Calculation of the Approaches to Cycle Service Level in Continuous Review Policy: A Tool for Corporate Entrepreneur

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Abstract

This paper presents two new approximations to compute the Cycle Service Level (CSL) in a continuous review policy, as a tool for corporate entrepreneur. These approximations are not only for the backordering case but also for the lost sales one. In order to develop it we focus on transforming a form of periodic review policy in a model of continuous review policies. As a result, the analogy and the transformation proposed in this paper are different from Silver classical model. Due to huge complexity of the exact CSL calculus the aproximate methods are needed.

The entrepreneurial dimension, based on internal reorganization and innovation, is an inherent, indispensable part of the discovery and creation of opportunities. Accordingly, this article contributes to the firms´ pursuit of competitive advantages by presenting methods of internal management for corporate entrepreneurship. Efficient stock-taking is a key issue for lowering production cost and boosting competitive advantages, and, by examining this area, this paper makes a significant contribution to the study of corporate entrepreneurship.

Keywords: Cycle service level, Management stock policy, Corporate entrepreneur

1. Introduction

Entrepreneurial activity yields competitive advantages that originate from market opportunities (Shane & Venkataraman, 2000; Shane, 2012), fresh combinations of factors that create opportunities via innovation (Schumpeter, 1934), or strategic and organization renewal (Zotto & Gustafsson, 2008)

The latter entrepreneurial dimension corresponds to corporate entrepreneurship, which is linked to the research contribution of this article. Organizational renewal, which equates to growth in productivity or new organizational forms that lead to cost savings, may boost the competitive capabilities of the firm. This renewal is the result of entrepreneurial activity facilitated by a deep knowledge of a business sector, and experience and knowledge of a firm´s internal management. An example that has received much atteention in the field of quality management and management in general is the stock-taking process (JIT) implemented by Toyota (Toyota Production System). Savings arising from this revolution in the company´s stock-taking method is a prime example of the results of corporate entreneurship –whereby entrepreneus act as leaders and collaborators within an organization-, allowing Toyota to compensate for the greater economies of scale enjoyed by the major American auto companies such as Ford and General Motors, and achieve comparable competitive advantages.

Thus, internal reorganization, which in this instance includes relationships with suppliers, was a key factor in Toyota´s strategic and organizational renewal. Just as with Matsushita or Sharp (Nonka & Takeuchi, 1995), the internal entreprenuership process based on innovation maintained and even increased the competitive advantages of this firm.

Therefore, in the field of corporate entrepreneurship, new combinations of factors may lead to a more efficient use of opportunities (Shane, 2012), or the *ex novo* creation of opportunities brought about by new production methods that competitors are slow to imitate. Likewise, such discoveries may lead to the identification of hitherto untapped value of resources, which suppliers only incorporate into their pricing models after a significant time lag (Shane & Venkarataman, 2000). As Schumpeter (1934) asserts, it might be the very reorganisation of productive or comercial activities (new combinations of factors or resources) that creates opportunities throught, "the different employment of the economic system´s existing supplies of productive means" (Ibid: 67), or, along the same lines, entrepreneurial activity as a complex phenomenon that includes "innovation, venturing and strategic renewal" (Zotto & Gustafsson,

2008, p. 97).

This entrepreneurial dimension, based on internal reorganization and innovation, is, as discussed above, an inherent, indispensable part of the discovery and creation of opportunities. Accordingly, this article contributes to the firms´ pursuit of competitive advantages by presenting methods of internal management for corporate entrepreneurship. Efficient stock-taking is a key issue for lowering production cost and boosting competitive advantages, and, by examining this area, this paper makes a significant contribution to the study of corporate entrepreneurship.

Below, in strictly technical terms, we develop the proposed research model.

One of the most usual measures of customer service is the cycle service level (CSL) that indicates the specific probability of no stockout per replenishment cycle. This definition can be applied to any stock policy and demand pattern, given a known stock level at the beginning of the cycle, (Cardos, Babiloni, Palmer & Albarracín, 2009). This paper presents a general approach to compute the CSL in a continuous review policies (s,Q) applying a model with analogies from the models used to calculate CSL in periodic review policy (R,S). This paper calculates a CSL approximation for inventory management policy (s,Q) when demand procces is stationary with discrete probability function, independent and identically distributed, and replenishment period L is constant. Analogy method is used due to huge complexity of the exact CSL calculus.

The paper is organized as follow. A briefly inventory management policy (s,Q), and CSL are introduced in Sections 2 and 3. Section 4 explains the periodic review approximations we will use to implement our analogy. In Section 5 we develop the analogy and develop the transformations proposed. The comparision between method and the analysis of the numerical results are carried out in Section 6. Finally, conclusions of the paper are found in Section 7.

2. Inventory Management Policy (s,Q)

Selection of inventory policy depends on how often is checked the inventory level (Cardos et al., 2009). Inventory management policies with random demand are divided into two main categories: periodical and continuous review. If the status of the inventory is permanently reviewed, we talk about continuous review policy. In the other case is periodical review policy.

The inventory management policy (s,Q) is called order point-order quantity or reorder point system (Krajewski & Ritzman, 2000), where s is reorder point and Q quantity ordered. The model (s,Q) is an important model in literature production and management in operations research and in practice. In inventory management policy (s,Q) a fixed quantity Q is ordered whenever the inventory position reaches reorder point s or falls below this (Silver, Pyke & Peterson, 1998). Order is received L periods later and L can be constant or variable. It is defined as:

Inventory Position (IP), measure the item´s ability to satisfy future demand (Krajewski & ritzman, 2000).

$$IP \;=\; OH + SR - BO \tag{1}$$

Where OH is on-hand, SR is scheduled receptions and BO is backorders. On (Silver et al., 1998) in addition to subtract the commitment (C):

$$IP \;=\; OH + SR - BO\text{-}C \tag{2}$$
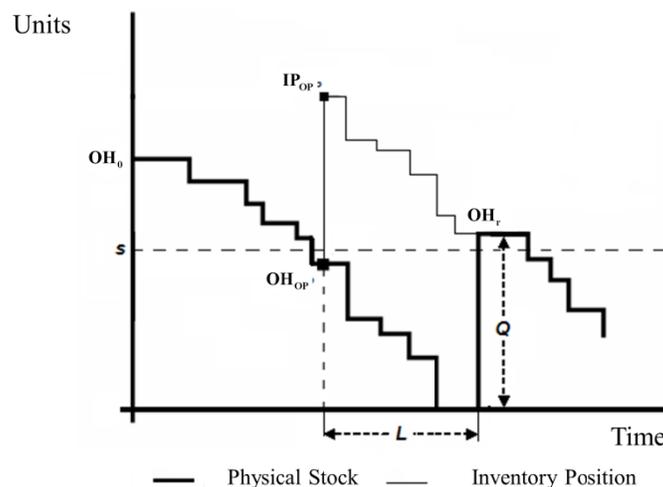
Figure 1. Evolution of physical stock and the inventory position in a system (s,Q). Source: Own

3. Cycle Service Level as a Design Requirement

Once management policy is defined, we must establish design the criteria to determine the policy parameters. Basically there are two methods:

1) Which minimize cost, and

2) Which minimize inventory average to a certain service level.

In the first case, inventory policies should be considered different types of costs (Schneider, 1981). In practice, these costs are difficult to establish and estimated, they are discarded in favour of a focus on a predetermined service level view satisfaction (Cohen, Kleindorfer & Lee, 1988; Larsen & Thorstenson, 2008).

Most commonly used design requirements are those related to customer service as CSL o P1 (Cardos et al., 2009: Cardós & Babiloni, 2011b; Vereecke & Verstraeten, 1994), and percentage of demand satisfied with physical stock, called fill rate (FR) o P2 (Dunsmuir & Snyder, 1989; Janssen, Heuts & Kok, 1998; Segerstedt, 1994; Strijbosch, Heuts & Van der Schoot, 2000). Present paper focuses on CSL.

In literature there are two definitions of CSL. First, hereinafter referred to classical, defines CSL as the probability of not incurring stock-outs during the replenishment cycle. This probability is equivalent to the safety factor used to calculate k when demand is normally distributed (Silver et al., 1998). Therefore, CSL is the fraction of cycles in which a stockout doesn´t occur:

$$CSL = 1 - P(stockout \text{ in a replenisment cycle})$$

(3)

Axsäter (2006) defines CSL as "probability of no stockout per order cycle". According to (Cardos & Babiloni, 2011b), this definition and the corresponding expression should be improved as follow:

1) Demand fulfilment is not taken into account and

2) There are a number of situations where this definition is scarcely useful.

Cardos, Miralles & Ros (2006) propose CSL definition: "fraction of cycles in which having demand nonzero is been fully satisfied with physical stock". When applied to continuous review policy, cycle demand is always positive so:

$$CSL = P(cycle \text{ demand} \leq available \text{ stock} | cycle \text{ demand} \geq 0)$$

(4)

Chopra & Meindl (2001) propose an estimation method:

$$CSL = P(Demand \text{ during lead time of } L \text{ weeks} \leq s)$$

(5)

4. Periodic Review Policy Approximations

4.1 Basic Notation and Assumptions

When a periodic review policy is applied "every R units of time a replenishment order is placed of sufficient magnitude to raise the inventory position to the order up to level S" (Silver et al., 1998). See Figure 2.

Table 1. Notation used in ecuations and figures

S	=	Order up to level (units)
R	=	Review period and replenishment cycle corresponding to the time between two consecutive deliveries (periods),
L	=	Lead time for the replenisment order (periods).
OH_t	=	Physical stock in time t from the first reception (units).
D	=	Demand (units).
$F_t(\cdot)$	=	Cumulative distribution functions of demand during t periods.

4.2 Approximation Models for Periodic Review

4.2.1 Approximate Method to Calculate CSL in a (R,S) policy with backlogs

From Cardos et al. (2009):

$$CSL = P(D_R \leq OH_R) = F_L(S)$$

(6)

4.2.2 Approximate Method to Calculate CSL in a (R,S) policy without backlogs

The classical approximation used to compute the CSL in a (R,S) system is based on assuming that there is a negligible chance of no demand between reviews and backlog is not allowed (Silver et al., 1998), and consequently the CSL is approximate with the following expression:

$$CSL = P(D\text{emand during R+L} \leq S) = F_{L+R}(S)$$

(7)

From Cardos et al. (2009):

$$CSL = P(D_R \leq OH_R) = P(D_R \leq OH_{R-L} - D_L) = P(D_{R+L} \leq OH_{R-L}) = F_{L+R}(OH_{R-L}) \leq F_{R+L}(S)$$

(8)

5. Development of Analogies

We make a transformation in equations seen in Section 4. Equivalences can be seen on Figure 2, explained and compared vs. Silver transformations in Table 2.
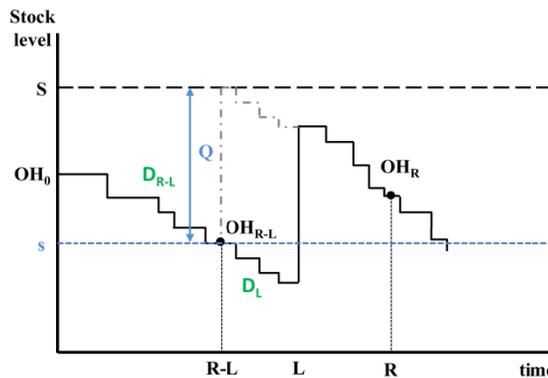
Figure 2. Evolution of physical stock and the inventory position in a system (s,Q). Source: Own

Be:

d = Average demand

R = Time to consume the average demand where R = Q/d

Q = Order quantity

S = Order up to level, where S = s+Q

s = Order point

Table 2. Transformations proposes vs. Silver et al. (1998) transformations

Transformation Proposes		Silver Transformation	
(s,Q)	(R,S)	(s,Q)	(R,S)
s+Q	S	s	S
Q/d	R[1]	Q	d*R
L	L	L	L+R

5.1 Approximate Method to Calculate CSL in a (s,Q) policy with Backlogs

Taking the ecuation (6) and doing the above transformations:

$$CSL = F_L(s+Q)$$

(9)

The approximation obtained through this method is equal to the approximation obtained by the authors Cardos & Babiloni (20011a). So we can say that this analogies method get developments consistent with other results obtained in this context, as we got the same result using a different path. It should be noted that the analogy here we used is different from that used (Silver et al., 1998).

5.2 Approximate Method to Calculate CSL in a (s,Q) policy without Backlogs

Taking the equation (1.7) and making the cited transformations:

$$CSL = P(D_{\frac{Q}{d}} \leq OH_{\frac{Q}{d}}) = P(D_{\frac{Q}{d}} \leq OH_{\frac{Q}{d}-L} - D_L) = P(D_{\frac{Q}{d}+L} \leq OH_{\frac{Q}{d}-L}) = F_{L+\frac{Q}{d}}(OH_{\frac{Q}{d}-L}) \leq F_{\frac{Q}{d}+L}(s+Q) \qquad (10)$$

In this case, using the analogies method we obtain a more complex than:

$$CSL = P(OH_{OP} \geq D_L) \leq P(D_L \leq s) = F_L(s) \qquad (11)$$

We should check whether expression (10) provides better approximations to the exact CLS that (11).

6. Illustrative Example

Comparison of exact method of CSL calculus, approximations methods for backlog and lost sales from Cardos & Babiloni (2011b) and the new approximation method are shown in Figure 3. In all these cases demand is assumed to be Poisson distributed with a known demand rate.
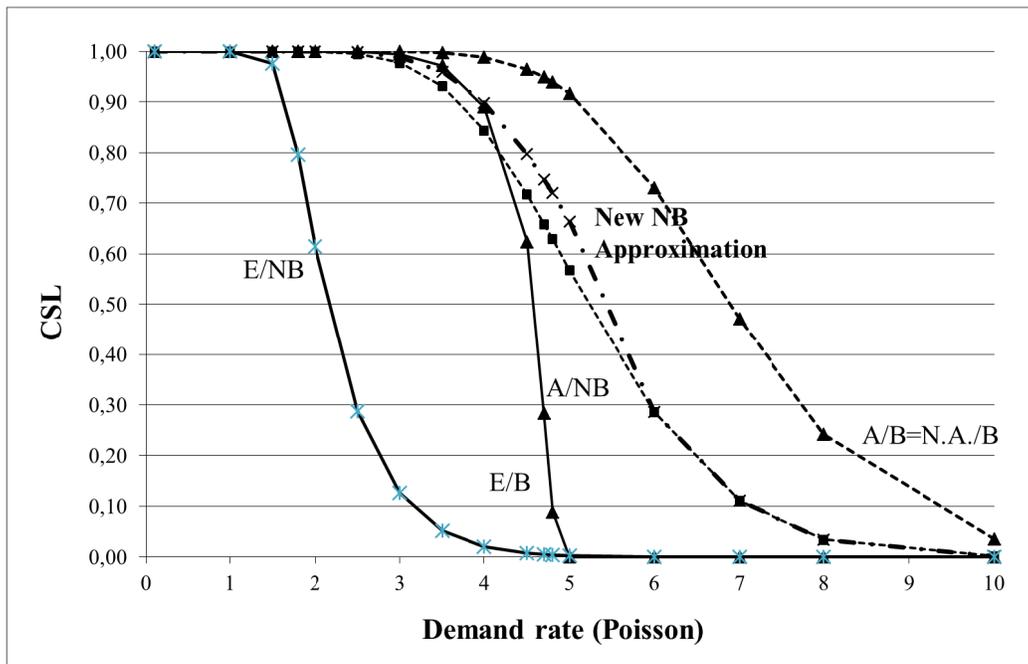
Figure 3. CSL vs. demand rate in a (s,Q) policy, (demand is Poisson distributed, s=15, Q=5 and L=3). Source: Own

7. Conclusions

Using a different path, the same result as the one develop by Cardos & Babiloni (2011b) for continuous review policy (s,Q) with backlog was found in Section 5.1. It could be assumed that the used analogy provides the same results obtained using other approaches. After the transformations shown in Section 5.2. we develop a more complex expression for continuous review policy (s,Q) with lost sales than the one developed by Cardos & Babiloni (2011b). It seems that this new approximation show performance similar to the above mentioned approximation, i.e. for higher demand rates decreases rapidly showing almost a step pattern and increasing the gap between the exact one. Finally, the example show in the Figure 3 reveals deviations from the other approximations and exact calculations. Therefore, based on the contributions included in this paper, for a future research an extensive analysis should be done to characterize at least the cases with the most important deviations including larger experiment, with a more extensive number of distribution functions and an adequate number of cases for exploring the different categories of demand and different parameter combinations of inventory policy.

The examined model is, at the same time, as we are talk in the introduction, a contribution for corporate entrepreneurship.

Acknowledgements

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Notes

Note 1. This is analogal to the Silver transformations.