

衡量報童類型產品的獲利能力
之可達成能力指標及其應用

Achievable Capacity Index for Measuring
Profitability of Newsboy-type Product and Its Applications

研究生：蘇榮弘

Student：Rung-Hung Su

指導教授：彭文理 博士

Advisor：Dr. W. L. Pearn



A Dissertation Submitted to
Department of Industrial Engineering & Management
College of Management
National Chiao Tung University
in partial Fulfillment of the Requirements
for the Degree of Philosophy
in
Industrial Engineering & Management

September 2011

Hsinchu, Taiwan, Republic of China

中華民國 一 百 年 九 月

誌 謝

本論文能夠完成，首先要感謝指導教授--彭文理，在學術上或是生活上，都給予我許多寶貴的知識及做事嚴謹的態度，讓我能在研究生涯中更順利。淡江大學碩士班的指導教授--黃文濤從旁的協助，讓學生不只是順利完成博士論文也給予生活上做人處事的寶貴經驗。此外還要感謝本系的鍾淑馨教授、徐世輝教授、王國雄教授及柯沛程教授，提供諸多的寶貴意見，使本論文更加完整。

特別謝謝我的女朋友素貞與我的好友，對於我在博士修業期間的關懷、體諒及鼓勵。再者，要謝謝實驗室MB517的學長姐、學弟妹及同學在課業上、生活上的砥礪、啟發與互相支持。最後我要把我最深的感謝留給我的家人。感謝他們讓我沒有經濟壓力地讀完這博士學位。希望我的表現能讓你們感到光榮。



蘇榮弘 謹誌於國立交通大學
管理學院工業工程與管理學系
中華民國一百年九月二十九日

衡量報童類型產品的獲利能力之可達成能力指標 及其應用

學生：蘇榮弘

指導教授：彭文理 博士

國立交通大學管理學院

工業工程與管理學系

摘要

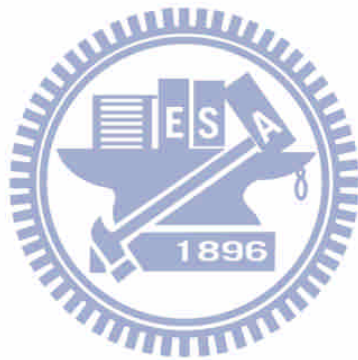
本論文提出一新指標“可達成能力指標 I_A ”，此可準確且簡易測量出常態需求的報童類型產品之獲利能力。此獲利能力定義為最佳訂貨條件下，達成目標利潤的機率。當分配的參數未知時，一個不偏並且有效的 I_A 估計量將被導出來估計實際的 I_A 。藉由所提出的指標，此論文也研究兩個常在存貨系統所發生的問題，產品評估問題和產品選擇問題。

首先，我們先考慮單一種舊產品被儲存。當新產被引進時，由於受到儲存空間的限制，某人應當決定舊產品是否依然值得被訂購或是應當被削減。因此，我們研究產品評估，即檢測舊產品的獲利能力是否達到所設定之需求。我們利用統計檢定方法來處理此問題。檢定的臨界值將被計算來決定評估的結果。在設定的檢定力與信賴水準下，樣本數所需的大小也被研究。生鮮產品的實例被呈現來討論所提出方法的適用性。

實際上，需求資料有時是多組樣本而非單一樣本。因此，我們估計及檢定 I_A 基於多組樣本。基於多組樣本的假設檢定用來處理產品評估問題被呈現出。實際案例有關甜甜圈的銷售被呈現出來探討此方法的適用性。

假如多種舊產品被考慮來互相比較，我們就得研究產品選擇問題，即比較兩產品並選擇其中一個具有最低獲利能力的產品。同樣的，統計的假設檢定被利用來處理產品選擇問題。檢定的臨界值將被計算出來去決定選擇的結果。在設定的檢定力與信賴水準下，樣本數所需的大小也被研究。應用實例關於英語教材雜誌的比較被呈現出來討論此方法的適用性。

關鍵字：可達成能力指標，估計與檢定，多組樣本，報童問題，常態需求，產品估計，
產品選擇。



Achievable Capacity Index for Measuring Profitability of Newsboy-type Product and Its Application

Student: Rung-Hung Su

Advisor: Dr. W. L. Pearn

Department of Industrial Engineering and Management,
College of Management, National Chiao Tung University

Abstract

In this dissertation, we develop a new index “Achievable Capacity Index, I_A ”, which can accurately and simply measure the profitability of newsboy-type product with normally distributed demand. Note that the profitability defines as the probability of achieving the target profit under optimal ordering condition. An unbiased and effective estimator of I_A is derived to estimate actual I_A as the parameters of distribution are unknown. By using the proposed index, this dissertation also investigate two common problems in the inventory systems, product evaluation problem and product selection problem.

First, we consider the single old stock product. If the new product is introduced, one ought to judge whether the old product is unworthy of being ordered or is curtailed due to the spatial constraint in the warehouse. Therefore, we investigate the product evaluation which examines whether the profitability meets a designated requirement. We utilize the statistical hypothesis testing methodology to tackle this problem. The critical value of the test is calculated to determine the evaluation results. The sample size required for the designated power and confidence level is also investigated. An application example for a fresh food product is provided to illustrate the practicality of the proposed approach.

Practically, the market information regarding demand is sometime obtained from multiple samples rather than single sample. Therefore, we estimate and test I_A based on multiple samples. A hypothesis testing for tackling the product evaluation problem based on multiple samples is presented. Critical values of the test are calculated to determine the evaluation results. A real case on the sales of donuts is presented to illustrate the applicability of our approach.

If the multiple old products are considered to compare each other, we study the product selection problem which deals with comparing two old products and selecting the one that has

a significantly lower profitability. Also, the statistical hypothesis testing methodology is performed to tackle this selection problem. Critical value of the test is calculated to determine the selection decision. Sample size required for a designated power and confidence level is also investigated. An application example on comparing English-teaching magazines is presented to illustrate the practicality of our approach.

Keywords: Achievable capacity index, estimating and testing, multiple samples, newsboy problem, normally distributed demand, product evaluation, product selection.



List of Contents

	page
Abstract (Chinese).....	i
Abstract (English).....	iii
List of Contents.....	v
List of Tables.....	vii
List of Figures.....	viii
 Chapter 1. Introduction.....	 1
1.1 Background.....	1
1.2 Motivation.....	4
1.3 Problem statement.....	4
1.4 Research approach.....	6
1.5 Thesis organization.....	8
 Chapter 2. Profitability Evaluation for Newsboy-Type Product with Normally Distributed Demand.....	 10
2.1 Notations and assumptions.....	10
2.2 Profitability measurement.....	11
2.2.1. Achievable capacity index I_A	11
2.2.2. Interrelationship between profitability and I_A	11
2.3 Estimation of I_A based on single sample.....	14
2.4 Hypothesis testing with I_A and evaluation results.....	16
2.5 Required sample size.....	16
2.6 Profitability evaluation for a fresh food.....	17
 Chapter 3. Assessing Profitability of a Newsboy-type Product with Normally Distributed Demand Based on Multiple Samples.....	 22
3.1 Estimation of I_A based on multiple samples.....	22
3.2 Testing I_A based on multiple samples.....	24
3.3 Application example.....	26
 Chapter 4. Product Selection for Newsboy-type Products with Normal Demands and Unequal Costs.....	 37
4.1 English-teaching magazine selection.....	37

4.2 Development of the exact method.....	39
4.2.1. Sampling distribution of $I_{A2}^c - I_{A1}$	
4.2.2. Selection determine	
4.2.3. Required sample size	
4.3 Magazine selection implementations.....	43
Chapter 5. Conclusions and Future Research.....	52
5.1 Conclusions.....	52
5.2 Future research.....	53
References.....	54



List of Tables

	page
Table 2.1 Critical values for rejecting $I_A \leq C$ with $n = 30(10)200$ and $\alpha = 0.05$	20
Table 2.2 Sample size required for testing $H_0 : I_A \leq C$ versus $H_1 : I_A > C$	21
Table 2.3 Sample data with 100 observations.....	21
Table 2.4 Critical values and decisions of testing the existing lunch box.....	21
Table 3.1 Critical values c_0 for $\alpha = 0.05, 0.025, 0.01$ based on multiple samples with $n = 3(1)5$, $m = 10(2)40$, and $C = 1.0(0.2)2.0$	29
Table 3.2 The profitability for $(p, c, c_d, c_s, k) = (25, 10, 1, 3, 2500)$ and $I_A = 100(0.01)$ 3.09.....	35
Table 3.3 The 5 Sample data each of 20 observations.....	36
Table 4.1 The demand units (in thousand)/month for the three magazines.....	48
Table 4.2 Critical values for rejecting $I_{A2}^c - I_{A1} \leq \delta$ with $n = 30(10)200$ and $\alpha = 0.05$...	49
Table 4.3 Sample size required for testing $H_0 : I_{A2}^c - I_{A1} \leq \delta$ versus $H_1 : I_{A2}^c - I_{A1} > \delta$...	51
Table 4.4 Critical values and decisions of testing the two magazines.....	51

List of Figures

	page
Figure 2.1 Profitability versus various values of I_A for the effects of changes p, c, c_d, c_s	18
Figure 2.2 PDF plots of R for sample sizes $n = 30, 50, 100, 150, 200$	19
Figure 2.3 Power curves for $C = 1.0, 2.0$, with sample sizes $n = 30, 50, 100, 150, 200$	19
Figure 2.4 Histogram of demand data.....	20
Figure 3.1 PDF plots of r for $n = 3, 4, 5$, and $m = 10, 25, 40$	27
Figure 3.2 Power curves for $C = 1.0, 1.4, 1.8$, with sample sizes $n = 3, 4, 5$ and $m = 10, 20, 30, 40$	28
Figure 4.1 CDF and PDF plots of W for sample sizes $n = 30, 50, 100, 150, 200$	45
Figure 4.2 Power curves for $I_{A1} = 2.0, 2.2, 2.4, 2.6$, with sample sizes $n = 30, 50, 100, 150, 200$	46
Figure 4.3 Histograms of the demand data for the Magazine I, Magazine II, and Magazine III.....	47