ATP vs CTP policies in co-production context: the winner is not always the expected one

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Abstract: The impacts of using different order promising policies in traditional manufacturing industries are usually well known and documented in the literature. However, for industries facing divergent processes with co-production (i.e. several products simultaneously produced from a common raw material) as in the sawmilling industry, the evaluation, comparison, and selection of policies is not a trivial task. In this paper we compare different sawmilling industry order promising policies for various market conditions and demonstrate how and when these characteristics may call for Available-To-Promise (ATP), Capable-To-Promise (CTP), or other policies. It has been demonstrated that the best policy often differs from what would have been optimal in a classical manufacturing context (e.g. assembly).

Keywords: Order promising, simulation, divergent process, co-production.

1 Introduction

For traditional manufacturing industries (e.g. assembly), the impact of order-promising policies (ATP, CTP, etc.) is well known and documented (e.g. [1] Slotnick, 2011). The literature typically shows the trade-off between accepting orders and losing sales ([2] Altendorfer and Minner, 2015). In contrast, for industries with divergent processes (i.e. several products from the same raw material) and co-production, the assessment of these policies regarding market conditions seems to have attracted less attention. In these industries, producing a specific product leads to the production of other co-products and by-products, which generates inventories for products that can be difficult to sell or that may have less value. This is the case of the sawmilling industry where standard commodity products as well as products designed for specific customers are produced from the same raw material and at the same time. Customer orders are handled by most North-American lumber sawmills by applying a make-to-stock production strategy. Certain others accept/refuse orders according to available-to-promise (ATP) quantities while a few use more advanced approaches like capable-to-promise (CTP) or mixed approaches combining both ATP and CTP.

In this paper, a simulation framework from [3] Dumetz *et al.* (2015) is used to compare these different policies for the sawmilling industry context based on various market conditions. This paper is different from the previous work by going further via more advanced order management strategies tested depending on various market conditions. It also assesses the impact of key parameters on the number of accepted orders. Results show that these advanced order acceptance policies like CTP (capable–to-promise) allow us to accept more orders in certain types of markets and, in contrast to classical manufacturing industries, ATP (available-to-promise) performs better for a huge demand than other policies.

The remainder of the paper is organised as follows. Section 2 presents preliminary concepts regarding mathematical models in lumber industry, as well as a description of the simulation framework used. Section 3 presents how the framework was used to compare and analyse the lumber industry performance when adopting different order promising policies based on various market conditions. Finally, Section 4 concludes the paper.

2 Preliminary concepts

Lumber production is a three-phase manufacturing process ([4] Gaudreault *et al.* 2010) that first involves a unit responsible for sawing logs into green rough lumber according to a certain cutting pattern. At this stage, the lumber produced varies in terms of quality (grade), lengths, and dimensions. The lumber must then be dried using a kiln unit so as to reduce its moisture content. The final step is conducted by the finishing unit to obtain the desired surface and thickness. The lumber manufacturing system is thus defined as a divergent process with co-production.

During the last few years, lumber production planning has been better supported by the development of many optimisation models. At the detailed operational level, [4] Gaudreault *et al.* (2010) proposed three MIP models that can be used to plan/schedule sawing, drying, and wood finishing operations. The objective function allows maximising production value and/or minimising order lateness. A basic coordination mechanism (heuristic) is provided to synchronise these plans. Improved coordination mechanisms are proposed in [5] Gaudreault, Frayret, and Pesant (2009) as well as in [6] Gaudreault *et al.* (2012). A stochastic version of the sawing operations planning was developed by [7] Kazemi-Zanjani, Ait-Kadi, and Nourelfath (2013). An improved version of the drying model was also proposed in [8] Gaudreault *et al.* (2011).

The previous production planning models try to minimise costs, maximise revenues or minimise customer orders lateness. At the detailed operational planning stage, it is difficult to find good solutions for these problems when faced with both divergent process and co-production. Indeed, even if there is one order for one specific product, the production process will produce several other products and by-products at the same time for which there will not necessarily be a demand. Not only will the production planning be affected, but it will also impact the order promising process.

An order-promising policy defines the rules for accepting or rejecting the orders depending on product availability and the capacity of the company. The best-known policies are available-to-promise (ATP) and capable-to-promise (CTP). [9] APICS,

(2012) defines ATP as "the uncommitted portion of a company's inventory and planned production at a designated location" while CTP as "the process of committing orders against available capacity as well as inventory".

In his thesis, [10] Islam, (2013) combines order promising and production planning via an MIP model. His object is to maximise the total revenues over a planning horizon of 52 weeks via promising orders and making a production schedule to fulfil orders. [11] Pibernik and Yadav (2009) made use of a combination of both ATP and CTP to optimise the target level without permitting back orders in a make-to-stock system. [12] Kilic *et al*. (2010) proposed a two-bound method for orders acceptance/rejection in the food industry, based on the resource level. [13] Azevedo, D'Amours, and Rönnqvist (2012) proposed an order-promising model in a make-to-stock environment for the Canadian softwood lumber industry. They proposed a three-step method that segments market based on customers' price sensitiveness. They maximised the profit while allowing back orders. Finally, [3] Dumetz *et al*. (2015) created a simulation framework to evaluate production planning and order management strategies for the sawmilling industry. Using the framework, the authors were successful in showing the importance of the length of the planning horizon for different order-promising policies like ATP as well as how a company's performance is affected by demand intensity by utilising such order-promising policies. However, CTP was not taken into account in their experiments.

Even though the mathematical models developed in the literature led to interesting results, it remains difficult for a company to evaluate the efficiency of which order-promising policy would be the most efficient one for its market contexts. This issue may therefore be dealt with by simulation through testing different scenarios in a dynamic environment and illustrating how diverse order-acceptance policies may impact a company's performance. Furthermore, the conclusions highlighted by the authors concerning the order-promising policy performance in classical manufacturing systems might not necessarily reflect the reality for a divergent/co-production process. As a result, the research we propose here aims to use simulation so as to compare order-acceptance policies for a sawmilling production system based on different market conditions.

3 ATP vs CTP according to production and market conditions

In this section, we describe how the simulation framework developed by Dumetz *et al*. (2015) was used to determine which policy should be adopted by a company facing a divergent production system according to specific market characteristics. The framework includes the generation, the acceptance/rejection, and the shipment of orders. It also includes an ERP system for inventory management, production, ATP and CTP calculation, etc. The simulation model was developed using Simio, while the ERP modules were developed using the C# programming language. During the simulation, the system generates orders. Each order can either be accepted or rejected according to certain parameters that define the policy used (ATP, CTP, or other). If the order is accepted, it waits until the delivery date and the availability of material. The order is then shipped. No order lateness is tolerated.

Three order management policies were compared, namely Stock, ATP, and CTP, since they are the ones most used by the sawmilling industry. Two different market contexts were also considered: one composed of commodity products only and another one composed of a combination of both commodity products and customised products. The demand intensity varies for each market. Demand intensity is a parameter expressing the total number of orders received as a percentage of the maximal production capacity, and is used to define the order arrival rate. The simulation horizon covered two years, each day was divided into two production shifts (periods) of 7 hours. This production was planned each week for a planning horizon of four weeks. The same optimisation model as in Dumetz *et al*. (2015) was used to generate the production plan. The demand lead, that is the time between the date we receive the order until the due date, is fixed to a triangular law (1,2,3). Some assumptions were also made when developing the experimentation: there is no stochastic event like failure in production; and raw material is infinite. A warm-up period of one year was set to reach a steady state situation. A total of 240 scenarios were simulated with a significant number of replications to have a desired confidence interval (95%). The volume of sales and the average inventory were the two key elements used to measure the performance of the company according to the order management policy selected.

3.1 Market with only commodity products

First, we compare how the different order-management policies selected perform in a 100% commodity-product market. Figure 1 gives the volume of sales (number of orders) according to the demand intensity for the order acceptance policies chosen (Stock, ATP, and CTP).

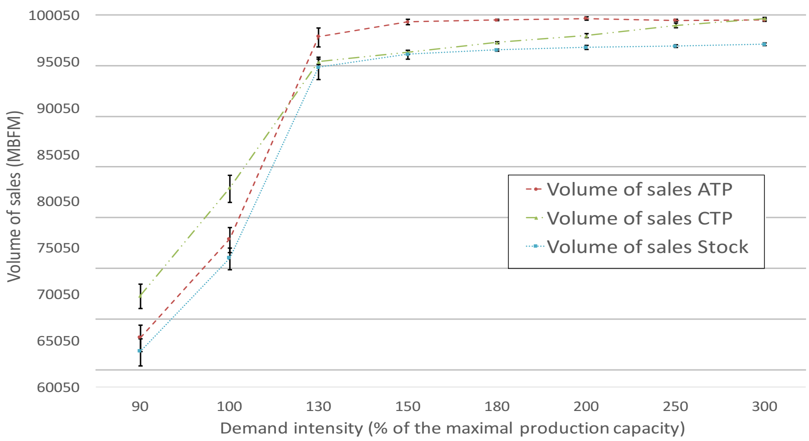

Figure 1: Volume of sales according to the demand intensity (Commodity product = 100%; accurate forecast)

As can be seen, CTP accepts more orders than ATP when the demand is low. It seems to be more profitable to reschedule the production according to customers' needs while avoiding missing opportunities. This is the same result we would get in classical manufacturing systems with no divergent/co-production processes. However, the particularities of the lumber industry come into play when demand intensity reaches 125%. From that point, ATP outperforms CTP. This is explained by the following reason. When demand intensity reaches 125%, demand is significant and all the production planned according to forecasts can be sold. With a CTP policy, the production processes are modified to best suit the most recent orders. However, by changing the manufacturing process used, the co-products produced change too, and nothing guarantees that in the short term, there will be a demand for these new co-products. On the other hand, the ATP policy maintains the same production plan that was established based on forecast and that volume is easily sold when demand is high. Therefore, what is an advantage when demand is low becomes a disadvantage when demand is high. This situation is a good example of the specific impact and difficulties associated to processes embedding co-production.

In order to show how the ATP/CTP trigger point is affected by forecast accuracy, Figure 2 provides results similar to Figure 1, but for a situation with inaccurate forecasts.

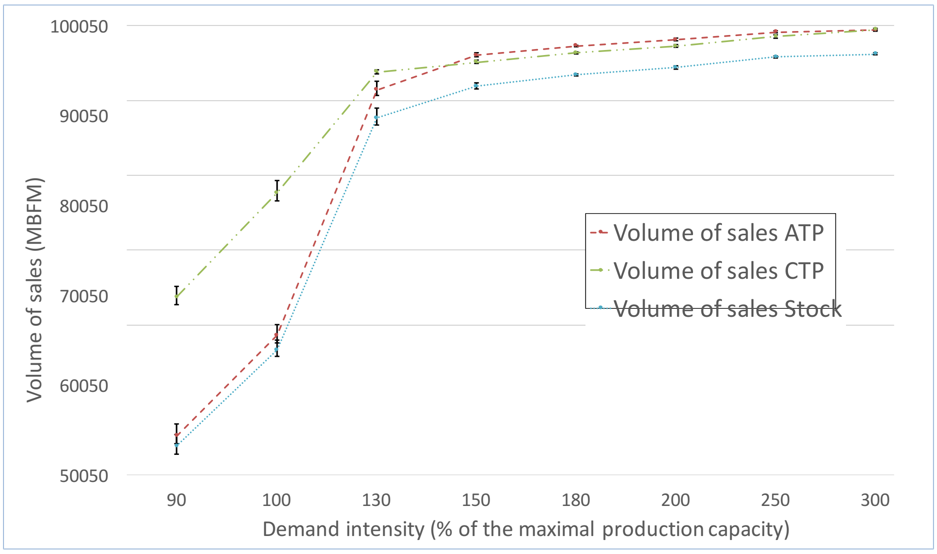

Figure 2: Volume of sales according to the demand intensity (Commodity product = 100%; inaccurate forecast)

In the previous experiments, planning was carried out using a forecast supposing that 80% of the most popular produced products would form 100 % of demand. In this new experiment, we suppose that 20% of the less popular products will form 100% of the demand. The trigger point is therefore shifted to the right in comparison to Figure 1 because ATP needs greater demand so that more low-demand products can be used to fulfil the demand.

3.2 Market with both commodity and customised products

In the previous subsection, we compared different policies (ATP, CTP, Stock) in a market composed of 100% commodity products. Forest products are standardised in North America by the NLGA[1] organisation, which allows the products to be considered as a commodity. However, the forest industry has to confront the increasing demand for customised product[2]. In the next experiments, when comparing the impact of different order-acceptance policies, both commodity and customised products are considered. To do so, some additional parameters were defined and a new order-acceptance policy included (a mixed approach called MIX that uses ATP for commodity product orders and CTP for customised products).

Figure 3 shows the results for a market composed of 70% commodity products and 30% customised products. CTP can again accept more orders than ATP as it can accept orders for customised products.

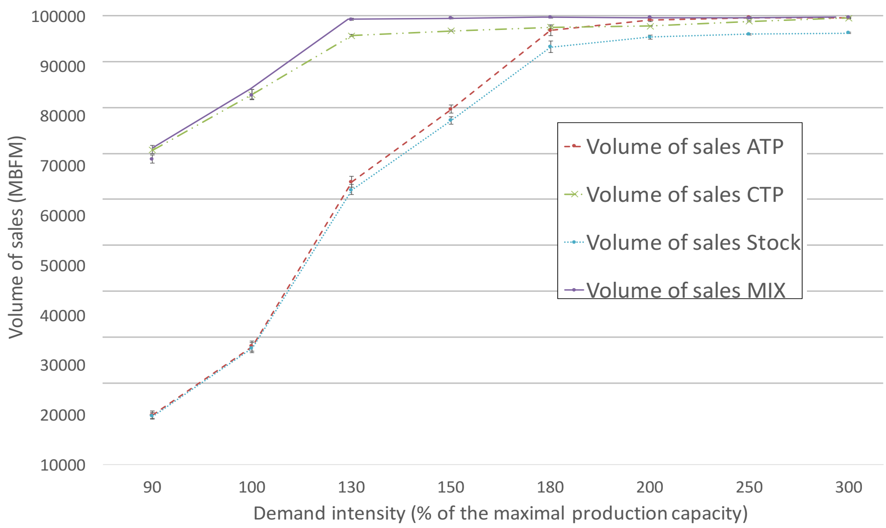

Figure 3: Volume of sales according to the demand intensity (Commodity product = 70%; accurate forecast)

However, when demand intensity is high enough, ATP is still able to use the entire capacity for commodity products only. ATP becomes better than CTP for very high demand (around 190% demand intensity) for the same reason explained previously.

Figure 3 also introduces the MIX policy, which, we recall, uses the ATP to satisfy demand for commodity products. It only generates a new schedule when there is demand for customised products. When demand is very low, ATP is outperformed by MIX (for the same reason ATP is outperformed by CTP). When demand intensity reaches 100%, MIX performs better than CTP because it benefits from the effect of

[1] NLGA: National Lumber Grades Authority.

[2] In Europe, customised products represent the main part of the market.

good forecasts, i.e. MIX uses ATP for commodity products and then keeps the same production plan that was established using forecast. When demand is high, that volume is easily sold. At a very high demand intensity level, the three policies are almost equal.

3.2.3 Impact on inventory

The previous analyses focused on the volume of sales to measure the performance of different order-promising policies according to demand intensity. However, when selecting the most efficient policy to put into practice the average inventory over the year must be considered. The new experiment takes this element into account for a market composed of 90% commodity products and 10% customised products with an accurate forecast.

As shown in Figure 4, for any policy, the average inventory decreases with an increase of the demand intensity. Nonetheless, greater demand intensity involves a larger difference between ATP/CTP and Stock policies. We observed previously that for a very high demand intensity, the number of accepted orders by ATP or CTP was equal. In contrast, the average inventory for CTP is smaller than for ATP because CTP can trigger a new plan each time an order is received, resulting in less time spent in stock.

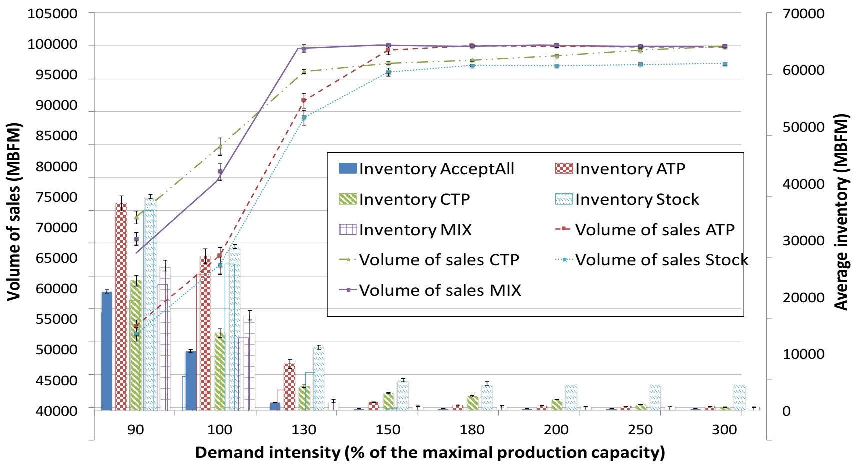

Figure 4: Average inventory over the year according to the demand intensity and the associated volume of sales (Commodity product = 90%; accurate forecast)

Finally, the AcceptAll policy appearing in blue in Figure 4 consists of accepting all orders whatever the consequences, which explains the low inventory level. However, since no company would accept orders they could not fill, this policy is utopic. It is used for comparison purposes only.

4 Conclusion

In this research, the simulation framework developed by [3] Dumetz *et al*. (2015) was used to compare different order-promising policies for a divergent production system with co-production. By testing different scenarios, we were able to measure the impact of well-known policies on the performance of a company in the sawmilling sector. This allowed us to illustrate that the best policy to use in a divergent production system often differs from the one that would have been optimal in a classical manufacturing (e.g. assembly) context. As an example, we showed that although *CTP* allows having a better income for certain types of market (i.e. where demand is very low), *ATP* performs better in some other cases. Moreover, we showed that using a mixed policy when market is composed of commodity products and customised products is a beneficial option.

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