



Economic Production Inventory model with the associated costs of internet advertising to acquire customers residing worldwide

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Abstract

In recent times, we are witnessing the technological revolution which provides access to tremendous changes in all the fields including the industrial sectors. The notable benefit of the modern technology is quick accomplishment of complex tasks within a short span of time, which has motivated the manufacturers to imbibe novelty techniques in the production process to enhance the quality of the product so as to retain its market position amidst the competitors. As globalization has gained more concern, the manufacturers employ internet advertising strategy to elevate the product to international level and to propagate the attributes of the products to the customers residing worldwide. In this paper an EPQ inventory model is developed in which the associated costs of technology, acquisition of local and international customers via internet advertising costs are included, a numerical example is also presented to validate the model.

Key Words: Inventory; internet advertising; technology.



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1. Introduction

Advertising has an extreme importance in today's society, and business companies invest constantly growing parts of their budgets in engineering ways to attract higher number of products and services they offer (Antonio.et.al., 2009). Advertising ,a one way communication about a product or organization that is paid by a marketer to persuade an audience (readers, listeners and viewers) to a commercial offering to take some action with respect to products, ideas, or services. It is a powerful educational tool capable of reaching and motivating the customers and drives consumer behaviour for commercial purpose. Virtually any medium can be used for advertising. Commercial advertising media can include wall paintings, billboards, street furniture components, printed flyers and rack cards, magazines, newspapers, radio, cinema ,television, web banners, mobile telephone, web popup. Among these mediums billboards, handbills, television which are the traditional mediums, followed by web and email, the recent mediums of advertising are used commonly due to its benefits and cost effectiveness.

Billboards, which are large structures located in public places which display advertisements to passing pedestrians and motorists (Cai., 2003). Most often, they are located on main roads with a large amount of passing motor and pedestrian traffic, however, they are also placed in any location with large number of viewers, such as on mass transit vehicles and in stations, in shopping malls or office buildings, and in stadiums. Distribution of handbills is also one of the mediums of advertising. The bills are issued to the people for them to get to know the attributes of the product and services provided by the retailers. Television is yet another medium which is considered to be the most glamorous and prestigious media which succeeded radio advertising. It has three main advantages (Ramalingam., 2006)

1. It manipulates the taste of consumers.
2. It reaches a large audience simultaneously.
3. The audio and video effects generate sturdy impact.

In addition to these traditional mediums of advertising, the first banner advertisement was introduced in 1994, and as a result of it, a new realm of advertising emerged (Ritu., 2007). It was then that the idea that the Internet could be used as a marketing communication tool became a reality. Over the last decade, the Internet has emerged as an important medium of advertising. According to a recent report of the interactive Advertising Bureau (2008), over \$ 23 billion has been spent in the US market alone, For the first 14 years of Internet advertising history after it first was introduced in 1995, the market increased by more than 400% in terms of total revenue. In 2008, the Internet advertising market was the third largest in the US after only television channels (including national, local and cable stations) and newspapers. The American Press Institute (2009) reported that the Internet advertising market took only 13 years to reach \$20 billion in revenue, while the newspaper took 127 years in the US. Without doubt, the Internet is the fastest growing marketing medium in the history. Retailers and the manufacturers spend nearly 22% of their total accounted costs in advertising. According to Interactive Advertising Bureau (2010) online advertising yearly revenue had reached \$25 billion with a double digit yearly growth. The share of Internet in media consumption was more than 25% in 2011 and it is expected to reach great heights in the forthcoming years. (These statistical data are taken from Yongma.et.al., 2011). Without doubt, the Internet is the fastest growing marketing medium in the history.

Search and Display are two major formats of online advertising. Search advertising refers to the use of search engine result pages such as Google or Bing where user can requests search relevant to keyword(s). Search is preferred if the customer makes search indicating interest. Display advertisements intend on creating consumer awareness or achieve memory rather than instantaneous response (Tanveer Ahmed.et.al.,2012). Email marketing is a form of direct marketing which uses electronic mail as a means of communicating commercial or fund-raising messages to an audience. In its broadest sense, every email sent to a potential or current customer could be considered email marketing. Opt-Email advertising or permission marketing, is a method of advertising via email whereby the recipient of the advertisement has consented to receive it. This method is adopted by several marketers to eliminate the disadvantages of email marketing. Thus there is a progressive growth in the field of advertisement which ranges from billboards to opt-in email advertising.

In 2010, spending on advertising was estimated to be greater than \$500 billion worldwide in near future. This gives a vivid picture of the significance of advertisement. In this technological world, the field of advertisement has emerged as a boon both for the suppliers and consumers which strongly emphasized the integration of the cost of advertising together with the costs of inventory for promoting and propagating the product to attract and acquire customers.

The ultimate aim of retailers and manufacturers is to gain profit amidst this competitive scenario; so they focus on the aspect of advertisement which is their hope of building and sustaining the brand name of the product. In general the advertising cost is shared both by the manufacturer and the retailer based on their agreement terms. The concept of co-op advertising was developed by Berger (1972), which highlighted that mathematical modelling could yield improved managerial decisions and better performance for the whole channel. Berger's model was then extended by researchers in a variety of ways under different co-op advertising settings .Crimmins (1970) remarked that the co-op advertising is in essence the financial arrangements between two firms, which specify how two firms share the costs caused by the promotion measures. Roslow, Laskey, and Nicholls (1993) studied co-op advertising in the supply chain and demonstrated that cooperation in advertising investment could increase the profit of the whole supply chain. Khouja and Robbins (2003) investigated the optimal expense of the local advertising and the ordering quantity under the newsboy framework.



However, most of the above literature on co-op advertising considered the co-op advertising policies. Huang, Li (2002), Zhu, and Chau (2002) developed independently a cooperative advertising model for a one-manufacturer–one-retailer supply chain. Few researchers considered the market structure in which the retailers' power is equal to or even more than that of the manufacturer. Huang and Li (2002) further discussed the cooperative advertising issue for the supply chain with one manufacturer and one retailer. Xie and Ai (2006) extended the models developed by Huang and Li (2002) and Li et al. (2002) to the case, where the manufacturer's marginal profit is relatively small. Yue, Austin, Wang, and Huang (2006), Szmerkovsky and Zhang (2009) further extended the work of Huang et al. (2002) and Huang and Li (2001) in developing a price discount model to coordinate the advertising expenses of the two parties. A generalization of the earlier works on cooperative advertising by Hempelmann (2006) covered the situation where two parties have asymmetric information on the marginal cost of sales. Later an optimal cooperative advertising integration strategy for organizations having a direct online channel was developed. Sheng et al. (2011) developed the cooperative advertising model that involves one-manufacturer and two-retailers.

The inventory models formulated so far dealt only with the cooperative advertising policies between retailers and manufacturers, but practically they cannot promote the products jointly at all situations due to the arise of disputes between them, expiry of the agreement period and other personal hurdles which obstruct in continuing the agreement. At that juncture if they wish to promote the products independently the earlier formulated models are not applicable, therefore new inventory models have to be formulated to determine the optimal order quantity and to minimize the total inventory costs. With this motive this inventory model is formulated which is not discussed by the researchers so far.

The paper is organized as follows Section 2 comprises of problem description. Section 3 deals with the formulation of the EPQ model. Section 4 presents a numerical example and Section 5 concludes the proposed work.

2. Problem Description

Suppose a manufacturing firm approaches the publisher to propagate the quality of the newly produced product out of innovative techniques via internet advertising, a fixed amount of money (V) is paid by the manufacturer in advance. The publisher gives two choices one is CPM (cost per impression) and the other is CPC (cost per click). Yongma et al. (2011) in his paper has given the advertisement expenditure for both the options (The CPM fee is p_n , The CPC fee is c_r) which is included along with the classical cost components. The manufacturers select CPM if $p_n < c_r$ and CPC if $p_n > c_r$. Therefore two cases are discussed.

3. Model Formulation

3.1. Notations

The following notations are used throughout to develop the EPQ model.

| | |
|-----|---|
| D | demand per unit time |
| P | production per unit of time |
| x | D/P |
| 1-x | the fraction of time the production process spends actually idling |
| A | fixed ordering cost/ set up cost per production run |
| h | holding cost per unit per unit of time. |
| F | Associated costs of the installation of modern technology to enhance the product quality. |
| V | fixed cost of casting advertisement |
| n | number of impressions |
| p | cost per impression |
| r | cost per click |
| c | click through rate |

3.2 Assumptions

1. Demand for items from inventory is continuous and at a constant rate
2. Production runs to replenish inventory are made at regular intervals
3. During a production run, the production of items is continuous and the production rate is greater than the demand rate.
4. Production set-up/ordering cost is fixed (independent of quantity produced)
5. The lead time is fixed and the replenishment is made incrementally.



3. 3. Model Development

Case (1) Determination of optimal order quantity when $pn < crn$

The EPQ cost per unit of time

$$C(Q) = \frac{AD}{Q} + \frac{hQ(1-x)}{2}$$

The technology cost per unit of time

$$C_F(Q) = \frac{F}{T} \text{ where } T = Q/D$$

Advertisement cost per unit of time

$$C_A(Q) = \frac{V + pn}{T}$$

The total cost per unit of time

$$\Psi(Q) = C(Q) + C_F(Q) + C_A(Q)$$

$$= \frac{AD}{Q} + \frac{hQ(1-x)}{2} + \frac{FD}{Q} + \frac{D(V + pn)}{Q}$$

$$\frac{\partial \Psi(Q)}{\partial Q} = \frac{\partial}{\partial Q} \left[\frac{AD}{Q} + \frac{hQ(1-x)}{2} + \frac{FD}{Q} + \frac{D(V + pn)}{Q} \right]$$

$$= -\frac{AD}{Q^2} + \frac{h(1-x)}{2} - \frac{FD}{Q^2} - \frac{D(V + pn)}{Q^2}$$

$$\sqrt{\frac{2D[A + F + V + np]}{h(1-x)}}$$

The optimal order quantity is $Q = \sqrt{\frac{2D[A + F + V + np]}{h(1-x)}}$

Case (2) Determination of optimal order quantity when $pn > crn$

The EPQ cost per unit of time

$$C(Q) = \frac{AD}{Q} + \frac{hQ(1-x)}{2}$$

The technology cost per unit of time

$$C_F(Q) = \frac{F}{T} \text{ where } T = Q/D$$

Advertisement cost per unit of time

$$C_A(Q) = \frac{V + crn}{T}$$

The total cost per unit of time

$$\Psi(Q) = C(Q) + C_F(Q) + C_A(Q)$$

$$= \frac{AD}{Q} + \frac{hQ(1-x)}{2} + \frac{FD}{Q} + \frac{D(V + crn)}{T}$$



$$\begin{aligned} \frac{\partial \Psi(Q)}{\partial Q} &= \frac{\partial}{\partial Q} \left[\frac{AD}{Q} + \frac{hQ(1-x)}{2} + \frac{FD}{Q} + D(V + \text{crn})/T \right] \\ &= -\frac{AD}{Q^2} + \frac{h(1-x)}{2} - \frac{FD}{Q^2} - \frac{D(V + \text{nrc})}{Q^2} \\ &= \sqrt{\frac{2D[A + F + V + \text{crn}]}{h(1-x)}} \end{aligned}$$

The optimal order quantity is $Q = \sqrt{\frac{2D[A + F + V + \text{crn}]}{h(1-x)}}$

4. Numerical Example

Consider an inventory system with the following data

$A = \$100$ / cycle, $h = \$5$ / unit/ cycle, $D = 50,000$ units/ year, $P = 75,000$ units / year, $V = \$ 500$, $r = \$ 10$, $n = 10,000$, $p = \$ 0.5$, $c = 0.001$ $F = \$ 1000$ / cycle (The values of n , p , r , c , are taken from Yongma.et.al., 2011.).The optimal order quantity is 19899 units if CPM is preferred and the optimal order quantity is 10099 units if CPC is preferred. Based on the economic feasibility, the firm can select either CPM or CPC.

5. Conclusion

This paper presents a general outlook of the significance of internet advertising. An EPQ model that includes the cost of advertising and technological costs is also presented. This model benefits the manufacturers in promoting the product and acquiring customers both at local and international level. This paper concludes that internet advertising carries the innovative and quality products across the world.

References

- Antonio.et.al., 2009. MyAds: A system for adaptive pervasive advertisements., *Pervasive and Mobile Computing* 5, pp 385-401.
- Berger,P.D.(1972).Vertical Co-operative advertising ventures.*Journal of marketing research*,9,309-312
- Cai, G., Chen, L., Li, J., 2003. Billboard advertising detection in sport TV.In: *Proc. Internat. Symp. on Signal Processing and its Applications*,pp. 537–540.Crimmins, E. C. (1970). *A management guide to cooperative advertising*. New York: Association of National Advertisers Inc.
- Hempelmann., 2006. Optimal franchise contracts with private cost information. *International Journal of Industrial Organization*, Volume 24, Issue 2, pp 449-465
- Huang, Z., & Li, S. X. (2001). Co-op advertising models in manufacturer–retailer supply chains: A game theory approach. *European Journal of Operational Research*, 135, 527–544.
- Huang, Z., Li, S. X., & Mahajan, V. (2002). An analysis of manufacturer–retailer supply chain coordination in cooperative advertising. *Decision Sciences*, 33(3), pp 469–494
- Khouja., Robbins (2003). Linking advertising and quantity decisions in the single-period inventory model. *International Journal of Production Economics* , Volume 86,Issue2,pp93-105.
- Li, S. X., Huang, Z., Zhu, J., & Chau, P. Y. K. 2002. Cooperative advertising, game theory and manufacturer–retailer supply chains. *Omega*, 30, pp 347–357.
- Ramalingam , B. Palaniappan , N. Panchanatham , S. Palanivel 2006, Measuring advertisement effectiveness—a neural network approach .*Expert Systems with Applications* 31 , pp 159–163.
- Ritu Lohtia ,Naveen Donthu, Idil Yaveroglu 2007.Evaluating the efficiency of Internet banner advertisements. *Journal of Business Research* 60 ,pp 365–370.
- Roslow, S., Laskey, H. A., & Nicholls, J. A. F. (1993). The enigma of cooperative advertising. *Journal of Business & Industrial Marketing*, 8, pp 70–79.
- Sheng- Dong Wang, Yong-Wu Zhou, Jie Min, Yuan-Guang Zhong. 2011 Cordination of cooperative advertising models in a one- manufacturer two- retailer supply chain system. *Computers & Industrial Engineering*, Volume 61, Issue 4, pp1053-1071.
- Szmerekovsky, J. G., & Zhang, J. (2009). Pricing and two-tier advertising with one manufacturer and one retailer. *European Journal of Operational Research*, 192,pp 904–917.
- Tanveer Ahmed.et.al.,2012. Pricing game of online display advertisement publishers., *European Journal of Operational Research*., Vol 219, pp 477-487.



Xie, J., & Ai, S. (2006). A note on cooperative advertising, game theory and Manufacturer–retailer supply chains. *Omega*, 34(5), 501–504.

Yongma Moon , Changyun Kwon., 2011. Online advertisement service pricing and an option contract., *Electronic Commerce Research and Applications* 10, pp 38–48.

Yue, J., Austin, J., Wang, M.-C., & Huang, Z. (2006). Coordination of cooperative advertising in a two-level supply chain when manufacturer offers discount. *European Journal of Operational Research*, 168(1), 65–85.

