this subject.
In the framework of the model, consumption is treated as consumption of forest products by up-stream industry and consumption by final consumers.

Consumption by up-stream industry Consumption is modeled by taking a top-down approach. We first determine the production pattern of final producers given as a set of assumptions and forecasts of industry specific variables as discussed in section 2. The supply pattern of raw-materials to the woodworking industry becomes a function of the raw-material demand of the woodworking industry given its trajectory of production. In this dissertation I will, however, only present results on lumber production. In principle, the model works such that the distribution of production is first calculated for the woodworking industry and in a second step these production figures enter as demand in the roundwood model. However, as already discussed, I present results of lumber production using a central gravity approach. In the case of roundwood / lumber co-production, economically free capacities of roundwood production can be used to compete on the final domestic market or on the export markets. Thus, in the model, *a priory* domestic demand for raw-material supply is given priority.

Demand for internal final consumption The IIASA GIS database system allows the calculation of distances of producers to the closest towns. We were able to obtain population data for individual towns, which enables us, after determining the approximate per capita consumption of timber products, to localize consumption centers.

Chapter 4

Scenarios

Most emphasis so far has been on model building, but now I shall turn to illustrate the model by different scenarios for the saw milling industry. The scenarios are illustrated in two ways. First I present the path of capacities (see for scenario I figure 4.4) and output (see for scenario I figure 4.3) of individual firms over time. In addition, I present supply slacks i.e. unsatisfied demand due to under-capacities dedicated to various markets (see for scenario I figure 4.5 for export markets, 4.7 for West- and East Siberian markets, and 4.5 for Far Eastern markets), price development (see for scenario I figure 4.6 for export markets, 4.8 for West- and East Siberian markets, and 4.11 for Far Eastern markets), and the investment path for foreign and domestic investment 4.11. Second, I present the cross-sectional results by plotting the simulation results of capacities on the geographic map of Siberia. Results are only presented for Scenario I were in figure 4.30 I show the initial distribution of capacities, in figure 4.31 five periods after, and in figure 4.32 ten periods after the initial state.

4.1 SCENARIO I

Scenario I is considered to be the base line scenario. In the description of the baseline case I pin down the parameter values of all parameter that occurred in the previous sections on model building. Further, I list variables which were previously discussed. I distinguish between endogenous and exogenous variables. Some endogenous variables, however, needed to be given a starting value and form a separate set.

Let me now briefly examine some of the results of scenario I-the baseline case. Figure 4.3 shows the supply pattern of individual firms over ten periods. The first year can be regarded as a self-calibration phase in the modeling process. This can be seen by looking at changes in the supply pattern from period one to period two. In period two there are 'suddenly' new enterprises popping up, despite the fact that there are no investments observed (see figure 4.11). These new enterprises are in fact old enterprises of gigantic size (see figure 4.4) and can only enter later when they resized and thus become cost competitive. This already happens in period two due to the high depreciation rate of unused capital. The effective total depreciation rate for these enterprises is $\delta_t \times \delta_t^* = 0.54$. This high depreciation rate is backed by the empirical fact, that these giants had to resize considerably by closing production lines in the real world.

Following this somewhat artificial process in period one, we can observe two processes that drive industry evolution. The first process can be called *resizing* the second *relocation*. The latter describes changes in the location of production whereas resizing can be described as adaption of existing firms to an 'optimal' size guaranteeing competitiveness. One can clearly observe that most of the giants are still forced to down-size in order to get closer to their optional size defined by the model technology, input and transportation costs. Some producers even have to exit the market due to their unfavorable geographic position or production scheme. Contrarily, in period four new enterprises are emerging and other enterprises start to add new capacities. The expansion of certain enterprises is due to losses of capacities of competing firms, foreign investment in the dynamic phase from period three to period four, and increased demand. After period three the industry resized to such an extent that oversupply vanished as a market phenomenon and demand and supply start to equilibrate [1].

Next we come to the phase of relocation. Firms depending on their competitive position either have to further down-size whereas others are able to expand. New capital additions of firms are starting to be financed by retained capital. Analysis of the trajectories of supply and capacities of individual saw mills reveal common patterns. This pattern is characterized by the continuous tendency of the industry to be structured around the optimal size. The optimal size, in this setting, is mainly determined by the parameters determining costs at time T. Here again most crucial are the indicators 'years of logging' [2] and 'terrain factor' (see changes of these parameters in the Scenario II and Scenario III).

Supply slacks can occur for several reasons. The two most important reasons are (1) the rapid depreciation of old capacities and depreciation of unused capacities causing a 'natural' gap between supply and demand (2) and changes in the relative prices among markets. Let me illustrate the latter by referring to a situation where for example prices to Japan increase more rapidly than prices gained at the Chinese market causing a run for the Japanese market. This causes export demand to China be left unsatisfied due to a lack of capacities installed. In such a situation more gravity is on the Japanese market compared to the previous period. This change in gravity causes a supply gap between capacities installed in Siberia and total demand on the Chinese market if capacities are limited as they are from period three onwards.

List of variables and parameters

Static phase and calculation of the quasi optimal state

In the previous sections I discussed the model and the model parameters in great detail. Here I will do only two things. First, I categorize some of the variables and parameters as already discussed at the beginning of this section. Secondly, I define parameter values. The list of exogenous and endogenous variables used for the calculation of SCENARIO I

[1] It is probably more accurate to say that there is a tendency that market forces are equilibrated. As already discussed we find price stickiness in the model and in addition investment lags the supply gap.

[2] This is the number of years a lumber mill operates in a certain area. After this period the mill is assumed to move and start operation in a new area with again 100 percent forest cover.

is as follows:

Endogenous variables
Endogenous variables can be defined as variables that are completely determined by the model's parameters and variables for the first period:

Y_{ijtk} ... Output of producer i which is delivered to market j at time t in the k^{th} tender

endogenous variable that had to be given a starting value

Ω_{ijt} ... Coefficient of comparative non-technological scale effects of producer i at market j at time t(see equation 2.1

$\bar{P}_{jtk}$ ... Vector of maximum total cost at market j where transaction is allowed at time t in the k^{th} iteration

Table 4.1: Base price $\bar{P}_{jtk}$ (US \$ per CUM) in beginning period $t = 1$ and the first tender $k = 1$ and maximum price $\bar{P}^{max}_{jtk}$ (US \$ per CUM) at time t and T (Abbreviations for the geographic regions are explained in figures 4.1 and 4.2).

	EK	PE	SE	NA	ZA	BL	VL	YS	MA	KA	DOM
$\bar{P}_{j11}$	70	70	70	70	70	70	150	150	100	100	50
$\frac{\bar{P}^{max}_{jt}}{2.5}$	160	160	160	160	160	160	240	240	120	120	120
$\frac{\bar{P}^{max}_{jT}}{2.5}$	120	120	140	140	140	140	240	230	140	140	120

$\bar{Y}_{itx}$ ... Production capacity of producer i at time t of technology x [3]

Exogenous variables

π_{ijkt} ... Profit per unit of producer i at market j in the k^{th} iteration at time t

π_{ijkt} $= f^{\pi}(C^P_{it}, C^T_{ijt}, \bar{P}_{jtk}, Y_{ijtk})$(see also equation 2.7).

C^P_{it} ... Production cost per unit of producer i at time t

C^T_{ijt} ... Transportation cost per unit for producer i to market j at time t

D_{jtk} ... Total tender volume at market j at time t in the k^{th} iteration

Exogenous parameters

α_i ... Degree of scale effects

γ_t ... Random variable drawn from a truncated normal distribution with $E(\gamma_t) \geq 1$ and $VAR(\gamma_t = \sigma_{\gamma_t} = 0)$ at time t

ζ_{jt} ... Coefficient of comparative advantage of new technology $\bar{Y}^N_{it}$.

η_{jt} ... Degree of profit maximization at market j at time t.

θ_{jt} ... Random number used for market j with $E(\theta_{jtk}) = A_k$ and $VAR(\theta_{jtk}) = \sigma_{\theta_{jt}}$ at time t for A_k]0,1]

ω_{jtx} ... Coefficient for non-technological scale effects of technology x at market j at time t

Y^{min}_{ij} = ... Minimum contract size

All parameters in table 4.2 are free to choose and were not derived with any kind of supporting methodology except for previous sensitivity runs to pin down the sensitive

Table 4.2: Table of exogenous parameters (Abbreviations for the geographic regions are explained in figures 4.1 and 4.2).

	EK	PE	SE	NA	ZA	BL	VL	YS	MA	KA	DOM
α_i	1.2	1.2	1.2	1.2	1.2	1.2	2	2	1.3	1.3	1.2
ζ_{jt}	1.3	1.3	1.3	1.3	1.3	1.3	3	3	3	2	1.2
η_{jt}	2	2	2	2	2	2	2.5	2.5	2.5	2	3
η_{jT}	2	2	2	2	2	2	3	3	3	2	3
A_1^t	0.15	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.05	0.1	0.1
A_1^T	0.5	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.3	0.5
ΔA^t	0	0	0	0	0	0	0	0	0	0	0
$\sigma_{\theta_{jt}}$	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2
$\sigma_{\theta_{jT}}$	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.01	0.01	0.01	0.05
$\Delta\sigma_{\theta_{jt}}$	0.005	0.005	0.005	0.005	0.005	0.005	0.001	0.001	0.001	0.001	0.005
ω_{jt}^o	0.3	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.5	0.2	0.01
ω_{jt}^n	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.01
Y_{ij}^{min}	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04

support intervals of the respective parameters. Without going into great detail let me verbally shortly sketch the content of table 4.2. I will make this point by comparing behavior of agents at the trading point EK (Ekaterinburg) and VL (Vladivosock). In Vladivostok buyers are more sensitive to the service coefficient (η_{jt}). This is especially true for the quasi-optimal state (η_{jt}), which crucially determines the firms' individual future trajectories of capacities. At the same time sellers are forced to sell off more at the base price (more generally lower prices) in Ekaterinburg (A_1^t and A_1^T). Transactions bear more risk in Ekaterinburg ($\sigma_{\theta_{jt}}$). For a Japanese trader it is more important to buy a product produced by new capacity (ζ_{jt}) where the size of the producer producing with new capacity is not of great importance (ω_{jt}^n). Contrarily, if a Japanese trader buys form a producer producing with old technology the trader will prefer to deal with large producers (ω_{jt}^o). Individual contracts have to exceed a minimum physical volume of 100 CUM (Y_{ij}^{min}) [4].

Indexes

N	$= 205$	Total number of enterprises at products market l
M	$= 28$	Ten export and eighteen domestic trading points
K_t	$= 100$	Number of auctions per period in each simulated period t
K_T	$= 250$	Number of auctions for calculation of the optimal allocation
T^s	$= 10$	Number of simulated periods

Dynamic phase

Capacity enlargement and Price determination

For the calculation of price changes some changes in the calculation of the equations discussed in 2.17 were made: $I^f = 0$, $E_t(\sum_i I^{\pi}_{ijt+t'}|Inf^{\pi}_t) = (t')\sum_i \pi_{ijt})|Inf^{\pi}_t$ with Inf^{π}_t be equal the constraint set as defined in 2.10 to 2.13, $E(ss_{jlt}) = (E_t(D_{j,t+t'}) - \sum_i \bar{Y}ijt) + (E_t(D_{jt-1}) - \sum_i Yijt - 1)$. This would mean that agents in the economy when deciding on price formation are not able to anticipate foreign investments, believe that investment

[4] Physical output is alway presented in '000' CUM.

out of own resources are equal to the level of the previous period, and finally take the current supply slack into account in the calculation of the expected supply slack. Overall the coefficients of the logistic filter were set such that price changes are modeled to occur rather smooth.

Another very important assumption that is build in the model is that I endogenize investment such that investment is equal to the difference between demand and the actual supply to a particular market in the previous period. It would be very interesting if we were to model investment as an exogenous process and see how capital constraints would affect the possible future industry structure. The interest rate plays no rule, and depreciation rates were set such that old technology would 'naturally' die out gradually with a low speed and excess capacity would depreciate moderately. 70% of the profits are retained in order to be invested in lumber production in the future.

Uncertainty does not play a significant role in the base-line case and agents are allowed to learn relatively fast in terms of their uncertain behavior. The contract modification factor was set such that the seller in this model is rather selective in choosing the most profitable contract.

β_t	$= 1$	Interest rate
ϱ_t	$= 0.7$	Portion of profits that is reinvested
δ_t	$= 0.7$	Depreciation of excess capital
δ_t^*	$= 0.9$	Depreciation of inherited Soviet-type technology
$\Delta\bar{Y}^{min}$	$= 60$	Minimum invested captal ('000' CUM)
$\bar{Y}_T$	$= 250$	Maximum size of a production unit in the optimal state ('000' CUM)
$I^f_{jt=1}$	$= 0$	Outside investment in the first period
$I^f_{jt>1}$	≥ 0	Outside investment in subsequent periods calculated by the non-negative difference between D_{jt-1} and $\sum_i \sum_k Y_{ijkt-1}$
t'	$= 2$	Planning time for price calculation
$c1$	$= 0.75$	Coefficient of logistic function
$c2$	$= 0.5$	Coefficient of logistic function
$c3$	$= -0.5$	Coefficient of logistic function
$c4$	$= 1$	Coefficient of logistic function
$\Delta^+ P_{jt}$	$= 1$	Increase in tender price
$(U-L)^B_{jt=1}$	$= 0.003$	Initial uncertainty level of the buyer
$(U-L)^S_{jt=1}$	$= 0$	Initial uncertainty level of the seller
ι^B	$= 0$	Scaling factor for adjustment of uncertainty of the buyer
ι^S	$= 0$	Scaling factor for adjustment of uncertainty of the seller
υ^B_{jt}	$= \frac{1}{t}$	Learning coefficient in uncertainty for buyers
υ^S_{jt}	$= \frac{1}{t}$	Learning coefficient in uncertainty for sellers
r_l	$= 0.4$	Contract modification factor for sellers

Cost Model
In the base-line case I model taxes and other input costs as they seem to be valid for saw mills and roundwood production in Siberia. The tax rate, overhead cost estimation and other costs were kindly be provided by some enterprise managers at the many excursion I made to enterprises throughout Siberia in the past years. Engineering indicators were taken from the literature and corrected as good as possible for the Russian conditions.

The two indicators, 'years of logging' and the 'terrain factor', vary from simulation and are used to illustrate effects of changes in the forest management scheme on the production scheme of this particular industry.

τ_t	$= 7.6\%$	Tax rate
Ø_t	$= 20\%$	Over head costs
ς^{Harv}	$= 1.5$	Number of working shifts for harvesters
ς^{Fwd}	$= 1.5$	Number of working shifts for forwarder
ς^{Truck}	$= 1.5$	Number of working shifts for Trucks
κ_t^{ul}	$= 700$	Total cost of one unit of labor
Ø_t^l	$= 20\%$	Labor specific over head costs
dt	$= 25\%$	Down time
GS_{it}	$= g_l st.txt$	Growing stock per ha
Tr	$= g_l st.txt$	Problem trees
d^{Harv}	$= 180$	Number of harvester operation days
d^{Harv}	$= 8$	Hours per harvester shift
$\Re_t^{Harv}$	1.2	Productivity factor due to Russian operators
$su_t(hg)$	14	Set-up time between trees
d^{Truck}	$= 180$	Number of truck operation days
d^{Truck}	$= 8$	Hours per truck shift
$\Im_i$	$= 70$	Year of logging
ls_i	$= 1.8$	Terrain factor
C^{road}	$= 0.00512$	Road cost per km
ξ	$= 1.25$	Road maintenance factor for panelizing large enterprises

4.2 SCENARIO II

Compared to the base case Scenario II describes an economy where buyers are more eager to buy from low cost producers (η_{jt}, η_{jT}). Sellers on the other hand are modeled to be rather selective in the selection of contracts (r_l). Prices are allowed to adjust more quickly (c_3) and the maximum price level ($\bar{P}_{jt}^{max}, \bar{P}_{jT}^{max}$) is somewhat lower than in the base scenario. Most of the returns are retained and positioned for new investment in lumber production (ϱ_t). Old capacities are difficult to maintain and depreciate rather quickly (δ_t^*). In addition capacities that were not used also depreciates faster (δ_t). Taxes are set to a higher level of 30% and yearly labor costs (κ_t^{ul}) were also chosen to be rather high. Lumber mills are forced to behave as they would have to operate for 40 years in a specific area, but harvestable forests are relatively widely dispersed (ls_i) suggesting are more extensive forest management scheme.

These changes are illustrated in the list changed parameters compared to the base line scenario (Scenario I in section 4.1). The following changes were made in the parameter values to generate the results for scenario II:

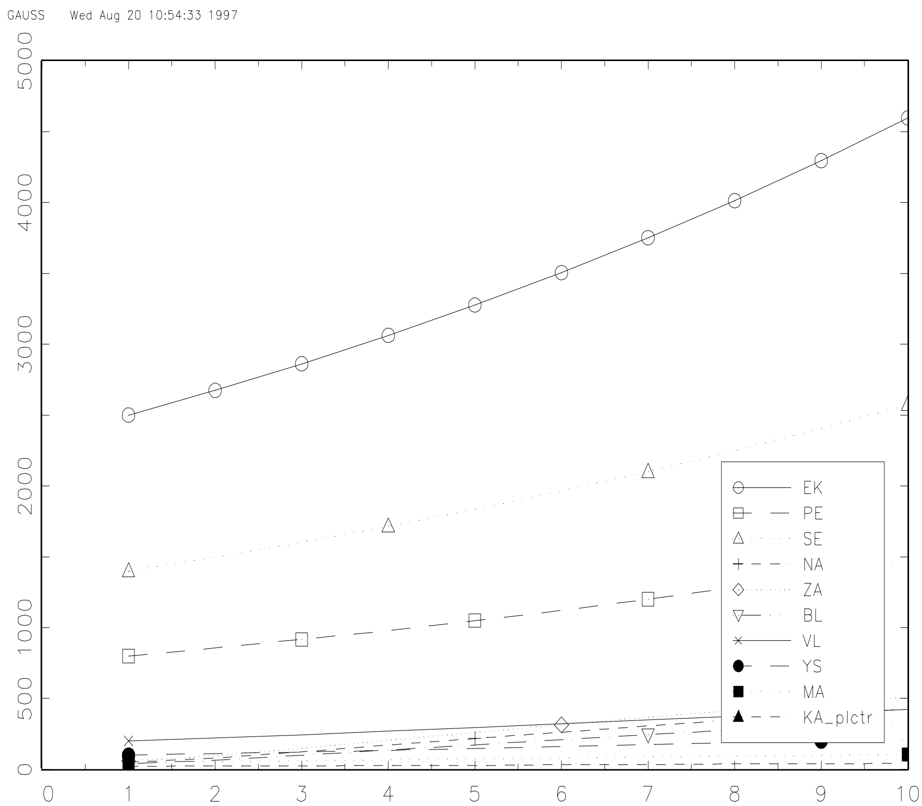

Figure 4.1: Demand of sawn timber ('000' CUM) on export markets projected for ten years. Abbreviations for the export regions in the legend are as follows: EK = Ekatherinburg, PE = Petropavlovsk, SE = Semipaladinsk, NA = Nauski, ZAS = Zabaikalsk, Bl Blagovescensk, VL = Vladivastock, YS = Yuschni Sachalinsk, MA = Magadan, KA = Petropavlovsk-Kamtschtski.

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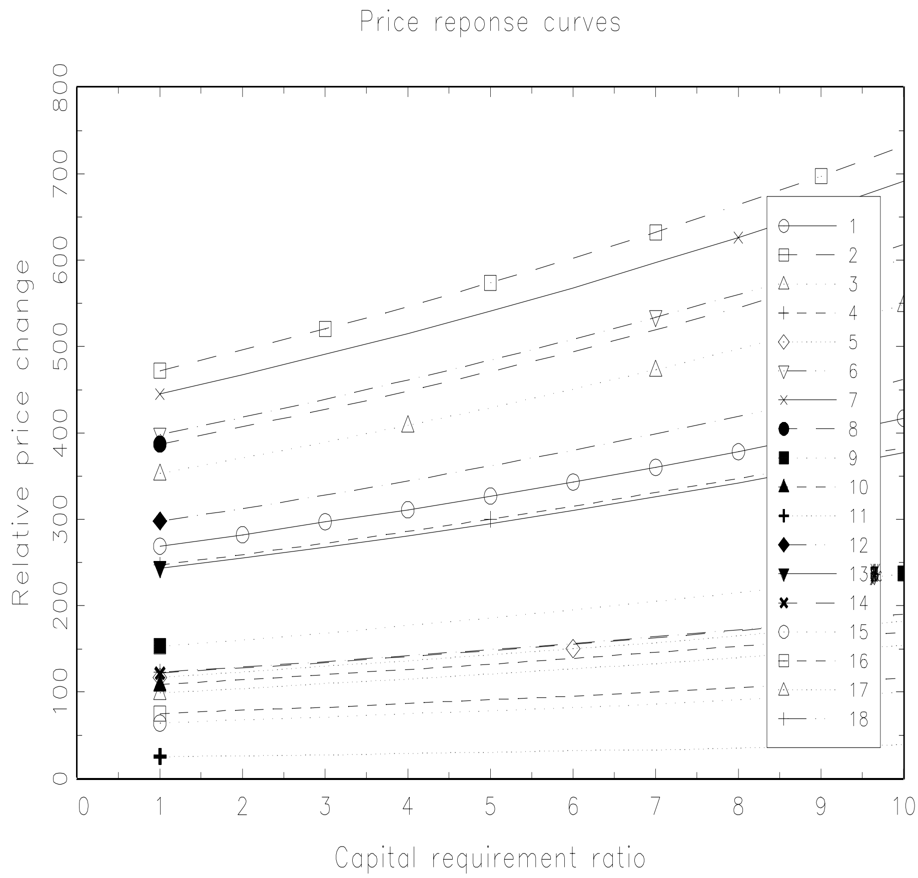

Figure 4.2: Demand of sawn timber ('000' CUM) on domestic markets projected for ten years. Abbreviations for regions in the legend are as follows: 1 = Altajskij Kraj,2 = Kemerovskaja oblast,3 = Novosibirskaja oblast,4 = Omskaja oblast, 5 = Tomskaja oblast,6 = Tyumenskaja oblast,7 = Krasnoyaskij kraj,8 =Irkutskaja oblast, 9 = Chitinskaja oblast,10 = Republic Buryatia,11 = Republic Tuva, 12 = Primorskij Kraj,13 = Khabarovskij kraj,14 = Amursaja oblast,15 = Kamchatskaja oblast,16 = Magadanskaja oblast,17 = Sakhalinskaja oblast,18 = Republic Yakutia.

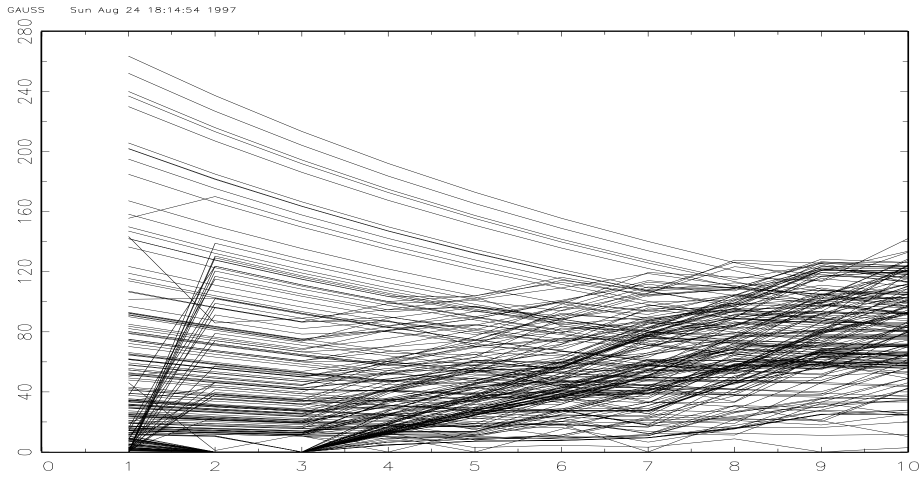

Figure 4.3: Supply path of individual saw mills over ten years according to Scenario I (Yearly output in '000' CUM sawn timber).

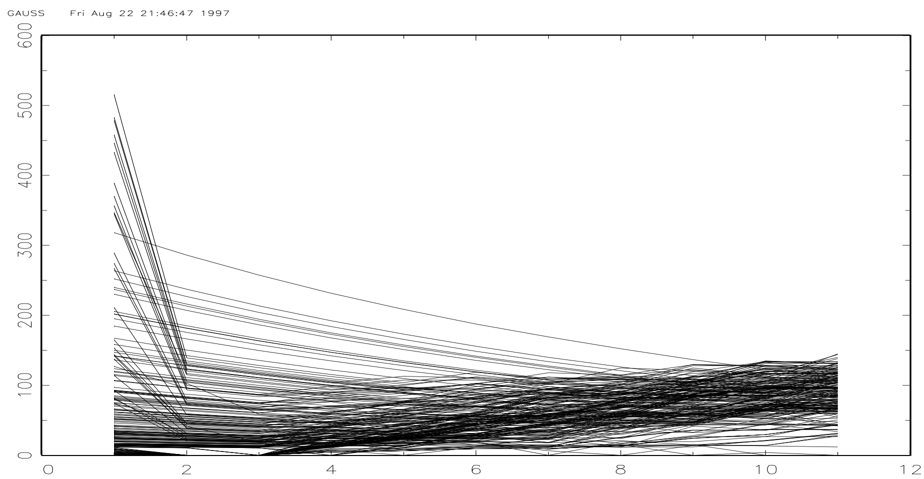

Figure 4.4: Distribution of installed capacities of individual saw mills over ten years according to Scenario I (Capacities in '000' CUM sawn timber).

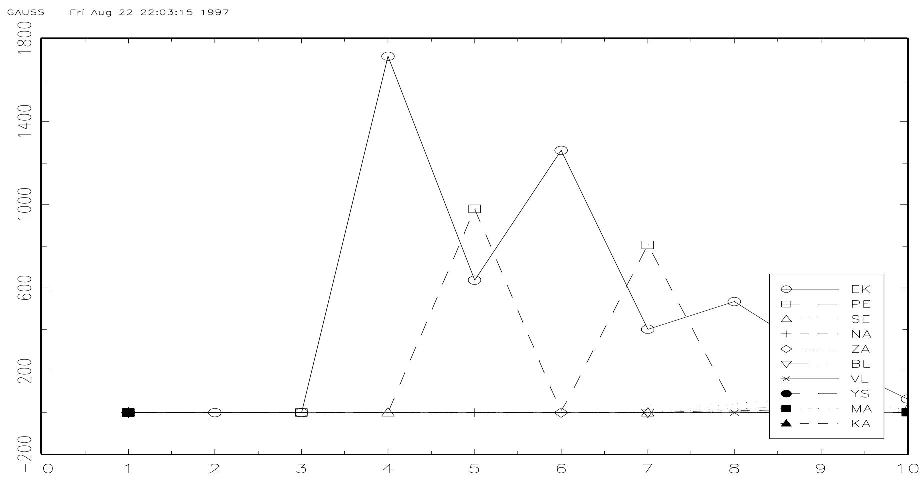

Figure 4.5: Supply slacks in '000' CUM sawn timber on export markets according to Scenario I.

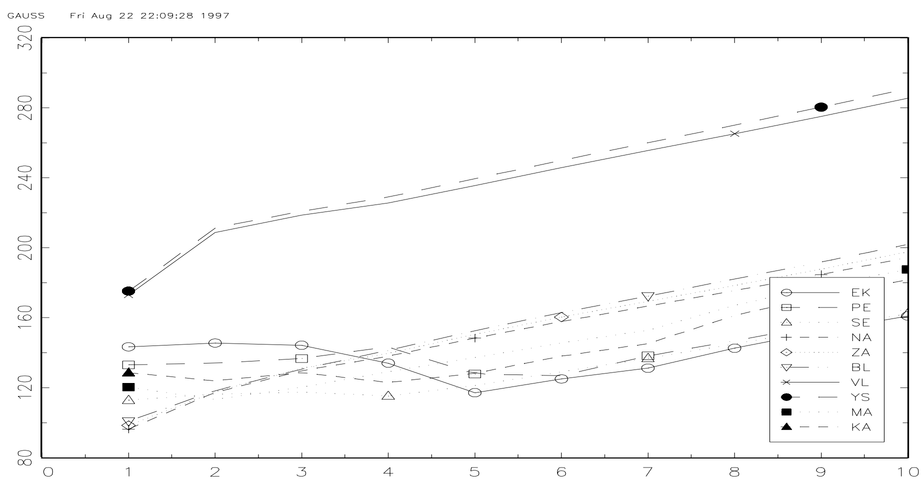

Figure 4.6: Price path for exported sawn timber over ten years in real constant (1990) US $ per CUM sawn timber according to Scenario I. Abbreviations in the legend are set as follows: EK = Ekatherinburg, PE = Petropavlovsk, SE = Semipaladinsk, NA = Nauski, ZAS = Zabaikalsk, Bl Blagovescensk, VL = Vladivastock, YS = Yuschni Sachalinsk, MA = Magadan, KA = Petropavlovsk-Kamtschtski.

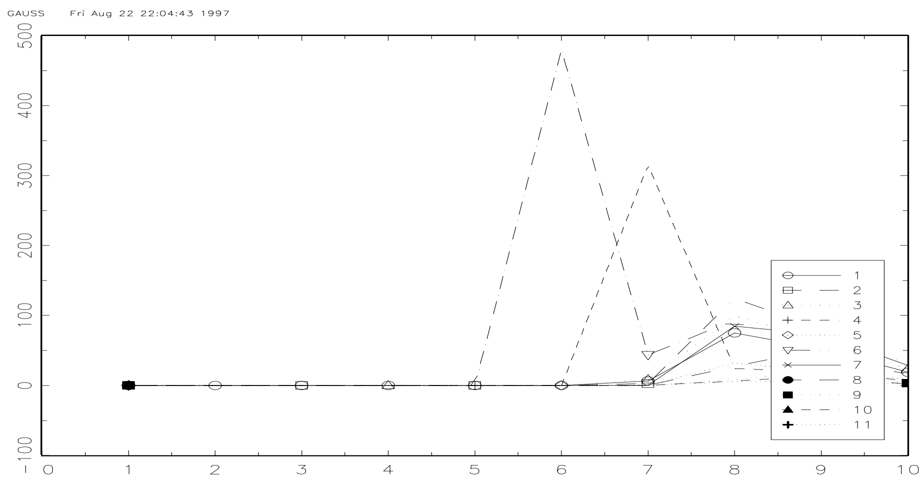

Figure 4.7: Supply slacks in '000' CUM sawn timber on domestic West- and East Siberian markets according to Scenario I.

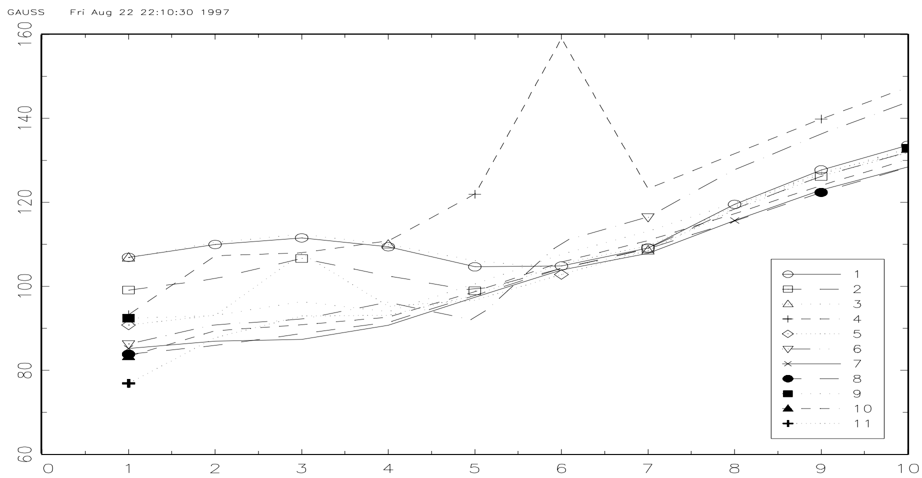

Figure 4.8: Price path for sawn timber over ten years in real constant (1990) US $ per CUM sawn timber delivered in West- and East Siberia according to Scenario I. Abbreviations in the legend are set as follows:1 = Altajskij Kraj,2 = Kemerovskaja oblast,3 = Novosibirskaja oblast,4 = Omskaja oblast, 5 = Tomskaja oblast,6 = Tyumenskaja oblast,7 = Krasnoyaskij kraj,8 =Irkutskaja oblast, 9 = Chitinskaja oblast,10 = Republic Buryatia,11 = Republic Tuva.

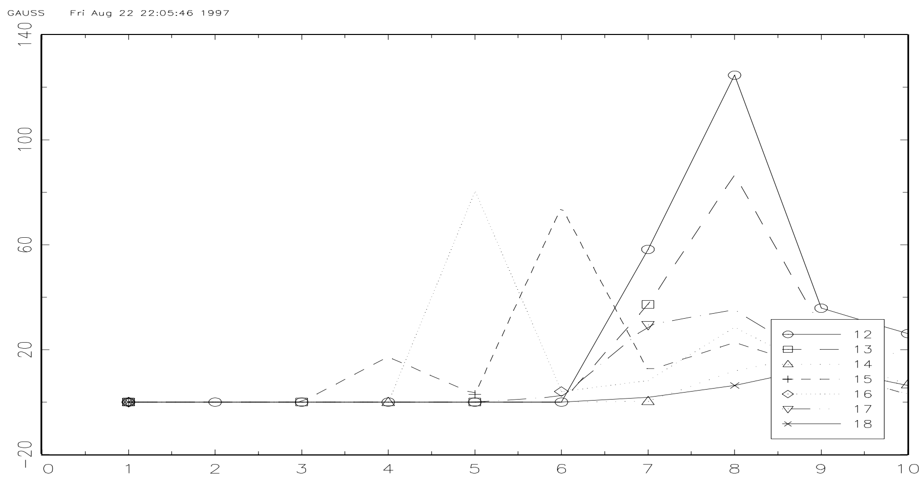

Figure 4.9: Supply slack in '000' CUM sawn timber on the Far Eastern market according to Scenario I.

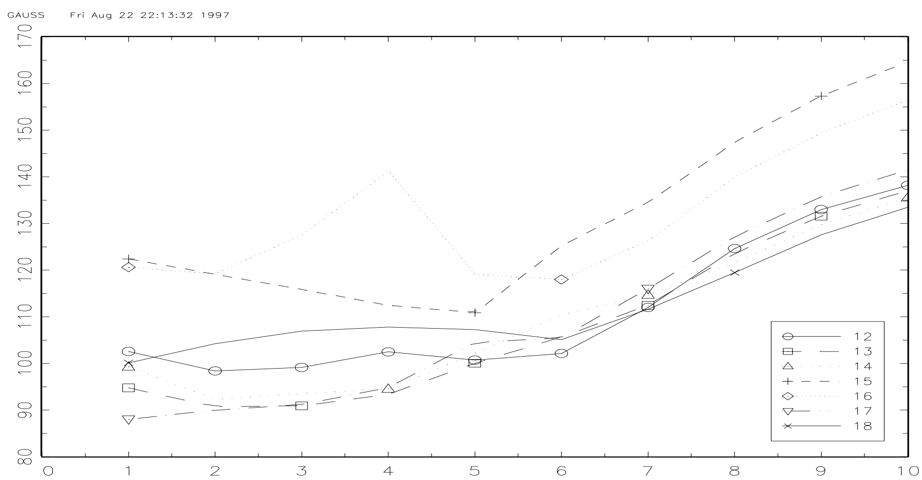

Figure 4.10: Price path for sawn timber over ten years in real constant (1990) US $ per CUM sawn timber delivered in the Far East according to Scenario I. Abbreviations in the legend are set as follows: 12 = Primorskij Kraj,13 = Khabarovskij kraj,14 = Amursaja oblast,15 = Kamchatskaja oblast,16 = Magadanskaja oblast,17 = Sakhalinskaja oblast,18 = Republic Yakutia.

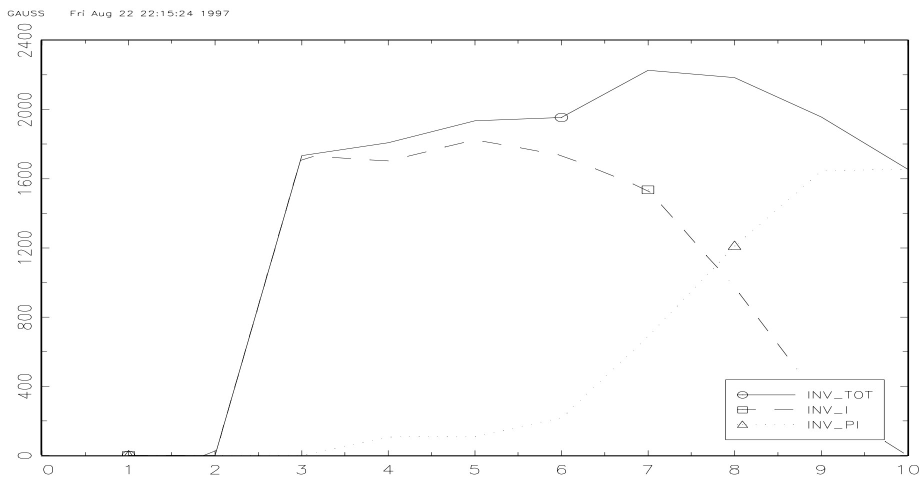

Figure 4.11: Total(inv.tot), foreign (inv.f), and investment financed from own profits (inv.pi) over ten years in '000' CUM sawn timber according to Scenario I.

$\frac{\bar{P}^{max}_{jt}}{2.5} \rightarrow \frac{\bar{P}^{max}_{jt}}{2}$
$\frac{\bar{P}^{max}_{jT}}{2.5} \rightarrow \frac{\bar{P}^{max}_{jT}}{2}$
$\eta_{jt} \rightarrow \eta_{jt} * 1.5$
$\eta_{jT} \rightarrow \eta_{jT} * 2.5$
$\varrho_t \rightarrow 0.9$
$\delta_t \rightarrow 0.5$
$\delta^*_t \rightarrow 0.8$
$c_3 \rightarrow -0.3$
$\Delta^+ P_{jt} \rightarrow 0.7$
$r_l \rightarrow 0.2$
$\tau_t \rightarrow 30\%$
$\kappa^{ul}_{t=1} \rightarrow 7000$
$\Im_i \rightarrow 40$
$ls_i \rightarrow 2.5$

The main results of scenario II can be stated as follows. From figure 4.13 we see directly the effect of the depreciation rate of old, inherited capacities (δ_t). Old capacities die out faster than in scenario I (compare figure 4.4). There seems to be the same phase structure of resizing and relocation. Where relocation is more pronounced in scenario II due to the fact that old mills close earlier. We see also that the producer structure is more differentiated which is a combined effect of relocation, higher cost differentiation (mainly driven by the the number of years of logging in the area), and the service optimizing behavior of buyers. Figure 4.20 indicates that external industry funding dominates. This is connected to the fast decline of old capacities and the resulting low profitability, and large supply gaps which become investment the following period. Supply slacks irrespective of the markets analyzed are larger in size and show almost the same pattern of fluctuation compared to scenario I.

Despite the fact that production costs are higher, prices show a smaller spread and are

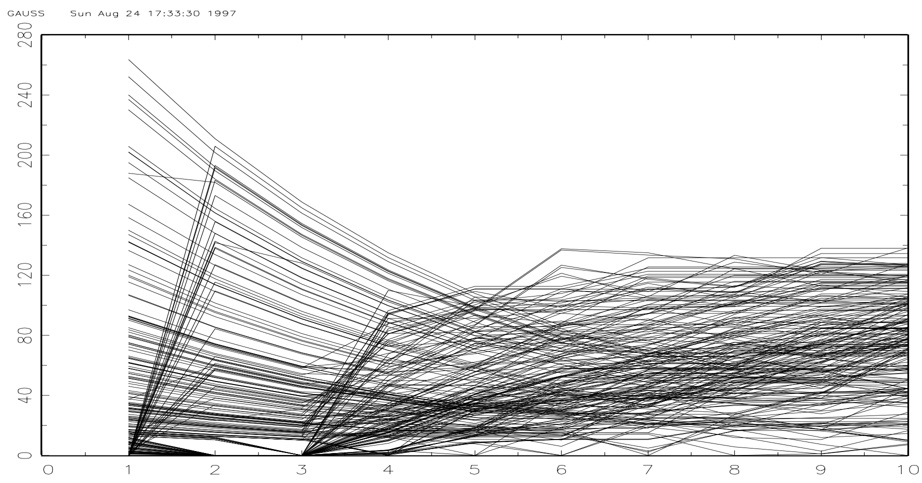

Figure 4.12: Supply path of individual saw mills over ten years according to Scenario II (Yearly output in '000' CUM sawn timber).

smaller in absolute value than compared to scenario I. This phenomenon can in part be explained by the smaller increase of the auction price from one auction to the other and by the change behavior of the buyers. Except, for Vladivostok and Yushni Sachalinsk the prices become almost stationary.

4.3 SCENARIO III

In the economy of scenario III buyers are even more concerned about buying from the least cost producer (η_{jt}, η_{jT}). Sellers on the other hand are not required to be highly selective. In the selection of contracts (r_l) sellers get fewer offers. These offers, however, are usually from buyers which offer high yield projects on a relative basis. Prices are allowed to adjust less quickly (c_3) and the maximum price level ($\bar{P}^{max}_{jt}, \bar{P}^{max}_{jT}$) is somewhat lower than in the base scenario. In the calculation of price changes the following changes in the calculation of the equations as discussed in 2.17 were made: $I^f = 0$, $E_t(\sum_i I^{\pi}_{ijt+t'}|Inf^{\pi}_t) = (t')\sum_i \pi_{ijt})|Inf^{\pi}_t$ with Inf^{π}_t be equal the constraint set as defined in 2.10 to 2.13, $E_t(\sum_i I^d_{ijt+t'}) = 0$, $E(ss_{jlt}) = E_t(D_{j,t+t'}) - \sum_i \bar{Y}ijt$. This would mean that agents in this economy, when deciding on price formation, are not able to anticipate foreign investments, and believe that investment from own resources are equal to the level of the previous period, further they do not take the current supply slack into account, and do believe that capital that is installed today will be entirely available tomorrow.
Most of the returns are retained and reserved for new investment in lumber production (ϱ_t). Old capacities used are maintained at low costs and if used do not depreciate (δ^*_t). Contrarily, capacities that were not used depreciate at a very fast rate (δ_t). Taxes are set to 20% and the yearly labor costs (κ^{ul}_t) were also chosen to be significantly higher than in the base scenario but higher than in Scenario II. Lumber mills are forced to behave as they would have to operate for 120 years (the almost sustainable case) and the harvestable forests are relatively widely dispersed (ls_i).

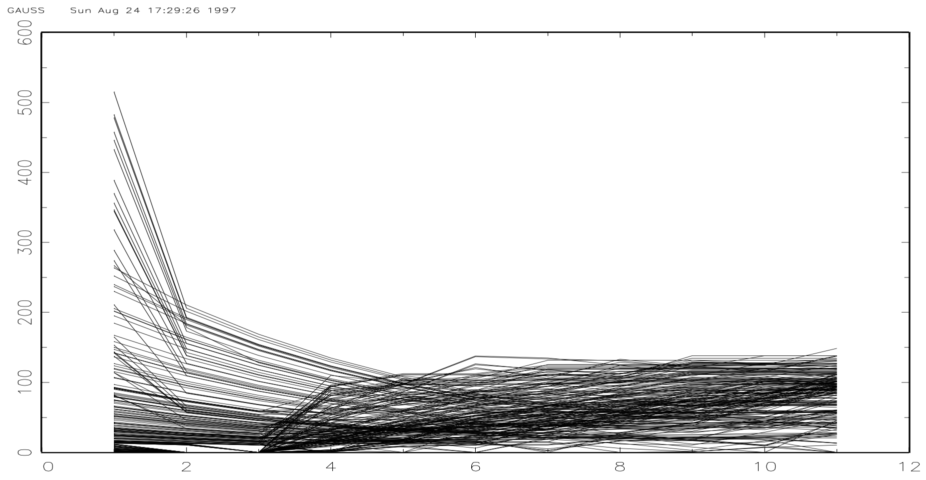

Figure 4.13: Distribution of installed capacities of individual saw mills over ten years according to Scenario II (Capacities in '000' CUM sawn timber).

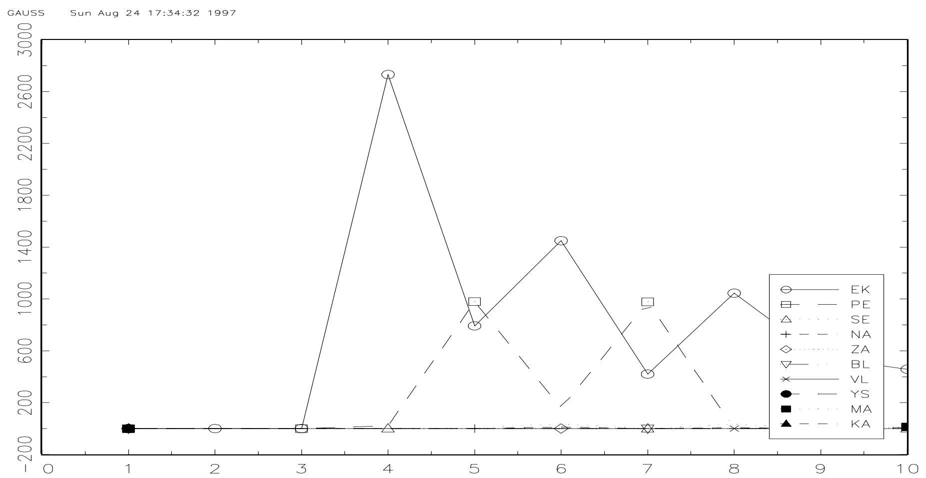

Figure 4.14: Supply slacks in '000' CUM sawn timber on export markets according to Scenario II.

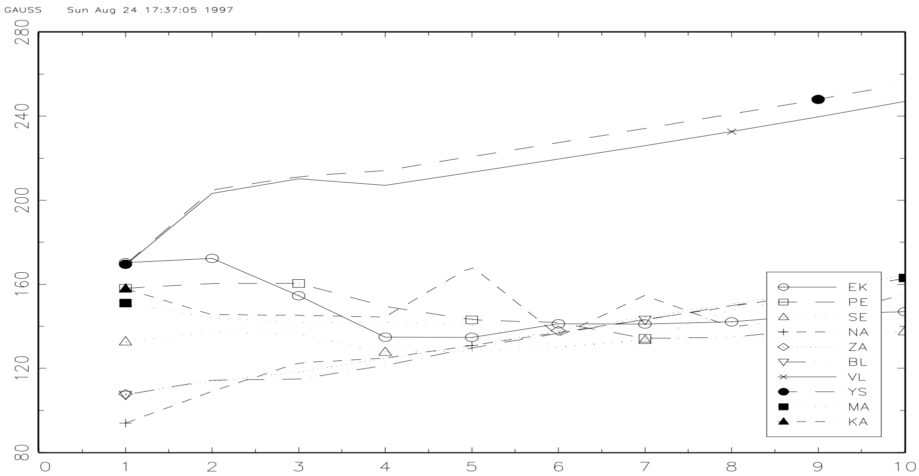

Figure 4.15: Price path for exported sawn timber over ten years in real constant (1990) US $ per CUM sawn timber according to Scenario II. Abbreviations in the legend are set as follows: EK = Ekatherinburg, PE = Petropavlovsk, SE = Semipaladinsk, NA = Nauski, ZAS = Zabaikalsk, Bl Blagovescensk, VL = Vladivastock, YS = Yuschni Sachalinsk, MA = Magadan, KA = Petropavlovsk-Kamtschtski.

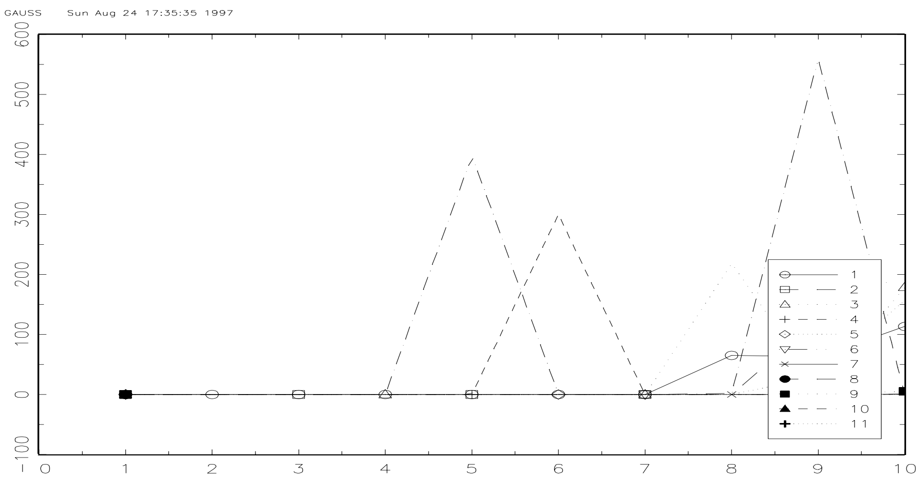

Figure 4.16: Supply slacks on the domestic West- and East Siberian market according to Scenario II.

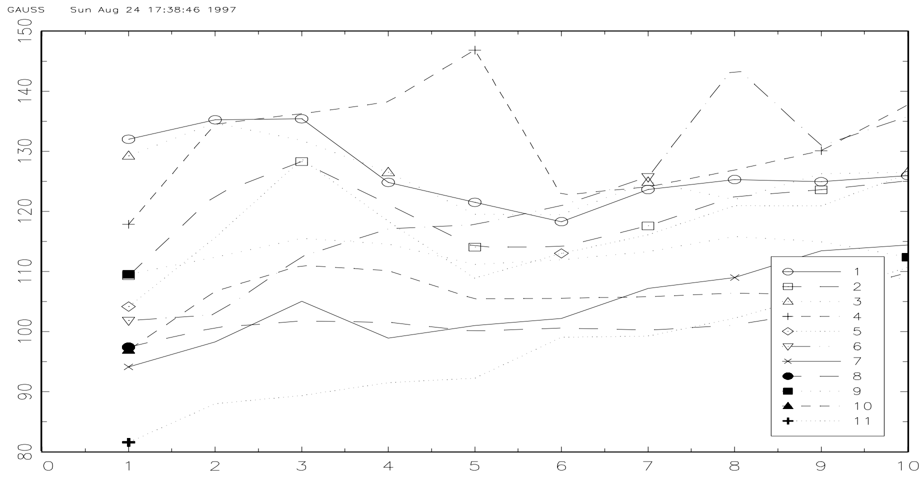

Figure 4.17: Price path for sawn timber over ten years in real constant (1990) US $ per CUM sawn timber delivered in West- and East Siberia according to Scenario II. Abbreviations in the legend are set as follows:1 = Altajskij Kraj,2 = Kemerovskaja oblast,3 = Novosibirskaja oblast,4 = Omskaja oblast, 5 = Tomskaja oblast,6 = Tyumenskaja oblast,7 = Krasnoyaskij kraj,8 =Irkutskaja oblast, 9 = Chitinskaja oblast,10 = Republic Buryatia,11 = Republic Tuva.

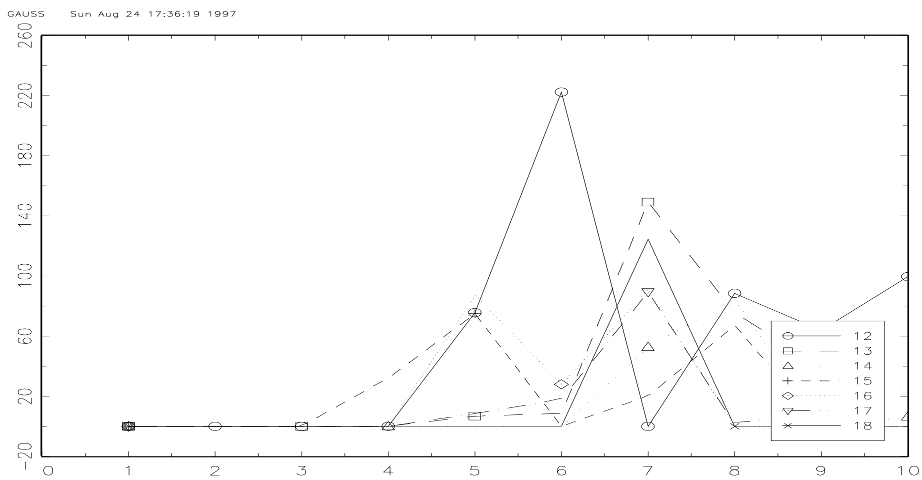

Figure 4.18: Supply slack in '000' CUM sawn timber on the Far Eastern market according to Scenario II.

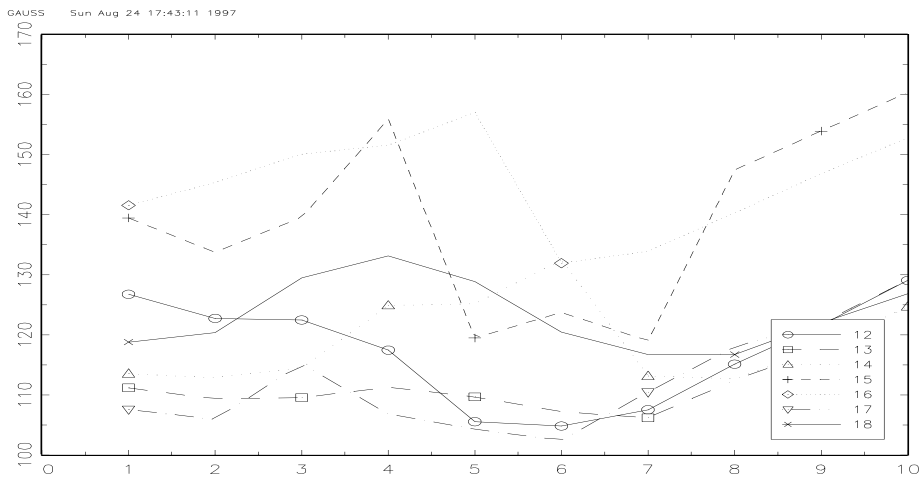

Figure 4.19: Price path for sawn timber over ten years in real constant (1990) US $ per CUM sawn timber delivered in the Far East according to Scenario II. Abbreviations in the legend are set as follows: 12 = Primorskij Kraj,13 = Khabarovskij kraj,14 = Amursaja oblast,15 = Kamchatskaja oblast,16 = Magadanskaja oblast,17 = Sakhalinskaja oblast,18 = Republic Yakutia.

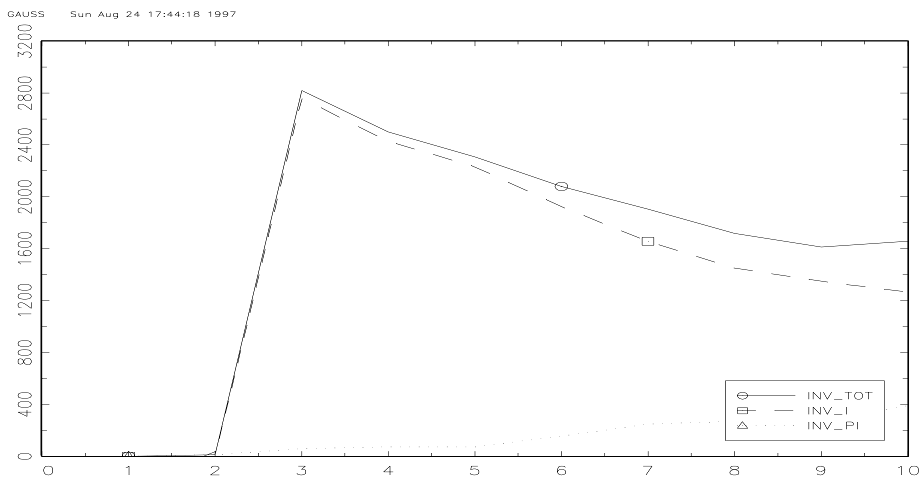

Figure 4.20: Total(inv.tot), foreign (inv.f), and investment financed out of own profits (inv.pi) according to Scenario II.

Here again, I only list changes of parameters values compared to the base line scenario (Scenario I 4.1). The following changes were made:

$$\begin{aligned}
\frac{\bar{P}^{max}_{jt}}{2.5} &\rightarrow \frac{\bar{P}^{max}_{jt}}{2} \\
\frac{\bar{P}^{max}_{jT}}{2.5} &\rightarrow \frac{\bar{P}^{max}_{jT}}{2} \\
\eta_{jt} &\rightarrow \eta_{jt} * 2.5 \\
\eta_{jT} &\rightarrow \eta_{jT} * 3.5 \\
\varrho_t &\rightarrow 0.8 \\
\delta_t &\rightarrow 0.3 \\
\delta^*_t &\rightarrow 1 \\
c_3 &\rightarrow -0.6 \\
\Delta^+ P_{jt} &\rightarrow 0.7 \\
r_l &\rightarrow 0.6 \\
\tau_t &\rightarrow 20\% \\
\kappa^{ul}_{t=1} &\rightarrow 5000 \\
\Im_i &\rightarrow 120 \\
ls_i &\rightarrow 2
\end{aligned}$$

The foregoing two scenarios were rather similar in the behavior of prices, capacity evolution and supply slacks. Scenario III looks very different form the previous scenarios. Let me very briefly elaborate on the results of Scenario III. In Scenario III the phases of resizing and relocation are very different. Resizing takes place in such a way that enterprises resize and stick to their production scheme. Outside investment almost completely dominates. The first large wave comes at the end of period two where there occurs a large supply gap for Ekaterinburg. Relocation can take place only to a limited extent. Old companies and the few founded at the end of period two stay rigidly in business, where increasing demand is taken up by small companies that continuously grow at the rate of increasing demand.

Prices are more volatile in this economy and reach higher levels. This is mainly due to the more expensive raw material supply which in turn can be explained by the changes in the forest management regime.

4.4 GIS representation of SCENARIO I

The option to illustrate the simulation results in a GIS representation is a very important feature of the entire modeling approach. This gives the user of the model, but also the practitioner working for industry the possibility to evaluate the plausibility of the results and also to come up with better policy conclusions. It seems that the human brain is more capable to process visually represented data than data presented in tables or charts of more aggregated data. One develops a certain 'feeling' of what the model does if parameters change. At the same time one learns how different policy options would affect the industry.

Figures 4.30 to 4.31 show nicely the patterns of relocation and size adaptation as already

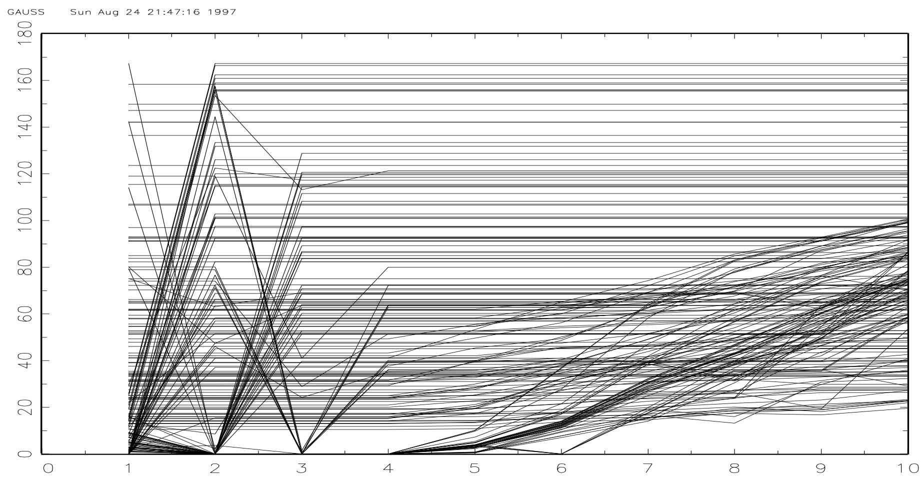

Figure 4.21: Supply path of individual saw mills over ten years according to Scenario III (Yearly output in '000' CUM sawn timber).

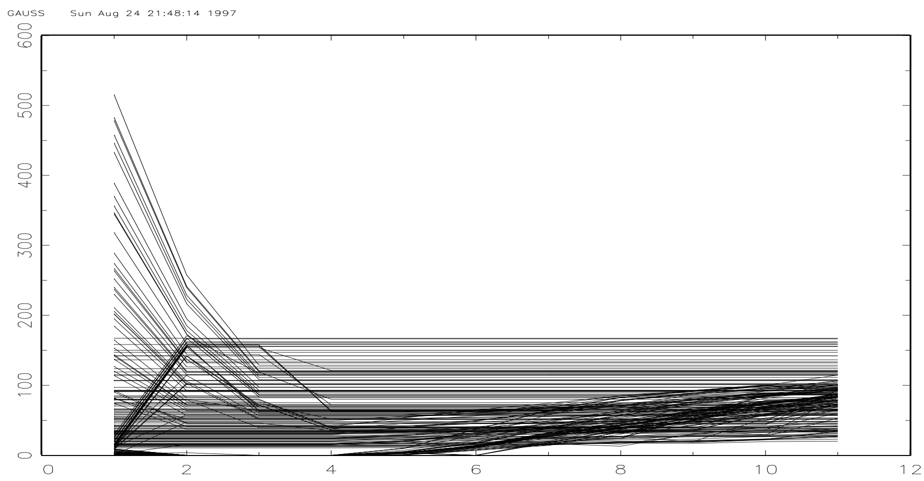

Figure 4.22: Distribution of installed capacities of individual saw mills over ten years according to Scenario III (Capacities in '000' CUM sawn timber).

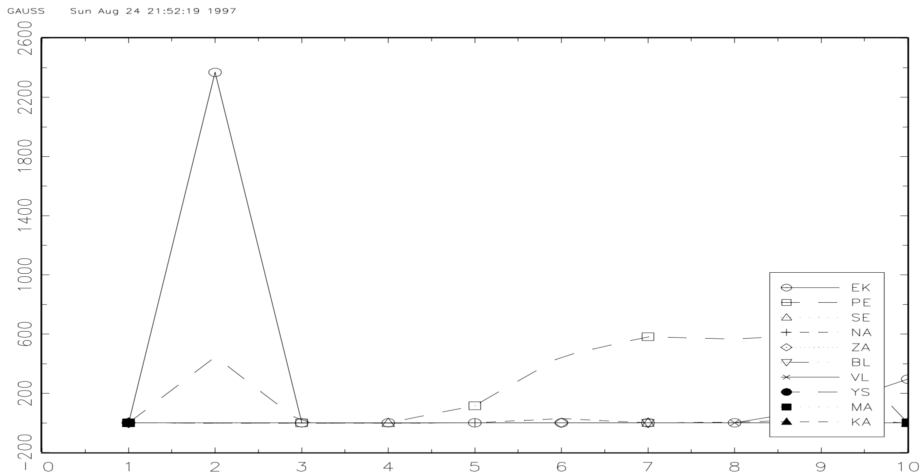

Figure 4.23: Supply slacks in '000' CUM sawn timber on export markets according to Scenario III.

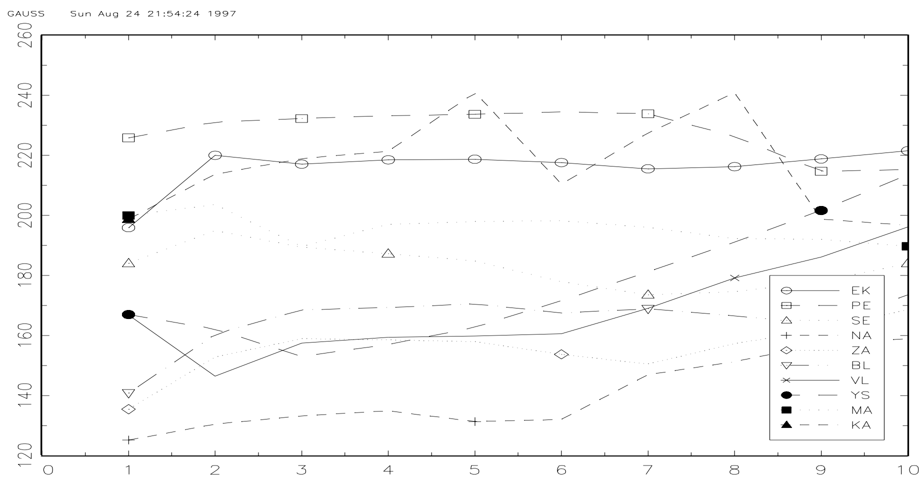

Figure 4.24: Price path for exported sawn timber over ten years in real constant (1990) US \$ per CUM sawn timber according to Scenario III. Abbreviations in the legend are set as follows: EK = Ekatherinburg, PE = Petropavlovsk, SE = Semipaladinsk, NA = Nauski, ZAS = Zabaikalsk, Bl Blagovescensk, VL = Vladivastock, YS = Yuschni Sachalinsk, MA = Magadan, KA = Petropavlovsk-Kamtschtski.

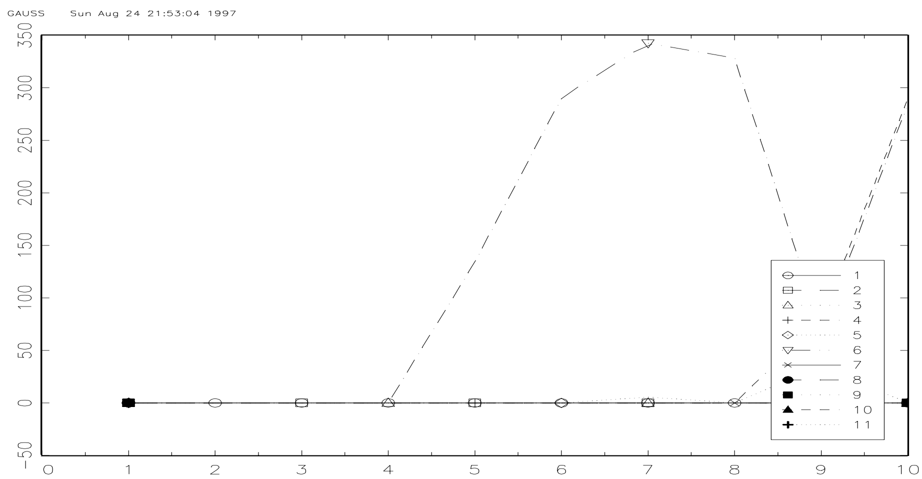

Figure 4.25: Supply slacks in '000' CUM sawn timber on the domestic West- and East Siberian market according to Scenario III.

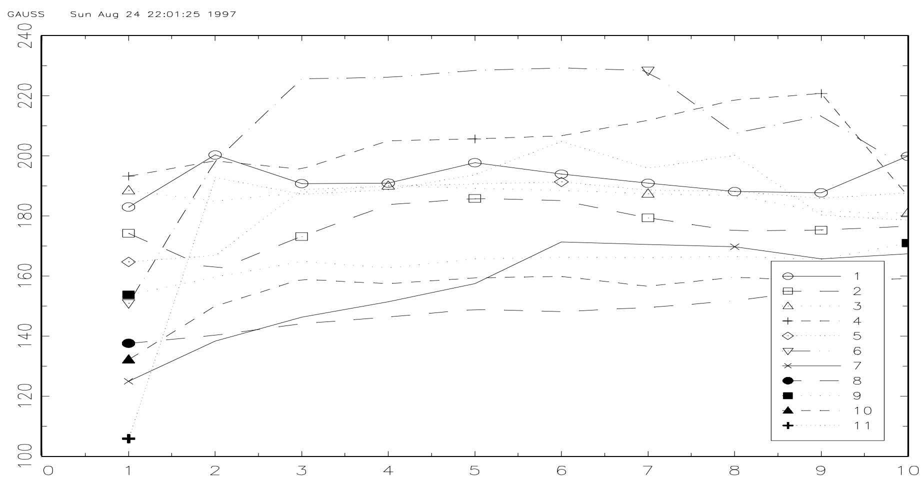

Figure 4.26: Price path for sawn timber over ten years in real constant (1990) US \$ per CUM sawn timber delivered in West- and East Siberia according to Scenario III. Abbreviations in the legend are set as follows:1 = Altajskij Kraj,2 = Kemerovskaja oblast,3 = Novosibirskaja oblast,4 = Omskaja oblast, 5 = Tomskaja oblast,6 = Tyumenskaja oblast,7 = Krasnoyaskij kraj,8 =Irkutskaja oblast, 9 = Chitinskaja oblast,10 = Republic Buryatia,11 = Republic Tuva.

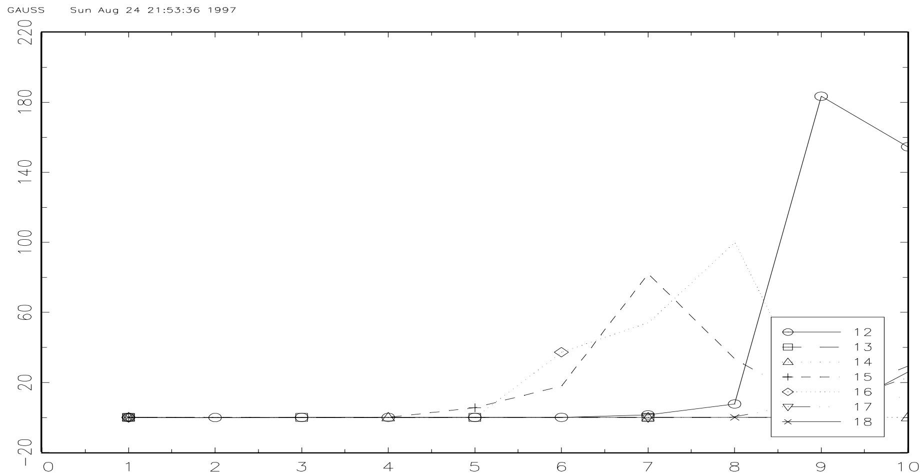

Figure 4.27: Supply slack in '000' CUM sawn timber on the Far Eastern market according to Scenario III.

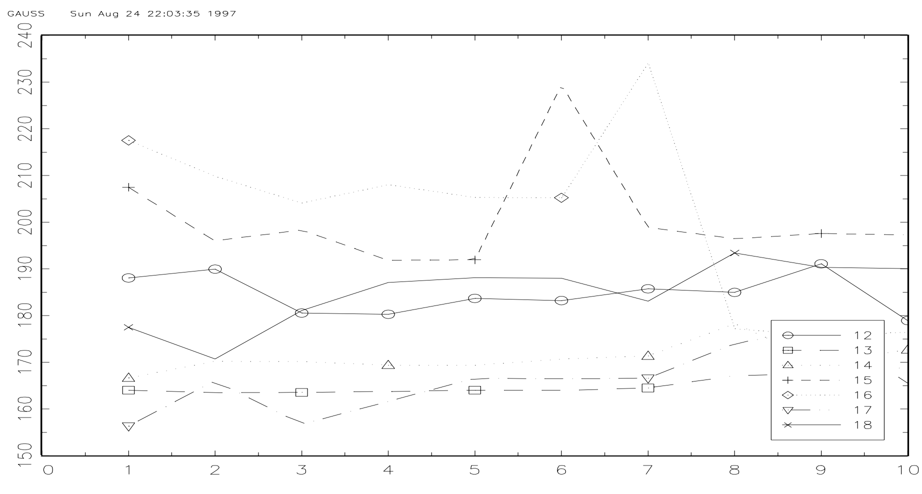

Figure 4.28: Price path for sawn timber over ten years in real constant (1990) US $ per CUM sawn timber delivered in the Far East according to Scenario III. Abbreviations in the legend are set as follows: 12 = Primorskij Kraj,13 = Khabarovskij kraj,14 = Amursaja oblast,15 = Kamchatskaja oblast,16 = Magadanskaja oblast,17 = Sakhalinskaja oblast,18 = Republic Yakutia.

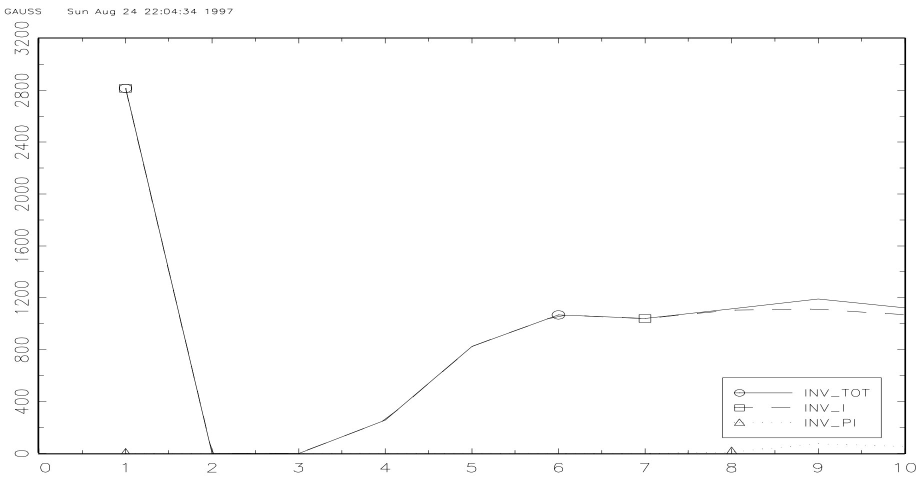

Figure 4.29: Total(inv.tot), foreign (inv.f), and investment financed out of own profits (inv.pi) according to Scenario III.

discussed in section 4.1 [5]. The most interesting insight gained from the GIS-representation of scenario I is the rather strong concentration of enterprises in the area of West and East Siberia. It seems that this result is due to the predicted demand structure and in part due to the fact that no green-field sites were allowed in the particular set of scenarios presented. Many experts would think that on a relative scale Far Eastern regions would be able to expand more.

[5]There is currently, however, one problem that is that the size is not plotted continuously but by categories. Thus the giants are sometimes underrepresented as to their real size and the small enterprises might on a relative scale appear as too large.

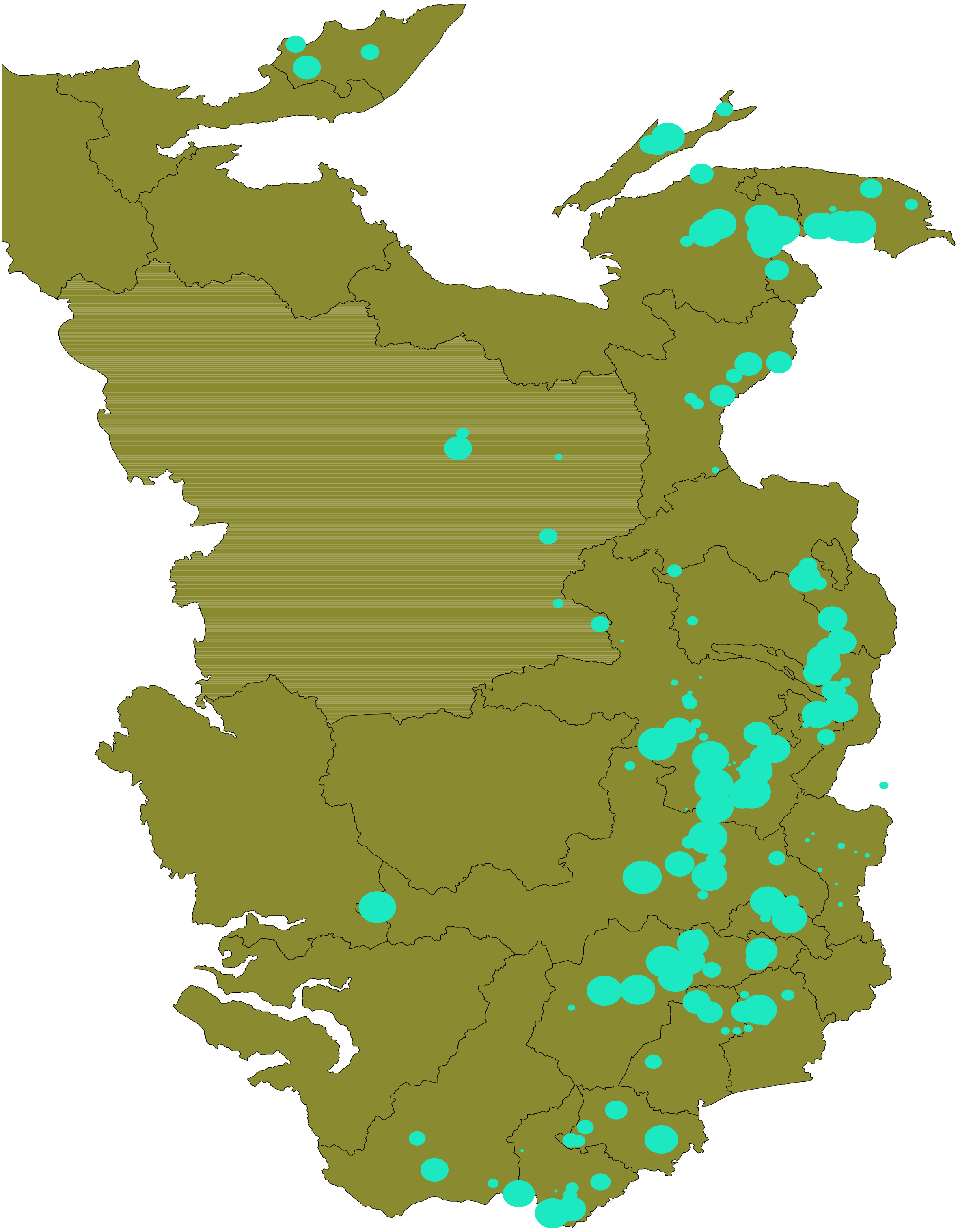

Figure 4.30: Distribution of productive capacities for lumber production in Siberia in 1989. Dots indicate the size category and geographic location of individual enterprises.

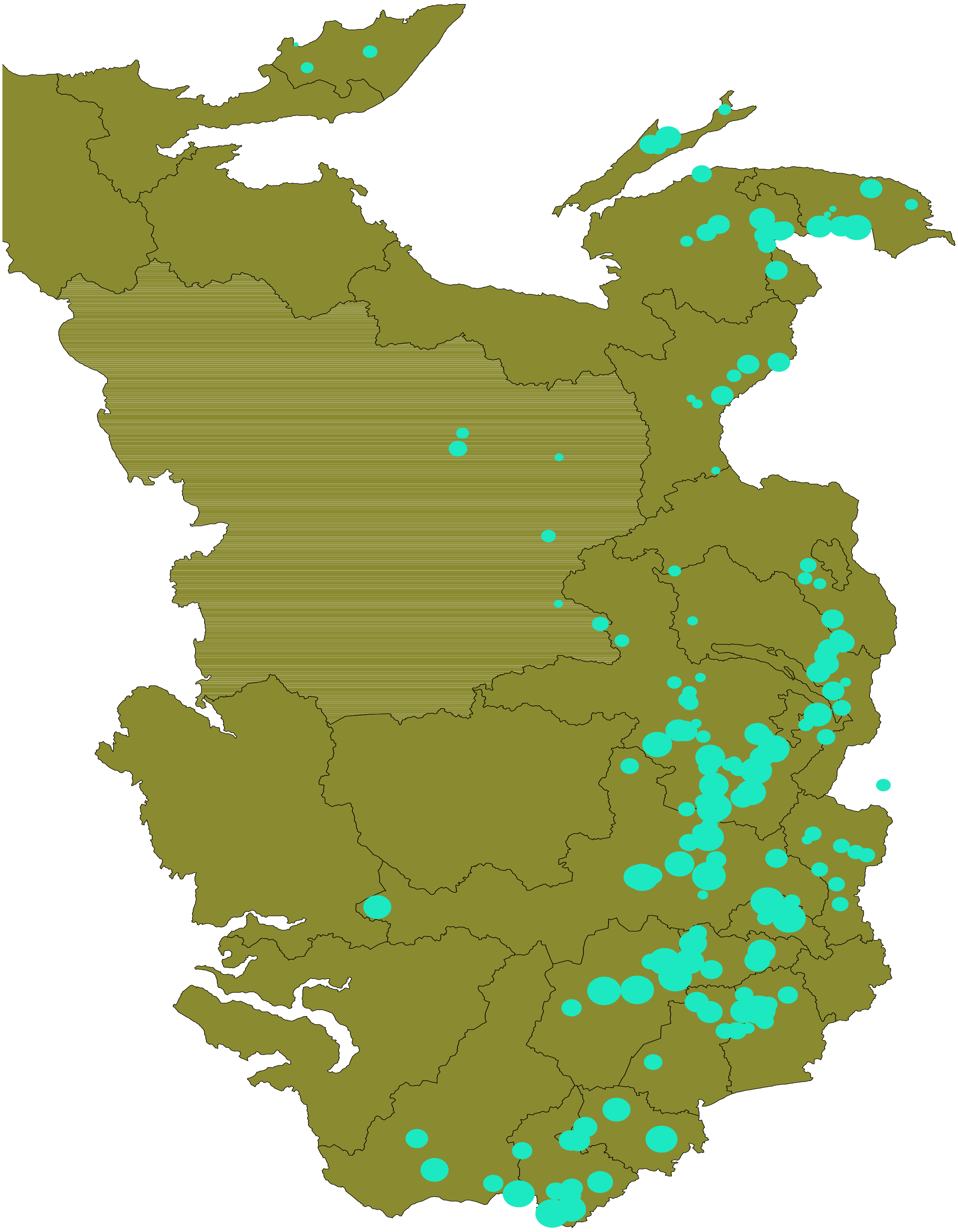

Figure 4.31: Distribution of productive capacities for lumber production in Siberia in period $t = 5$ according to Scenario I.

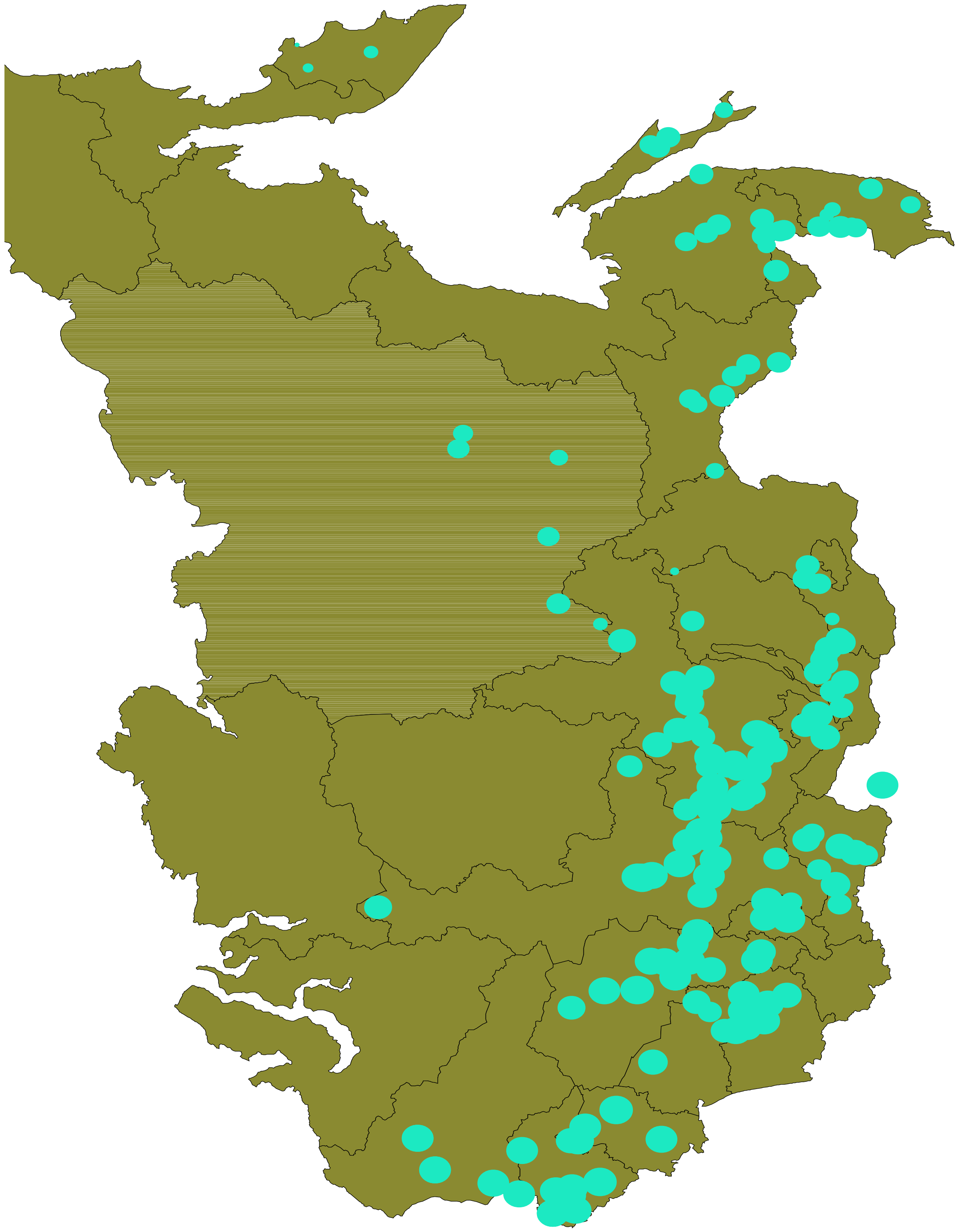

Figure 4.32: Distribution of productive capacities for lumber production in Siberia in period $t = 10$ according to Scenario I.

Chapter 5

Summary and Conclusions

Russian industry experienced a serious economic crisis that resulted in a major drop in output in the forest industry. This caused a dramatic decrease in real employment and income in forest industry based communities. Especially, in the more distant regions of Siberia the economic down-turn has been more severe compared to the Russian average. In addition, Siberia's forest sector has recently gained considerable international interest for its environmental problems. So far little is known about the possible future path of Siberia's forest sector and its role on the international forest products markets. I have developed a model that can be used as a decision making tool for policy analysis of various scenarios and levels of detail analyzing the forest industries of Siberia. The entire economic system is modeled on the basis of the behavior of individual firms.

The PSFIM was designed to model allocation pattern of the production of individual producers in the Siberian forest sector during transition from a command economy to an economy based on market principles. Due to the unplausibility of assumptions built in standard economic models combined with the possibility to link to an extensive resource data base, the modeling strategy was to build an easy-to-understand and easy-to-compute economic model which makes sense and takes maximum use of existing data and expert knowledge. The model is based on Vickery's Nobel Prize Winning auction theory in order to simulate the possible future formation of Russia's forest industrial sector. In the model I distinguish between a static phase and a dynamic one. The static phase describes the auction mechanism, which is applied for each period, leading to a partial market clearing depending on the producer and price constraints. In the dynamic phase, product prices adjust, producers invest or depreciate capital, contract partners revise contract policies and, finally, prices change according to the overall economic development.

Enormous amounts of data from many different sources and expert knowledge have been compiled and have been woven into the model. The core model is flexible in the sense that new knowledge or data can rapidly be included. This is usually achieved by to combining other models with the core model. So for example a cost module and a demand module are attached to the core model in the current version. The cost module calculates costs as a function of a number of variables starting from forest inventory information, forest management rules, to harvesting and processing technology. The demand module predicts demand on the basis of demand functions, which were estimated with the help of econometric tools. In the current version I developed a Bayesian panel data model, which has never been developed in the economic literature. Another very important feature of the model is that issues of international trade can be addressed. Trade, and especially international trade flows, not only depends on predicted predicted supply and demand patterns of importing and exporting regions, but also factors like transportation costs, loading and reloading costs, tariffs and quotas. The effects of all these factors can be explored with the PSFIM. In addition, the model is capable to model the effects of differences in the business approaches of different cultures on the international trade pattern. As an illustration one can consider a Chinese trade who is more concerned about prices whereas Japanese markets require high contract reliability and product quality.

It is worth pointing out that the distinguishing feature of the entire modeling approach is that exchange is not simulated by a very specific class of trade game (i.e. general equilibrium or Bertrand competition), but by negotiations in an auction mechanism. Auctions are simulated using multiple decision criteria with different negotiation capabilities and market power of individual agents. However, optimizing behavior of any kind can be treated and implemented as special cases. In addition, I allow for heterogeneity in the cost structure, and behavior of agents. Depending on the market power of the buyers or sellers the algorithm either allows the buyers purchase at a low price or the sellers sell at a high price. Either the producers or the buyers gain relatively more from the transaction. An increasing price auction with a reserve price is iteratively conducted until either producer or buyer constraints are violated. Buyers propose contacts to a selected subset of sellers, which after a screening of all received contracts decide to accept, modify or reject the proposals made by the buyers. Due to the nature of the auction set up it is impossible (also theoretically by backward induction) for the individual agents to compute their optimal strategy in the auction nor is it possible to compute the optimal strategy over periods using an inter-temporal optimization procedure. Nonetheless, the agents' behavior tends towards a quasi-optimal state in a distant future period.

Typically, output is given at an individual enterprise level of the final product. Trade flows between individual agents, prices negotiated by individual bargain, supply slacks, capital formation, profits, investment and many other details can be reported on an individual mill or even contract level. Despite the fact that the model was not yet fine tuned, preliminary results seem to indicate that the model is capable to match reasonably well the pattern of output decline and relocation. Also price development, especially for export prices, can almost realistically be reconstructed.

These are all very encouraging results. Nonetheless, the model will still have to be further extended and fine tuned. The most recent results from theory will have to be continuously incorporated into the model. Especially, there is a need to further strengthen the theoretic basis for the transition algorithms used in the dynamic phase. Also, empirical experiments will have to be carried out in order to pin down negotiation behavior across different cultures.

At this stage it is impossible to foresee the future of the PSFIM. All depends on how this new modeling approach is accepted by the scientific community and the many possible practitioners.

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