THE THEORETICAL ADVANTAGE OF JIT PURCHASING IS PROBABLY OVERSTATED

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Abstract: The literature on the use of just-in-time (JIT) and the economic order quantity (EOQ) purchasing has increasingly favored JIT in recent years, especially when firms are purchasing to meet high and consistent levels of demand and the JIT operation can take advantage of inventory physical plant space reduction. This paper suggests that the theoretical advantages of JIT purchasing may have been overstated. By expanding the classical EOQ model, this paper shows that it is possible for the EOQ approach to be more cost effective than the JIT purchasing approach even if the JIT approach can experience inventory physical plant space reduction. The survey and case study conducted in the ready-mixed concrete industry in Singapore supports this proposition.

Key words: EOQ; JIT; Cost indifference point; Inventory facility

1 Introduction

The Just-in-time (JIT) production philosophy, which contains a comprehensive set of principles and techniques, is probably one of the most important productivity enhancement management innovations of the 20th century (Schonberger, 1982). Among all the principles and techniques of the JIT philosophy, JIT purchasing of materials is one of the most important policies adopted by JIT companies (Norris, 1992). Companies in various industries that still use the economic order quantity (EOQ) purchasing system are increasingly faced with the decision of whether or not to switch to the JIT purchasing policy (Chyr et al., 1990). This decision is a very difficult one, as it requires careful examination of the EOQ and JIT system and the possible impact on a variety of factors such as cost, quality, flexibility in production, customer service and organizational competitiveness (Fazel, 1997).

To help companies that were still using the EOQ system in managing their raw materials procurement to make an informed decision as to whether or not to switch from the EOQ purchasing system to the JIT purchasing system, Fazel (1997) developed a series of innovative mathematical models to directly compare the cost difference between the EOQ purchasing system and the JIT purchasing system. She suggested that although the choice of either the EOQ or the JIT system depends on many parameters, an indifference point (i.e. the level of demand at which the costs were the same) existed between the EOQ and the JIT purchasing system. Beyond the indifference point, usually at lower levels of annual demand, JIT inventory purchasing was not preferable. However, Fazel’s (1997) EOQ-JIT cost function was developed based on Harris’s (1915) EOQ model, where storage facilities operating costs including “rental, utilities and personnel salary” were treated as “fixed costs” (Fazel, 1997, p.501). These “fixed costs” were therefore not considered in Fazel’s (1997) mathematical models. While quoting the research findings of Schonberger (1982), Wantuck (1989) etc, Schniederjans and Cao (2001) argued that those “fixed costs” would constantly go down during JIT inventory operations. Schniederjans and Cao (2001) then suggested that some important cost information could be left out of Fazel’s (1997) mathematical models thus Fazel’s models could be improved by including some of these cost components. Some of these cost items for example could include the cost of the physical plant space, utilities, personnel salaries, etc (Schniederjans and Cao, 2001). Schniederjans and Cao (2001) further argued that while any one or all of these cost items might rightfully be included in a model, they would demonstrate that the inclusion of but a single additional cost item could have a substantial impact on the conclusions reached by Fazel (Schniederjans and Cao, 2001). By including a single additional cost item, namely, the physical space savings into Fazel’s (1997) models, Schniederjans and Cao (2001) derived their own EOQ-JIT cost indifference point. The magnitude of the revised EOQ-JIT cost indifference point derived by Schniederjans and Cao (2001) was significantly higher than that arrived at by Fazel (1997). Schniederjans and Cao (2001) then argued that the revised EOQ-JIT cost indifference point was so large, that the only way
inventory could be ordered would be on a continuous, JIT basis. Otherwise, the purchaser would be so inundated with inventory that major purchase of additional space would have to be acquired, again forcing a new round of additional facility space costs favoring a JIT system (Schniederjans and Cao, 2001). Schniederjans and Cao (2001) further argued that saving space and using it to house additional increasing amounts of inventory to meet larger annual demand were juxtaposed issues. They thus concluded that in situations where plants adopting the JIT operations experienced or could take advantage of physical plant space square meter reduction, a JIT system would virtually always be preferable to an EOQ system (Schniederjans and Cao, 2001). However, Schniederjans and Cao (2001) had difficulties to either scientifically or empirically ascertain the capability of an inventory facility to hold the EOQ-JIT cost indifference point’s amount of inventory.

JIT purchasing is not always successful. Many companies are still using the EOQ based inventory ordering system to purchase their raw materials. This is despite the fact that the plants adopting JIT operations may experience or can take advantage of square meter reduction (Wu, 2004). Fazel’s (1997) models appear to be unable to clearly explain the wide adoption of the JIT policy in many companies. Likewise, Schniederjans and Cao’s (2001) models seem to be unable to clearly explain the success achieved by the EOQ companies. This suggests that the real EOQ-JIT cost indifference point has not yet been derived. One possible reason is that the EOQ-JIT cost difference functions proposed by Fazel (1997) and Schniederjans and Cao (2001) were developed from Harris’ (1915) EOQ model, where some inventory operating costs were assumed to be “fixed”. Hence the purpose of this study is to expand Harris’ (1915) EOQ model to include those inventory operating costs that were left out. This is to derive the formula of the real EOQ-JIT cost indifference point, called the revised EOQ-JIT cost indifference point, as an extension of Fazel’s (1997) and Schniederjans and Cao’s (2001) works. This would be developed and tested through a case study conducted in the ready-mixed concrete industry in Singapore. This paper will demonstrate that by including the “physical plant space” factor, as well as all other factors which were omitted by Fazel (1997), it is still possible for an EOQ system to be more cost effective than a JIT system.

2 Harris’ (1915) EOQ model

Both Schniederjans and Cao’s (2001) and Fazel’s (1997) EOQ-JIT cost difference functions were based on Harris’s (1915) EOQ model, namely, the classical EOQ model. The classical EOQ model aims to minimize the total of ordering and holding costs, while assuming that some inventory operating costs such as rental, utilities and personnel salary, etc are “fixed” costs. The total annual cost of the classical EOQ system, $TC_E$, is the sum of the inventory ordering cost, inventory holding cost, and the cost of the actual purchased units, or:

$$TC_E = \frac{kD}{Q} + \frac{Qh}{2} + P_E D \quad \text{Eq. 1}$$

Where $Q$ is the fixed order quantity, $h$ is the annual cost of holding one unit of inventory in stock, $k$ is the cost of placing an order, $D$ is the annual demand for the item, $P_E$ is the purchase price per unit, $D/Q$ is the annual ordering frequency, and $Q/2$ is the annual average inventory level in the inventory facility. Chalos (1992) suggested that $k$ and $h$ are the most subjective components in Eq. 1. Nevertheless, $k$ usually includes the inventory delivery charges and transaction costs of clerical paperwork, and $h$ often includes opportunity cost of the working capital tied up in purchased goods, taxes and insurance paid on inventory items, inventory spoilage cost and inventory obsolescence cost. The classical EOQ model provides appropriate inventory ordering decisions only when its assumptions can be met. These assumptions are: (1) the inventory operating costs, rental, utilities and personnel salary, etc are constant; and (2) $h$ the annual cost of holding one unit of inventory in stock and $k$ the cost of placing an order are constant. It should be noted that although the term “the total annual cost of an inventory item under an EOQ system” is widely used to refer to “$TC_E$” in Eq. 1,
“$TC_E$” is not the actual total annual cost of an inventory item under an EOQ system. The actual total annual cost of an inventory item under an EOQ system should be the sum of “$TC_E$” and the “fixed costs”.

As mentioned earlier, that the so called “fixed costs”, including “rental, utilities, and personnel salary” were excluded from the inventory holding cost item in Eq. 1 was also an important assumption made by Fazel (1997), and Schniederjans and Cao (2001) when they derived their EOQ-JIT cost indifference points. However, since (a) It is agreed that the so called “fixed costs” were left out from the so called “total annual cost of the EOQ system”, and (b) Gaither (1996) suggested that the annual inventory holding cost should include the opportunity cost of the working capital tied up in purchased goods, taxes and insurance paid on inventory items, inventory spoilage cost and inventory obsolescence cost, together with the cost of physical storage, and (c) Schonberger (1982), Wantuck (1989) etc proved that the so called “fixed costs” would no longer be constant during JIT operations, and (d) Schniederjans and Olsen (1999) and Schniederjans and Cao (2000, 2001) observed that the saved inventory facilities can be rented out when the annual average inventory level dropped, then there is a reason to include all components of inventory holding costs into the holding cost item, when comparing an EOQ system with a JIT system. To sum up, one of the assumptions of the classical EOQ model, namely, the so called “fixed” costs are excluded from the holding cost item, needs to be revised. Consequently the traditional EOQ model needs to be expanded when comparing an EOQ purchasing system with a JIT purchasing system.

To include the so called fixed cost into the holding cost item, this study assumes that the inventory physical storage costs under the EOQ system, for example, rental, utilities and personnel salaries are linearly related to the average inventory level. However, it should be noted that the inventory physical storage cost under the EOQ system is not necessarily a linear function with the average inventory level. For instance, let us put ourselves in the position of a warehouse man storing cubic boxes. All the boxes are identical. The area of each surface of each box is $\alpha m^2$. Let us look at a simple scenario of 3 boxes and then extend it to a more complicated scenario of $n$ boxes. For 3 boxes, the total inventory space occupied may be $\alpha$, $2\alpha$ or $3\alpha m^2$. This is shown in Fig. 1. For $n$ boxes, the total inventory space occupied may be $\alpha$, $2\alpha$, $3\alpha$ … $(n-1)\alpha$, or $n\alpha m^2$. This is shown in Fig. 2. Hence, the total inventory space taken up by $n$ boxes does
not have to be \( n \alpha \ m^2 \), which is the logical extension of the assumption made in this study. Figures 2 shows that this assumption is biased against the EOQ model, as the \( n \) boxes may be stored in an inventory space with an area that is smaller than \( n \alpha \ m^2 \).

Hence, the assumption made by the authors tended to be quite conservative for the eoq system when compared with a jit purchasing system, provided that the annual cost of holding one unit of inventory in stock is determined based on the average value of inventory facilities. This study shows that it is still possible for the eoq system to be more cost effective than the jit purchasing system even when (a) the jit operation can experience physical plant space reduction; and (b) an unfavorable assumption is made against the eoq system.

### 3 Revised eoq model

The total cost under the revised eoq model is thus:

\[
TC_{Er} = \frac{kD}{Q} + \frac{HQ}{2} + P_e D \quad \text{Eq. 2}
\]

\( TC_{Er} \) is the sum of the inventory ordering cost, the expanded inventory holding cost, and the cost of the actual purchased units. \( TC_{Er} \), with the inclusion of the so called “fixed costs”, is the actual total cost of the eoq ordering system and is thus greater than \( TC_E \) in eq. 1. The optimum order quantity of the revised eoq model, \( Q_r^* \), derived from eq. 2 is:

\[
Q_r^* = \sqrt{\frac{2kD}{H}} \quad \text{Eq.3}
\]

Eq. 4 results in a total annual optimal cost under the eoq purchasing approach of:

\[
TC_{Er} = \sqrt{2kDH} + P_e D \quad \text{Eq.4}
\]

Under the JIT system, the ordering cost and holding cost, including the so called “fix costs” are mainly transferred to the supplier. The total annual cost under the JIT system, \( TC_J \), thus, is the annual purchase cost (fazel, 1997), given by:

\[
TC_J = P_J D \quad \text{Eq.5}
\]

Where \( P_J \) is the unit price under the JIT system. \( P_J \) is greater than \( P_e \). This is to partially reflect the holding costs and ordering costs that have been transferred to the materials suppliers [3]. The cost difference between an eoq purchasing system and a JIT purchasing system, \( Z_r \), thus is:

\[
Z_r = \sqrt{2kDH} + P_e D - P_J D \quad \text{Eq.6}
\]

Setting \( Z_r \) equal to zero, the root of eq. 7 is the revised eoq-jit cost indifference point, \( D_{indr} \):

\[
D_{indr} = \frac{2kH}{(P_J - P_e)} \quad \text{Eq.7}
\]

### 4 A case study

Ready mixed concrete (rmc) is a product that is widely used in the construction of building and civil works in the construction industry. The production of rmc is a highly repetitive manufacturing process. Cement, one of the raw materials of rmc may be purchased either using the eoq system or the JIT system (wu, 2004; tommelein and li, 1999). In Singapore, most of the cement consumed was imported mainly from Japan by 40,000-ton cement carriers. The cost of placing an order for 40,000 cement carriers from Japan was \( k = \$ 432,000 \) order for transportation alone. The annual cost of holding one ton of cement was \( H = \$ 344 \) /year per ton. Purchasing cement according to the eoq model costs \( P_e = \$ 40 \) /ton. If cement was purchased under a jit
system, the cost was \( P_s = \$65 \) /ton. The data for this case study were collected by interviewing the overseas investment manager, the financial manager, the production manager and the customer service supervisor of the cement division of a supplier. Based on eq. 3, the economic order quantity was \( Q^*_r = 36,139 \) ton / order, which was close to the routine order quantity 40,000 ton / order. Hence, eq. 7 can be used to derive the eoq-jit cost indifference point. According to eq. 7, \( D_{indr} \) the eoq-jit cost indifference point was 475,545 ton. A survey revealed that the rmc suppliers in singapore, whose annual cement demand were greater than \( D_{indr} \) purchased their cement in an eoq fashion (wu, 2004).

5 Conclusion

Jit purchasing is not always more cost effective than the eoq purchasing system. By expanding the classical eoq model, conducting a case study and a survey in the rmc industry in singapore, this study suggests that it is still possible for the eoq purchasing system to be more cost effective than the jit purchasing system, even when jit operation can capitalize on inventory physical plant space reduction.

Reference