Evaluation of Supply Chain Strategies in Lithuanian Forest Enterprises: a Case Study

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In this study evaluation of supply chain strategies is done and estimation of lead times and delivery precision are made for roundwood deliveries from two different forest enterprises in Lithuania. The two enterprises represent case studies of efficient and flexible supply chain strategies. Lead times are defined as the time between harvest start and delivery. Delivery precision is defined as the difference between actual roundwood sales (delivery volume) and planned sales (agreed volume). The results showed that shortest lead times were found for the high value veneer assortments (22 days). It was followed by sawlogs (39 days), pulpwood (49 days) and pallet wood (58 days). The study shows the shortest lead times for the high value assortments and species, which are more in focus for the enterprise with the flexible supply chain strategy. Delivery precision was found to be relatively poor during the study period for both enterprises. For the whole year the percent of fulfilling of sales agreements was –14.8 % for the efficient enterprise and –33.8 % for the flexible enterprise. Four of 10 (40 %) customers or the efficient enterprise purchased within 20 % of their agreed volumes. The corresponding number for the flexible enterprise was 2 of 10 (20 %).

Key words: supply chain, timber market, wood supply, wood demand, supplier, customer, stand, assortment, delivered volume, agreed volume.

Introduction

The timber markets in Lithuania have been greatly affected by the political transition during the past decade. Throughout the 1960s, 1970s, 1980s approx. 3.2 million m³ per year were harvested annually and the annual allowable cut (5-6 million m³) has not been exceeded. During this period approx. 2 million m³ were imported from other parts of Russia for processing in Lithuania. Now, after many years of the forest sector being almost invisible to other European countries Lithuania has re-entered the European wood markets.

Lithuania has 43 state-owned forest enterprises. These comprise approximately two thirds of the forest area. The state-owned enterprises typically harvest between 34 000 m³ to 220 000 m³ per year depending on the size of enterprise. In 2001 (Anon. 2002) one enterprise on average harvested about 119 000 m³ of timber. The sawmills have made a particularly rapid recovery, which is important because of their role as supplier to other wood-working industries. Lithuania now exports 33 % of roundwood, 80 % of sawnwood, 81 % of fibreboard and 66 % of furniture (Gaižutis 1998) and the sector is responsible for 10 % of the national export incomes.

During the Soviet-period, timber sales were mainly been driven by silvicultural requirements, pushing timber on the market. This is called the biological forestry where the main production function concerned a maximisation of volume. Now in the new situation, wood supply is becoming more and more market-oriented where current demands pull timber into the market (Heinemann 2000). This represents a major change in strategy for which there is limited experience to build. The lack of appropriate market information hinders operational decisions and this situation requires a radical redesign of the production control system (Harstela 1993).

In other sectors, varying production approaches are classified as supply chain (SC) strategies. Fisher (1997) characterizes two such strategies for manufacturing industries: innovative and efficient. Lehtonen (1999) adapts this dichotomy to the paper sector and characterizes two relevant variants: flexible and efficient. In Lehtonen's dichotomy high utilisation of production facilities, even-flow of materials, standard product range and poor customer service levels are common features of the so-called efficient strategy. This is a strategy which still prevails in much of the Nordic and Lithuania forest sector, resulting in slow

response to market fluctuations. In turn, the flexible supply chain strategy is characterised by an uneven-flow of materials and a wider product range, and where high customer service levels play a major role in companies' performance (Lehtonen 1999). This strategy matches production to customer demand more closely and represents a clear transition from the commodity market situation with a high number of alternative suppliers where price is the only factor determining market share and company success.

In the new market conditions it is hypothesized that there is very little price differentiation between suppliers. The ability of a company to react to the changing demand is the crucial element for a wood procurement enterprise to win market shares and stay competitive in the market. This transition to a demand-driven supply process, however, places the forest sector in the same potential danger as manufacturing industries have had for many decades. The potential consequences of demand amplification in industrial supply chains, termed *industrial dynamics*, were first analysed by Forrester (1958). Forrester (1958) demonstrated how small variations in final customer demand may be amplified upstream in the supply chain, initiated by slow order handling, lack of downstream sales information and immediate corrective actions for inventory discrepancies. The degree of amplification and typical cycles vary from sector to sector, however, the greater the degree of pull control in the forest sector will make knowledge of industrial dynamics potentially more useful. With a greater degree of pull control, short lead times are crucial if production flexibility (high operator gain) is to result in precise response (Fowler 1999).

One of the challenges for forest enterprises in Lithuania is the variation in demand signals. These changes require both adequate planning and good system control in order to satisfy customer needs. Lead times and delivery precision can play an important role in a company's performance in the new situation. So far, many basic variables such as lead time and response (or delivery) precision within the wood supply system have not been examined. Hopefully, the study will give a first view into the range of strategies within the Lithuanian forest sector.

Aim

To evaluate efficient and flexible SC strategies in forest enterprises.

Tasks

1. To work out the system of criteria for evaluating efficient and flexible SC strategies in forest enterprises.

2. To estimate hypothetical efficiency and flexibility of forest enterprises.

3. To estimate actual efficiency and flexibility of forest enterprises.

Methods and materials

A case study has been carried out in two state forest enterprises. They are situated close to each other and at the same distance to biggest customers.

The first task was solved by colleting factors known in the literature, which characterize efficient and flexible SC strategies. The goals of supply chain strategy are defined as competitive criteria. O'Laughlin's and Copacino's (1994) founded competitive criteria are low cost, customer service (mainly delivery), value-added services (assembling, pricing, ticketing), flexibility (ability to customise logistics for each segment) and regeneration (being innovative). Bowersox (1986), in turn, mentions cost, service and quality. According to Ballou (1992) the objectives of a logistics strategy are cost reduction, capital reduction and service improvement. Fisher (1997) characterizes two supply chain strategies for manufacturing industries: innovative and efficient. According to him functional products should have an efficient supply chain and innovative products a market-responsive one. Finish researcher Lehtonen (1999) adapted this dichotomy to the paper sector and characterized two relevant variants: flexible and efficient. He mentions 7 criteria: production strategy, production metrics, production control, competitive advantage, efficiency measure, connection between production and marketing, product palette. Another adoption of Fisher's SC dichotomy in the forest sector was study in Scandinavian paper mills carried out by Hameri and Nikola (1999). The criteria used in their research for selecting samples was the following: type of supply chain, volume, product mix and production strategy.

Solving the second task the two studied forest enterprises were evaluated by interviewing the personnel on a base of corresponding criteria.

Finally, solving the third task the actual efficiency and flexibility of forest enterprises were estimated. It was done by estimating basic variables such as lead time and response (or delivery) precision within the wood supply chain, which play an important role in a company's performance.

Lead times

In manufacturing sectors lead-times are defined as the time from the order is given to when goods are delivered to the customer. It includes the sum of re-planning time and time spent for harvesting, storage and transportation. In forestry this variable shows how

fast the enterprise is able to adjust the flow of roundwood to the customer.

In this study, this figure is calculated as the time from the start date of stand harvesting and the date of shipment delivery. The shipment delivery in this case means the delivery of timber to the customer who was in this case a sawmill, a dealer, or a private person, etc. This definition of lead time includes only the time from stump top industry. The data on lead times were collected from following sources in the enterprise: inventory plans, harvesting plans, harvesting, forwarding and sales reports. The data were analysed for five different groups of assortments including sawlogs, pulpwood, pallet wood, veneer and particleboard and also according to the type of species including pine, spruce, birch, black alder, aspen, oak, ash and lime.

In the experiment 30 stands for each enterprise were studied including 15 stands with typically high demand (e.g. high value birch) and 15 stands with typically low demand (e.g. spruce pulpwood). The stands were selected randomly according to dominant species. The harvesting type in selected stands was final cutting. The studied enterprises produced 71531 m^3 and 47340 m^3 annually, respectively. For both enterprises total volume of delivered (harvested) timber from analysed stands made about the same figure which for efficient enterprise was 9560 m^3 and for flexible was 9705 m^3. The 30 stands sample for the efficient enterprise consisted of 313 individual shipments (daily delivery volumes per assortment and customer). For the flexible enterprise the corresponding number was 414. The average size of the shipment was 31 m^3 and 23 m^3, for efficient and flexible enterprises, respectively.

Delivery precision

Delivery precision is defined as the ratio between delivered volume and planned volume for the order period of time. This measure shows how accurately the supplier/customer trade follows the agreed sales plan. The agreements with customers for raw timber in both enterprises are made in the similar manner. At the end of the year an enterprise usually sends to the potential customers the list of expected composition of assortments, which will be produced the next year. Then the customer replies with what it would like to buy and for what price. The selling agreements are signed with ones who offer the highest price for a given assortment. For efficient enterprise the agreements are signed for each quarter separately, whereas in flexible enterprise it is signed for the whole year by equally dividing the total volume for each month. So far the agreements are not the compulsory documents and do not carry any legal obligations.

The relevant data for this study was mainly gathered from selling agreements and from monthly sales reports for 2001. The number of customers for efficient enterprise was 57 and for flexible was 53, in 2001. Almost all customers were from domestic market except 2 and 4 customers from foreign markets, for efficient and flexible enterprises, respectively.

The data were analysed in two ways. Firstly, delivery precision was studied and comparison was made according to the type of assortment. The total number of assortments reached 16 including sawlogs (spruce (SS), pine (PS), birch (BS), aspen (ASPS), black alder (BAS), oak (OS), ash (AS) and lime (LS)), shortlogs (oak (OSH)), veneer (birch (BV)), pulpwood (birch (BP), pine (PP) and spruce (SP)), palletwood (coniferous (CPL) and broadleaves (BPL)) and particleboard (PB). The ash and lime sawlogs were not harvested for studied period in efficient enterprise. The composition of assortments is seen in Figure 1.

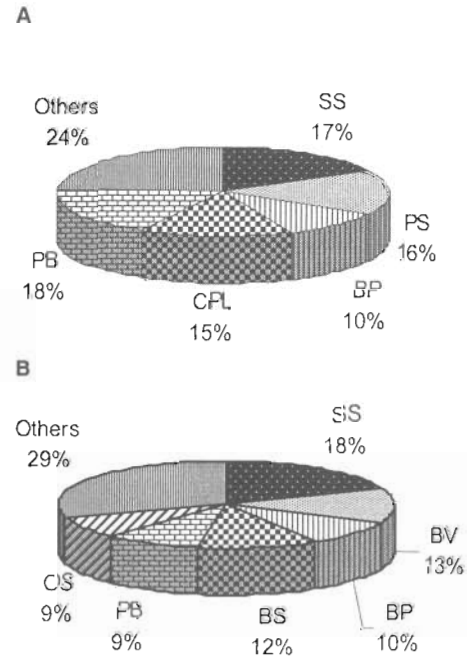

Figure 1. The composition of roundwood sales in the sample for delivery precision according to the type of assortments (See the explanation of abbreviations above in the text). The enterprises with the efficient (A) and flexible (B) supply chain strategies are shown on the left and right, respectively

As seen in Figure 1, the composition of assortments in the studied enterprises was not even. The dominant assortments in the efficient enterprise were wood for particleboard, spruce and pine sawlogs, coniferous and broadleaves palletwood while in the flex-

ible enterprise assortments with higher value of quality including: spruce sawlogs, birch veneer and sawlogs and birch pulpwood. After the monthly comparison of delivery precision for 2001, the sales agreements were analysed for the 10 biggest customers in each enterprise. Delivery precision was then analysed for each of these customer.

The statistical analysis of lead times was conducted in the SAS statistical package. The data were analysed with the General Linear Models (GLM) procedure. Differences were considered significant at $p<0.05$.

Results

The selection of the criteria was made by choosing most suitable one's according to specifics of the Lithuanian forest sector. Criteria defined by Lehtonen (1999) demonstrated relevance and were adaptable to the conditions of the forest sector in Lithuania. They are following: production strategy, production metrics, production control, competitive advantage, connection between production and marketing and product palette.

The second task was accomplished by interviewing. It was assumed that differences were reflected in performance where the efficient enterprise usually produces standard products and delivers timber in large shipments whereas the one with flexible strategy has more types of assortments especially more high-value birch assortments and smaller shipments. Flexible enterprise was assumed to plan harvesting according to the present demand by collecting the required assortments from the different cutting sites in the forest and leaving one still standing if it does not have a potential customer. Whereas in efficient enterprise work was carried out mainly by trying to finish harvesting one cutting site completely and then to transfer workers and facilities to another site.

The calculation on lead times and delivery precision demonstrated the following results.

Lead time

The average leads were on average 45 days for efficient and 42 days for flexible enterprise. In a complete statistical model (Table 1) studied factors included: assortment (assort), species (spp), enterprise (ent) and combinations of assortment–species (assort*spp) and assortment–species–enterprise (assort*spp*ent). The enterprise was the only factor that was not correlated with a statistically significant difference.

Table 1. The ANOVA table for lead times: factors included are assortments (assort)., species (spp) and enterprises (ent).

Source	DF	Type I SS	Mean Square	Pr>F
assort	4	2384491,647	596122,91	<.0001
spp	7	544034,242	77719,177	<.0001
ent	1	21907,948	21907,948	0,1812
assort*spp	10	382292,617	38229,262	0,0006
assort*spp*ent	15	764818,771	50987,918	<.0001

The results showed that shortest lead times for assortments were found for the veneer. The average lead time for this assortment was 22 days. It was followed by sawlogs (39 days), pulpwood (49 days) and palletwood (58 days). The comparison of lead times among assortments for the two studied enterprises is showed in Figure 2.

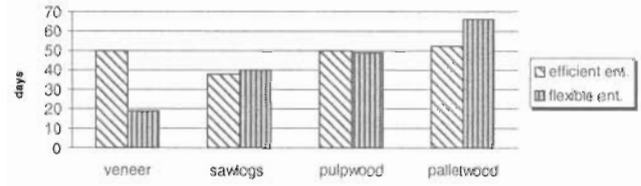

Figure 2. The length of the lead times for different assortments in the enterprises

Lead times also varied considerably between species. The shortest lead times were for birch (34 days) and longest were for black alder (56 days). The ANOVA analysis of combination of assortments and species demonstrated that the shortest lead times were found for higher quality timber like in this case, birch veneer (21 day) and birch sawlogs (29 days). Whereas the longest lead times were characteristic of lower quality timber including birch particleboard (69 days) and birch pulpwood (65 days).

Finally, the analysis according to the interaction between assortments, species and enterprises showed that the best results were found for birch veneer (19 days) and oak sawlogs (20 days) in flexible enterprise. The longest lead times were found for black alder palletwood (72 days) in flexible enterprise and aspen palletwood (66 days) in efficient enterprise.

Delivery precision

The analysis of delivered volumes in relation to sales agreements per quarter showed average values for the efficient enterprise fluctuating between –29.1% (2nd quarter, 2001) to –12.3% (3rd quarter, 2001). For the whole period of 2001, actual sales fell short of agreed sales by 12 673 m^3 (-17.8%). The situation in the flexible enterprise had different features. The best periods, in terms of fulfilling sales agreements were the 1st and 4th when precision was –1.7% and + 6,7%, respectively. These quarters however were interspersed poorer precision during the 2nd and 3rd quarters when the actual sales were only 50 % of agreed sales. This situation led to the negative result at the end of year when actual sales fell 21.9% short of agreed sales. The

comparison of planned and actual sales each month can be seen in Figure 3.

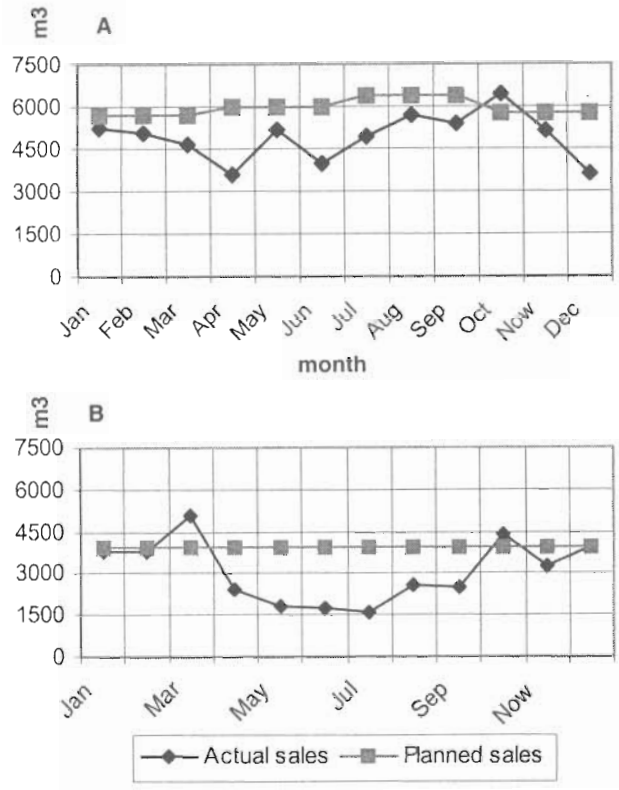

Figure 3. The comparison of actual sales (delivered volume) and planned sales (agreed volume) for 2001. The enterprise with the efficient (A) and flexible (B) supply chain strategies are shown on the left and right, respectively

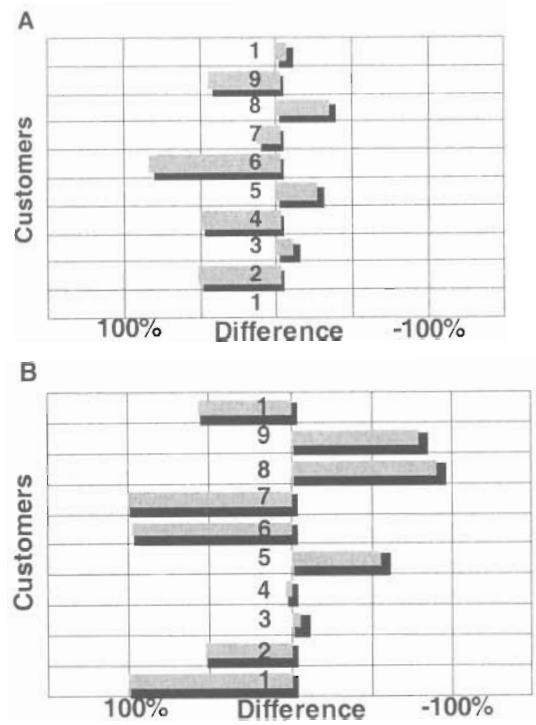

Figure 4. The difference between actual sales (delivered volume) and planned sales (agreed volume) in % for the 10 biggest customers in the efficient (A) and flexible (B) enterprises

In the second part of the analysis the sales agreements were studied for the 10 biggest customers for each enterprise. All customers were from the domestic market. The sum volume of sales agreements for these customers was 48 500 m^3 for efficient and 29 905m^3 for flexible enterprise. These volumes represented 67% and 63% of total annual agreements, respectively. The average volume per agreement was 35% higher for the efficient enterprise than the flexible enterprise.

For the efficient enterprise 5 customers purchased volumes below the agreed sales and other 5 purchased volumes above the agreed volumes (Figure 4). For the flexible enterprise 3 customers made non-or insignificant purchases. For the remaining customers, 3 purchased volumes under the agreed volumes and 4 purchased volumes over the agreed volumes. For the whole year the percent of fulfilling of sales agreements was –14.8 % for the efficient enterprise and –33.8 % for the flexible enterprise. Four of 10 (40 %) customers of the efficient enterprise purchased within 20 % of their agreed volumes. The corresponding number for the flexible enterprise was 2 of 10 (20 %).

Discussion

The theoretical analysis demonstrated that most suitable criteria for Lithuania forest sector defining flexible and efficient SC strategies are characterized by Lehtonen (1999) and currently are used in Scandinavian paper industry.

The two case studies were not able to confirm all the characteristics of the respective enterprise types, which were expected from the literature on supply chain dichotomies. Average lead times, for example, were almost the same. However, significant influences were determined for the different assortments, species, which the respective enterprises focused their production activities on.

Data analysis in terms of assortments showed that in both enterprises the shortest average lead time was for veneer and longest one was for palletwood. The analysis of lead times according to species demonstrated that this factor had a statistically significant influence and shortest lead time was for birch while for black alder was the longest one. This situation can

be explained by the fact that birch wood is more often used for making higher quality timber products. This status of timber requires shorter lead times in order to keep the timber in the appropriate quality. This explains a general directive in the flexible enterprise that high quality timber had to be delivered to the customer within two weeks after harvesting. This approach is especially acute in summer time when timber loses it'-s quality due to dry cracks, fungi and insect attacks. In contrast black alder wood was not in such demand and its common products were of lower quality including palletwood and particleboard. The wood for particleboard is usually the lowest price and does not require high quality timber and this factor explains why the length of lead time for black alder is so long.

Finally, the analysis of lead time for the interaction of assortments, species and enterprises demonstrated the biggest differences between enterprises. The shortest lead time in the efficient enterprise was for birch sawlogs but it was almost twice longer compared with birch veneer in the flexible enterprise, which in this case had the shortest lead times. Black alder palletwood in flexible enterprise and aspen palletwood in efficient enterprise had the longest lead times. This part of the analysis showed that the average lead times for higher quality wood were shorter in flexible enterprise. This fact confirmed the characteristics of flexible enterprise to react quicker to market changes and to generate adequate responses for higher quality timber compared with efficient one.

The second part of the studies dealt with the analysis of sales agreements. Although the actual delivery volumes for both enterprises were inadequate when compared to agreed sales, the biggest differences between actual and agreed sales was found for flexible one where only 2 of 10 customers purchased within 20 % of their agreed volumes, compare to 4 of 10 for the efficient enterprise. The best record for the flexible enterprise was found for the 1st and 4th quarters. This situation could be explained by the limitation of stands accessibility. The dominant stands had moist ground conditions and they were accessible only during wintertime when the ground is frozen. The highest price periods also matched these quarters. Due to this, the enterprises tried to increase the sales during these quarters in order to avoid the situation when harvested timber was not accessible and also to get the highest price for their products. In contrast, the sandy soils and very dense forest road network enable the efficient enterprise to distribute their sales more evenly during the year. These conditions enabled the enterprise to achieve better capacity utilization of machines and workers. Interestingly enough, the level of agreed sales for the efficient enterprise were highest during the 2nd and 4th quarters. This would appear to be a case of either over-ordering in response to expected rationing or shortage gaming or in order to take advantage of price variations (Lee et al. 1997). This ordering behaviour is one of the basic causes for demand amplification cited in the literature and documented also in the paper sector (Hameri 1996). Regardless, on the whole, these case studies demonstrated a more stable relationship between supplier and customer for the efficient enterprise.

Based on the Centre of Forest Economics (CFE) Bulletin reported that in year 1999 the average price per m^3 of the timber delivered from the flexible enterprise was 7% in year 2000 - 13% and in year 2001 – 19% higher compared with the average price of all other forest enterprises. The price difference was especially significant for birch timber and it was sold for about 30% higher price in years 2000 and 2001. This information and the results of this study confirm on most points the theoretical background of definition different supply chain strategies on which base the study objects were selected. However, a complete economic analysis does not fall under the scope of this study.

Conclusions

1. The system of SC strategy criteria used in Nordic paper industry could be adapted the forest sector in Lithuania.

2. There is no significant difference in average lead times. Lead times for higher quality timber were twice shorter for flexible enterprise compared with efficient one.

3. Delivery precision both in efficient and flexible enterprises was low and during studied period fell short by 17.8% and 21.9% and in terms of biggest customers by 14.8 % and 33.8 %, respectively.

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ОЦЕНКА СТРАТЕГИЙ ЦЕПНОГО СНАБЖЕНИЯ НА ПРИМЕРЕ НЕКОТОРЫХ ЛЕСНЫХ ПРЕДПРИЯТИЯХ ЛИТВЫ

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Резюме

В данном анализе оцениваются стратегий цепного снабжения и сравниваются времена выполнения заказов и своевременность доставок для круглых лесоматериалов в двух разных лесных предприятиях в Литве. Эти два предприятия представляют продуктивные и гибкие стратегии цепново снабжения.

Время выполнения заказа исчисляется как время между началом рубки до доставки. Своевременная доставка характеризуется как разница между фактическои продажи (объём доставки) и предусмотренной продажей (договорённый объём). Результаты показывают, что самый короткий срок выполнения заказа был установлен для сортимента фанеры высшего качества (22 дня). За ним следовали пиловочные брёвна (39 дней), древесная масса (49 дней) и деревянные поддоны (58 дней). Исследования показывают наикратчайший срок выполнения заказа для сортиментов и пород высокого качества, в которых в большей степени заинтересованы предприятия с гибкой стратегией цепново снабжение. Во время исследований установлена довольно низкая точность доставки обоих предпрятий. За весь год выполнения заказов по продаже было – 14,8 % для эффективно работающего предприятия и 33,8 % - для гибкого предприятия. Четыре из десяти покупателей (40 %) эффективно работающего предприятия покупали 20 % своего договорённого объёма. Соответствующие значения на гибком предприятии 2 из 10 (20 %).

Ключевые слова: цепное снабжения, лесной рынок, лесоснабжения, лесопотребность, древостой, сортимент, объём доставки, договорённый объём.