

The Operation of Consignment Stocks by Vendors of Short-Lived Supplies

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Abstract

In many vendor-manufacturer partnerships, it is quite typical for the vendor to hold consignment stock on behalf of the manufacturer, usually through an 'in-plant' from the vendor organization who is resident at the manufacturer's premises. However, empirical evidence suggests that where the buyer is dominant, suppliers are often forced to carry inventory either as part of the contract or to qualify for selection: "It seems that most of the costs are the suppliers' and most of the benefits are the customers'" (Waters-Fuller, 1995).

However, in a certain vendor-manufacturer partnership in the NZ forestry sector, we found that while the vendor had initial reservations in terms of holding stock on a consignment basis for the manufacturer, it subsequently fully supported the move; according to the vendor's commercial manager, it was ideal for the company with chemicals that had short shelf-lives. Accordingly, with recourse to inventory modelling, we seek to better understand the benefits from the vendor's management of consignment stocks of short-lived supplies. In particular, a simple model confirms the intuition that under positively skewed probability distributions of shelf life, the vendor stands to gain more than the manufacturer from the operation of consignment stocks through an in-plant.

1 Introduction

In many vendor-manufacturer partnerships, it is quite typical for the vendor to hold consignment stock on behalf of the manufacturer. However, empirical evidence (e.g., Holmlund & Kock, 1996; Kalwani & Narayandas, 1995) suggests that where the buyer is dominant, suppliers are often forced to carry inventory either as part of the contract or to qualify for selection: "It seems that most of the costs are the suppliers' and most of the benefits are the customers'" (Waters-Fuller, 1995).

The present research is a spin-off of an earlier, empirical investigation of a process industry partnership concerning a NZ manufacturer of forest products (WoodCorp) and its partner-vendor of chemicals (ChemCorp) (Wilson & Sankaran, 2001). ChemCorp stood to gain in several respects by managing and retaining ownership of chemicals at WoodCorp's factory that would be invoiced only as the chemicals were used. This was because of the perishable nature of some chemicals. The partnership manager of ChemCorp acknowledged that the benefits from the vendor's holding consignment stock "does depend on the type of business of course, but it is ideal for this company with chemicals that have short shelf-lives."

Accordingly, in the present note, we invoke inventory modelling to better understand the benefits from the vendor's management of consignment stocks of short-lived supplies. In particular, a simple model confirms the intuition that under positively skewed probability distributions of shelf life, the vendor stands to gain more than the manufacturer from the operation of consignment stocks through an in-plant.

2 Benefits from the Vendor's Managing Consignment Stocks of Short-lived Supplies

In the ChemCorp-WoodCorp partnership, the benefits relating to short-lived chemicals were as follows.

- (a) *Continuous monitoring of short-lived chemicals at WoodCorp's site.* The procurement manager of WoodCorp remarked, "ChemCorp are responsible for monitoring the tanks [at WoodCorp's premises] and ensuring that the chemicals don't go to the 'pavlova' stage just before it goes off; they can return the chemicals to their plant, rework it, and dispatch it again." (The reference here is that if chemical "is left standing too long, the soft solids of the chemical will start to separate.") Such control was possible by the use of an in-plant at WoodCorp's site, who had direct responsibility for monitoring stocks of chemicals.
- (b) *Improved coordination of WoodCorp's production schedules with the management of inventories of short-lived chemicals.* The partnership manager of ChemCorp noted, "We do the ordering of the [short-lived chemicals] anyway, so we work off the production schedule of WoodCorp. We obviously try to tailor the supply to the schedule, but schedules are notorious for being changed. So it does take some fancy footwork at times, but we do get their assistance to make sure that product is used up."
- (c) *Shorter replenishment lead-times for WoodCorp.* The manufacturing manager observed, "We tend to put pressure on other customers to order earlier ahead; we ask for a week's advanced ordering from other customers whereas with WoodCorp, we would ask for a day or something like that."
- (d) *Longer usable lives of short-lived chemicals for WoodCorp.* The manufacturing manager of ChemCorp remarked, "We deliver it [short-lived chemical] just in time. We happen to be doing one [production of a batch of short-lived chemical] this week, they start delivery of that tomorrow, well we will probably only finish off making that this afternoon. Basically I guess what the partnership does it gives WoodCorp some precedence over our production schedule, so we would much rather inconvenience some other customer than WoodCorp, and that is how we can make sure that the shorter shelf-life chemicals get the longest time on their site. So, as I say, it will go tonight or tomorrow morning and it will only be a day old, so that will allow them to use over the next two weeks."
- (e) *The practice of risk pooling.* Owing to the generic (commodity) nature of chemicals, ChemCorp could realize the benefits of consolidation of stock for chemicals, especially for those chemicals with short shelf lives, by practicing risk-pooling (Simchi-Levi et al., 2000). WoodCorp's procurement manager referred to it as being "the advantage of moving the product [chemicals] around the country from customer to customer."

3 Model Preliminaries

We now present a simplified model that purports to capture some key benefits from the partnership with regard to the management of inventories of short-lived chemicals. Specifically, we explore the relative benefit to vendors and manufacturers from having

in-plants from the vendors operate consignment stocks of short-lived chemicals at the manufacturers' sites. While describing the model, we clarify how its structure is grounded in interview data.

We note that modeling-oriented literature on vendors' operation of consignment stocks is scant. Hung et al. (1995) developed a model for the optimal control of consignment stock in a real-world, discrete-part fabrication/assembly context involving the Consumer Electronics Division of Philips at Chungli in Taiwan. Their focus was on the optimal specification of time-varying replenishment frequencies and safety stocks.

Corbett (2001) used principal-agent models to study the effects of information asymmetries about setup cost and backorder cost. His analytic framework is not pertinent to the present context, which is characterized by openness and the sharing of information. The technical services manager of ChemCorp commented, "I sit in on the business unit teams which is for senior management [of WoodCorp]. At those meetings, we discuss the most sensitive issues of WoodCorp in terms of new product development, new markets, pricing strategies, etc." According to the partnership manager of WoodCorp, "[ChemCorp] attend all our staff forums where we put all our figures on the table and discuss our issues." In those forums, as noted by her counterpart in ChemCorp, "We [ChemCorp] show them our prices, margins, market share, raw materials, etc... We don't supply it every month, but it is available on request and we certainly don't hide anything." In addition to such exchanges, each company shares end-of-year financial information and, as clarified by WoodCorp's procurement manager, "If it is necessary, we go through the review process [where] the progress of both ChemCorp and ourselves [WoodCorp] can be openly discussed." During the regular review meetings, there is free and open discussion on topical issues within each business.

Importantly, Hung et al. (1995) and Corbett (2001) did not address the case of short-lived supplies, which is the crux of the issue at hand. As reported by the partnership manager of ChemCorp, the shelf lives of "some [chemicals] go down to a week, well two weeks actually. You sometimes see a drop off in performance after a week, but generally two weeks is the shortest." The procurement manager of WoodCorp clarified that "a lot would depend on the ambient conditions at the time, for example, temperature and [to a lesser extent] relative humidity."

In light of this, we let shelf life of a batch of short-lived chemical be $L+X$ where L is the minimum shelf life ($L > 0$), and X is any random variable that assumes non-negative values. Without loss of generality, we assume the minimum possible value that X can assume is zero. We also assume X is continuously distributed with cumulative distribution function $F(x)$ and probability density function $f(x)$.

The procurement manager of WoodCorp observed, "Well certainly, if we require 20t and they [ChemCorp] supply 20t and we use 10t, and it has a shelf life of a month, and let's say in the first week of the month we use 10t and the last week of the month we plan on using the remainder, but find the chemical has deteriorated to a point where it is no longer fit for use, then that is the responsibility of ChemCorp." The partnership manager of WoodCorp clarified that "if WoodCorp's schedule shows that they need 20 tons of chemical, and we only end up using 10t, and 10t goes off, it is WoodCorp's responsibility to pay for it. If our schedule shows we need 20t, and ChemCorp supply 30t, and we only use 20t, then ChemCorp are responsible for that extra, so costs are split depending on who is responsible." She also noted that whether ChemCorp returns the spoiling chemical to their plant, reworks it, and dispatches it again "obviously depends

on the volume that is worth their while returning to their plant, so 5 or 6 tons they may decide to waste and dump.”

On the basis of the above, we suppose that if a batch of chemical spoils before the expected shelf life, the vendor incurs the cost of replacement. On the other hand, if chemical is not consumed before the expected shelf life and if it spoils thereafter, the manufacturer has to bear the cost of replacement.

We assume the manufacturer’s demand is constant and deterministic. We assume the manufacturer evenly consumes the short-lived chemical in lots of Q tons; thus, as one would expect, the manufacturer’s demand for chemical is assumed lumpy.

The replenishment lead-time is assumed zero for all customers of the vendor, including the partner-customer. In light of the comments of ChemCorp’s manufacturing manager as reported in the preceding section, this assumption is reasonable for the likes of WoodCorp. The assumption is possibly generous for the likes of WoodCorp’s competitors but importantly, will cause us to underestimate (rather than overestimate) the benefits to manufacturers from having the vendor operate consignment stock through an in-plant.

The base case (traditional relationship between vendor and customer-manufacturer) is as follows. The materials manager at the manufacturer’s site reviews the inventory position each time a quantity of Q tons is required for production purposes. If chemical is stocked out or spoiled, the materials manager places a replenishment order to immediately bring the inventory position, net of the backorder of Q tons, up to MQ where M is an integer. Therefore, after the immediate requirement of Q tons is satisfied, the residual stock of chemical will be MQ tons; hence, to avoid trivialities, we assume $M \geq 1$.

Given the continuous distribution of shelf lives, the expected shelf life of a batch could well transpire between off-takes of chemical for production purposes. Therefore, for accounting purposes, we assume that in the base case, the materials manager also observes the condition of the stock of chemical *at* the expected shelf life. If chemical has spoiled by then, she debits the vendor for the amount that has spoiled.

The alternate case (operation of consignment stock by the vendor through an in-plant, as with WoodCorp and ChemCorp) is as follows. The in-plant continuously reviews the stock of chemical on the partner-customer’s site and when chemical begins to spoil, immediately sends it for rework. For the sake of consistency in comparison with the base case, we assume that the manufacturer receives a batch of $(M+1)Q$ tons at the time of the next requirement. Further, this batch has the same minimum shelf life of L , as in the base case.

Note that the unpredictable shelf life of chemical constitutes a supply-side uncertainty. Nevertheless, even if the replenishment lead-time is positive, safety stock of perishable chemical at the manufacturer’s site is inapplicable in the present context – when chemical begins to spoil, the *whole tank* is unusable, and not just a portion of it. Therefore, given that shelf life is independent of the quantity stored, the manufacturer will not store any quantity of chemical that is surplus to requirement.

We may note here that much of the prevalent literature on inventory control of perishable items reckons inventories in discrete units, e.g., bottles of blood in a blood bank that are distinct from one another. In the present situation, the obsolescence of one unit automatically entails the obsolescence of *all* remaining units, which is not the case in inventory models extant in the literature. This aspect of the problem lends a rather unique character to our analysis. Indeed, most research that addresses the case of

random product lifetimes assumes that a constant fraction on hand becomes useless each unit of time (Silver et al., 1998: 403), an assumption that is acceptable for perishable consumer goods but perhaps not for industrial goods such as chemicals for forestry.

4 Basic Results

We may now present the principal result of this section. The result holds under the mild assumption that the median of X is no greater than the expectation, i.e., $F(E(X)) \geq 0.5$. This assumption holds for instance for symmetric distributions as well as those distributions that are positively skewed such as the exponential distribution, which is a plausible choice for X .

Result 1: If $F(E(X)) \geq 0.5$, then in the base case, the expected loss incurred by the vendor through spoilage of chemical in a batch is at least as great as the manufacturer's expected loss.

Result 1 confirms the intuition that under a mild assumption of the shelf life distribution, the vendor stands to gain more than the manufacturer from the operation of consignment stocks through an in-plant. This is because: (a) in many situations, the batch of chemical is more likely than not to spoil prior to the expected shelf life, which is when the vendor is liable; and (b) the residual stock of chemical in the batch, that is susceptible to spoilage, decreases over time owing to regular consumption by the manufacturer. Our analysis helps clarify the remark of WoodCorp's procurement manager that "it would be fair to say that ChemCorp did have some reservations to start off with [about holding stock on a consignment basis] but they fully support the move now."

In Result 2, we examine the total expected waste in relation to minimum shelf life.

Result 2: The total expected waste of chemical per replenishment batch of size $(M+1)Q$ is non-decreasing as the minimum shelf life decreases.

5 Conclusion

We have presented the elements of an inventory model that purports to clarify why vendors positively view the operation of consignment stocks at their customer-manufacturer premises when shelf lives are short. We propose to extend the analysis of the present paper to non-zero replenishment lead-times and minimum rework quantities. We also intend to analyze risk-pooling that results from the centralization of stocks of perishable items, as well as the benefits that ensue from the ability of the in-plant, in conjunction with the manufacturer, of massaging the manufacturer's production requirements so that short-lived supplies are used up before they begin to spoil.

6 References

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