From a bucking-to-value to a bucking-to-demand system in Norway: A case study in forests with varying growth conditions

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Abstract

A bucking-to-value optimization system has traditionally been used by applying price matrices in bucking control to maximize the value of single stems and thereby the income of Norwegian forest owners. This system improved the possibilities of customization of sawlog supply, but the differences between the demand and the output sawlog distribution are still significant. Hence, a new bucking system, called bucking-to-demand, was developed in Sweden in the late 80s and was also introduced in Finland. To better meet the demand of single sawmills, the harvesters use a new demand matrix in addition to the price matrix.

The main objective of this case study was to evaluate the potential of achieving a more market-oriented sawlog production in Norway by utilizing the bucking-to-demand system in bucking optimization.

The results showed that a bucking-to-demand system gave a higher apportionment degree than a traditional bucking-to-value system. Bucking-to-demand had a larger effect (apportionment degree) than bucking-to-value in forests with high site indexes compared with forests with low site indexes. Additionally, the value discrepancy between the two bucking systems tended to be smaller on low-productivity forest sites than on high-productivity sites.

The results imply that the bucking-to-demand system can be an effective tool for achieving a more customized log production in Norway, which in turn will increase the added value in the Norwegian forest products value chain.

Keywords: harvesting, market-oriented sawlog production, bucking-to-value, near-optimal bucking-to-demand

Introduction

Recently, there has been an increased focus towards market-oriented and customized sawlog delivery in Norway (Birkeland *et al*. 2008). This has to a great extent been a matter of the possibility of affecting the sawlog outcome when developing functional instructions for bucking, as well as the correct way of using these instructions. Functional instructions for bucking include the operating framework for harvesting, including log type, its price matrices, and requirements for different dimensions and qualities.

Research has given new knowledge about variation in wood quality. During the last 30 years, several studies in Norway and Europe have been performed concerning the relationship between raw materials and end products, log utilization, customized log delivery, bucking, and modelling and mapping of wood quality (e.g. Palm 1976, Näsberg 1985, Bjurulf and Spånberg 1994, Bues 1996, Puumalainen 1998, Kellomäki *et al*. 1999 and Malinen *et al*. 2007). The research has shown a potential for increased exploitation of raw materials through a more product- and market oriented log production. Several Norwegian publications, mostly dealing with spruce and pine, confirm this potential (e.g. Vestøl 1998, Høibø *et al*. 1999 and Øyen 1999).

A traditional bucking-to-value optimization system has been based on applying a price matrix in bucking control to maximize the value of single stems. This system improved the possibilities of customization of sawlog supply, but the differences between the demand and the produced sawlog distribution is still significant. Hence, a bucking system, called bucking-to-demand, was developed in Sweden in the late 80s and was also introduced in Finland. To better meet the demand of single sawmills, the harvesters use a new demand matrix in addition to the price matrix. This system has recently been introduced in Norway. It has been argued that the bucking-to-demand system will not work as well in Norway due to larger variations in e.g.: forest growth conditions. Following the literature, one should assume that these variations are not an argument for not using the bucking-to-demand system in Norway (e.g. Sondell, 1991, Bergstrand 1994, Möller and von Essen 1997, Kivinen and Uusitalo 2002, Kivinen 2004, Malinen and Palander 2004, Kivinen *et al.* 2005, Kivinen 2006). In this study, we will look closer at this topic in a Norwegian context.

The main objective is to evaluate the potential of achieving a more market-oriented sawlog production in Norway by using bucking-to-demand. This will be addressed through a case study in a defined area in Norway with a broad range of growth conditions (site index).

Theoretical background and research questions

In mechanized logging in the Nordic countries there are two principles in use for computerized bucking. In bucking-to-value the goal is to optimize the value of each log according to the current price matrix (Bergstrand 1994). Bucking-to-value is a one-sided value optimization (Bergstrand 1994, Kivinen and Uusitalo 2002). By bucking-to-value, the price and the price range between the log types and dimensions are used as directives for the bucking and log outcome. Different log types are priced differently, and have different minimum requirements for dimensions and quality.

Bucking-to-demand is a system where the computer is permitted to deviate from the strict bucking-to-value, and instead guide the bucking towards required lengths and diameters of the logs (Möller and von Essen 1997). In addition to the price matrix, a matrix defining the demand for logs within different dimensions and qualities (demand matrix) is computed. Moreover, a maximum accepted deviation from the highest value in the price matrix restricts the system from only taking the demand matrix into account when optimizing the bucking of a stem. While logging, the bucking system seeks to approach the preferred dimensions, working within the permitted value of price discrepancy. The demand matrix can be expressed in different ways. The most common way is a relative number or volume of logs in different lengths per diameter class. Several studies concerning bucking-to-demand have been carried out in Sweden and Finland. The method has been used in these two countries for the last 15 years (Bergstrand 1990, 1994, Larsson and Lidfeldt 1990, Sondell 1991, Möller and von Essen 1997, Henriksson 2000, Kivinen and Uusitalo 2002, Kivinen 2004, Malinen and Palander 2004, Kivinen *et al*. 2005 and Kivinen 2006). The bucking-to-demand function was developed by The Forestry Research Institute of Sweden, and has been used in harvesters in Sweden since 1990.

Bucking-to-demand versus bucking-to-value

Bucking-to-demand means that one can more efficiently manage the output of logs towards the defined goal. Log dimensions that are in demand, but in shortage, will be prioritized, while logs with other dimensions that are surplus will be given less priority. The system is not tested in Norway, but preliminary simulations indicate that a bucking-to-demand system can be an effective method to seek a more customized log production (Birkeland *et al*. 2008).

Apportionment degree expresses how well the produced logs match the demand. The difference between output of harvested logs and the demand matrix is used as an inverse measure of apportionment degree. Results from Sweden, reported by Bergstrand (1994), showed that the apportionment degree when applying bucking-to-demand varied depending on the size of the trees. This is reasonable because small-sized trees have fewer alternative bucking solutions than large trees.

The log trade payments system has traditionally been based on the price matrix. When changing to a bucking-to-demand system, one has to compensate for potential value discrepancy (value loss for the log seller). Value discrepancy is the difference between value achieved by the bucking-to-value system and the value achieved with the bucking-to-demand system (Skogforsk 2006).

In this study we will look at a defined area in Norway with relatively large variation in growth conditions. The key questions are: a) *How will a bucking-to-demand system affect the apportionment degree compared to a bucking-to-value system?; b) Is the* *apportionment degree affected by forest growth conditions (site index)?; and c) Is the value discrepancy (technical value loss) affected by forest growth conditions (site index)?*

Material and methods

Material

The main data in this study consisted of high-quality stm-files from 15334 Norway spruce trees on various sites (Figure 1). The harvester data was collected by Viken Skog BA (forest owners' association) in the south-eastern part of Norway in 2008. Begna Bruk AS was the buyer of the sawlogs, and formulated the bucking instructions in collaboration with Viken Skog BA. All the data were collected from the same harvester.

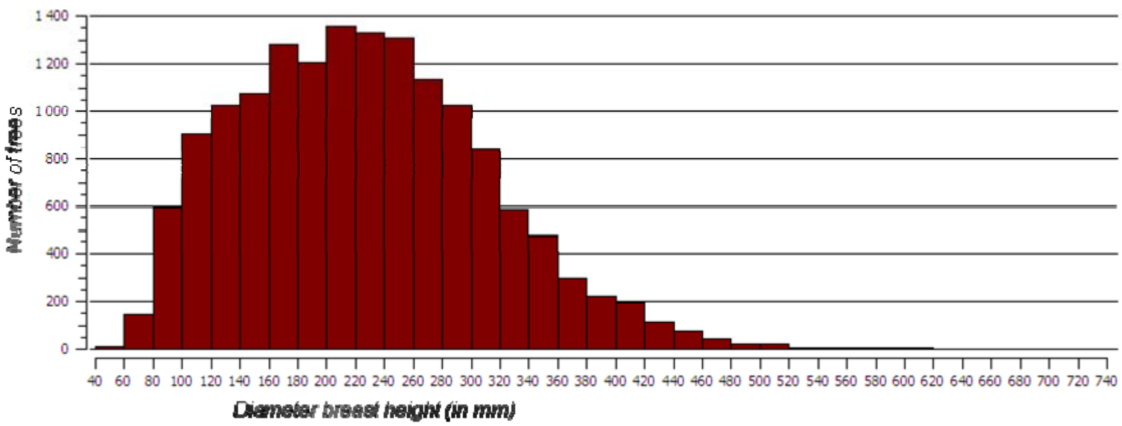

Figure 1. The figure shows the number of trees in different diameter classes

Information used for the bucking simulation was: 1) harvested log data (stm-files), and 2) price and log demand matrices and log type description, which together are equal to the apt-file. The data were collected in three different forest categories. Forest Category 1 was defined as low site index (H40) G8-G11, Category 2 was defined as medium site index (H40) G14-G17 and Category 3 was defined as high site index (H40) G20-G23. The value of the site index reflects the dominant tree height at 40 years age at breast height (Tveite 1977).

Table 1. The number of trees in each site index (H40) categorized class and meters above sea level for the total sample of 15334 Norway spruce

Sample Description	Number of trees within each site index *(H40)	Meters above sea level
Forest Category 1	G8: 1958 G11: 5489	800 – 830
Forest Category 2	G14: 449 G17: 3525	200-380
Forest Category 3	G20: 841 G23: 3072	155 – 200

**) Site Index (H40): G23 is high-productivity sites, G8 is low-productivity sites (Tveite 1977).*

Methods

The data was analyzed with OptApt Version 2. OptApt is a bucking simulator that uses dynamic programming, shown by Näsberg (1985), to compute the most profitable bucking of a stem into logs. The simulation takes quality, dimensions (log diameter and length) and the price of the logs into account when computing an optimal bucking pattern of the stem. During the last year, OptApt has implemented the near-optimal bucking-to-demand system. In this study, we concentrate on the near-optimal bucking-to-demand approach, not the adaptive price matrix method (Möller and von Essen 1997)

All data were analyzed with the bucking-to-value and bucking-to-demand systems in OptApt. Bucking-to-demand was analyzed with the near-optimal method (Möller and von Essen 1997) with 5 percent value discrepancy permitted. All analyses were performed on the same 15334 stems in the same stm-files. All assumptions were equal to the current situation in log supply from the forest owner association and the sawmill. The applied log assortments were pulpwood, energywood, palletwood and two types of sawlogs (with different quality and dimension requirements). Stepwise bucking based on the whole stem length was used in OptApt to make the analyses similar to the harvesters.

Results

The simulation of the optimization in OptApt showed that the apportionment degree increased from 79% for the bucking-to-value system to 88% for the bucking-to-demand system (Table 2 and Table 3).

Table 2. Results from the bucking-to-value simulation on the total sample.

Log assortment	No. of logs	Value, NOK *	Volume, m3	Log price, NOK/m3 *	Average length, cm	Volume proportion, %	Apportionment degree, %
Sawlog 1 **	10 958	1 170 080	2 259	518	477	43	79
Sawlog 2 **	331	35 946	78	459	399	1	-
Pallet	12 670	629 749	1 679	375	411	32	-
Energy	3 522	81 476	407	200	348	8	-
Pulp	17 673	247 300	865	286	392	16	-
Rejects	1 886	0	21	0	26		
Total	**47 040**	**2164551**	**5 310**	**408**	**399**		

**)USD 1 = ca NOK 5,5,*
***) Sawlogs with different quality and dimension requirements*

Table 3.Results from the bucking-to-demand simulation on the total sample.

Log assortment	No. of logs	Value, NOK *	Volume, m3	Log price, NOK/m3 *	Average length, cm	Volume proportion, %	Apportionment degree, %
Sawlog 1 **	11 040	1 156 915	2 240	517	474	43	88
Sawlog 2 **	331	35 946	78	459	399	1	-
Pallet	12 654	630 025	1 680	375	411	32	-
Energy	3 522	81 476	407	200	348	8	-
Pulp	17 655	246 513	862	286	392	16	-
Rejects	1 854	0	22	0	27		
Total	**47 056**	**2150875**	**5 290**	**407**	**399**		

**)USD 1 = ca NOK 5,5,*
***) Sawlogs with different quality and dimension requirements*

The simulation in OptApt showed that the apportionment degree increased from 71% for a bucking-to-value system to 79% for a bucking-to-demand system in Forest Category 1 and from 77 to 89 in Forest Category 3 (Table 4). The results also showed that the differences in the apportionment degree were lower in Category 1 than in Categories 2 and 3.

Table 4. Apportionment degree for bucking-to-demand and bucking-to-value and the difference between them in the three different forest types.

	Apportionment degree, %		
	Bucking-to-value	**Bucking-to-demand**	**Difference**
Forest Category 1	71	79	8
Forest Category 2	74	86	12
Forest Category 3	77	89	12
Total	**79**	**88**	**9**

Value discrepancy was calculated using the same analyses as described above. The results are presented in Table 5. The results indicate that the value discrepancy when going from a bucking-to-value to a bucking-to-demand system is smaller in forests with a low site index, than in forests with high site index.

Table 5. Value discrepancy in percent, NOK/m3 sawlogs and totals for the three different forest categories and the total value discrepancy.

Category (C)	Value discrepancy in Percent	Value discrepancy In NOK/m3 sawlogs *	Value discrepancy NOK/m3 total *
C1 - Total	0,46	5,27	1,80
C1 – Sawlogs	0,93	4,74	1,62
C2 - Total	0,83	6,90	3,51
C2 – Sawlogs	1,10	5,79	2,94
C3 – Total	0,70	6,19	2,89
C3 – Sawlogs	1,34	6,94	3,24
Total - Total	0,63	6,05	2,58
Total – Sawlogs	1,13	5,83	2,48

**)USD 1 = ca NOK 5,5,*

Discussion and Implications

The results indicate that a bucking-to-demand system will give a higher apportionment degree than bucking-to-value when applied under Norwegian conditions. The results also indicate that bucking-to-demand will have a larger effect (apportionment degree) than bucking-to-value in forests on high site indexes compared with forests on low site indexes.

The value discrepancy tends to be smaller in low site index (H40) forests than high site index (H40) forests. This is not important for the choice of bucking method, but implies that the technical value discrepancy, which is an input to the bucking-to-demand system, can be lower in a low site index forest. The value discrepancy has relevant implications for the economic settlement between seller and buyer. Regardless of this finding, the real value has to be negotiated separately and should not be influenced by the bucking system.

Lack of knowledge in Norwegian forestry and sawmilling in general, and fear of reduced log value, can explain why bucking-to-demand has not been introduced. One important reason for this is that most of the lumber is sold to the home market and lumber department stores. Countries such as Sweden and Finland are significantly more export-oriented. During the 1990s, when bucking-to-demand was introduced in Sweden and Finland, Norway had an increasing focus on modifying and customization of the traditional price matrices. Because of the rather small-scale sawmill industry in Norway and a lower lumber export compared to Sweden and Finland, our mills operate in a less demanding market (Birkeland *et al*. 2008).

The results imply that the bucking-to-demand system can be an effective tool for achieving a more customized log production in Norway, which in turn will increase the added value in the Norwegian forest products value chain.

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