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STABILITY ANALYSIS FOR DEA MODELS: AN EMPIRICAL EXAMPLE

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ABSTRACT

This paper provides a framework for finding stable Data Envelopment Analysis (DEA) efficiency classifications. The approach is innovative in (1) assigning DEA efficiency classifications of efficient (E), inefficient (IE), or unstable (US) based upon cluster analysis of sensitivity scores and (2) comparing different analytical approaches, such as the Cobb-Douglas Production Function and ratio analysis, to DEA. A case study with 36 Jordanian hospitals illustrates the methodology. The DEA hospital classifications are robust with respect to input-output variable selections and surprisingly stable across reference sets for different years. However, differences between constant-return-to-scale (CCR) and variable-return-to-scale (BCC) DEA models suggest the importance of initial model formulation. Cobb-Douglas efficiency shows considerable agreement with DEA in this case. Ratio analysis has a bias for finding units efficient relative to the other methods.

INTRODUCTION

The purposes of this study are to layout and illustrate a methodology to find stable efficiency classifications. Efficiency literature shows that classification of decision-making units (DMU's) strongly depends on the method used. In particular, the attempt to determine the relative efficiency of various types of hospital is confusing, if not contradictory. For example, traditional ratio analysis has shown that private hospitals are more efficient than their public counterparts. On the other hand, using DEA Valdmanis (1990) reported that public hospitals appeared to be more efficient than private non-profit hospitals. White and Ozcan (1996) again using DEA found that religious hospitals were more efficient than secular (public) nonprofit hospitals. These contradictory outcomes may result simply from the use of analytic procedures that lead to unstable efficiency classifications. Thus, assurance of stable classifications is crucial for drawing credible policy implications from the application of DEA or other efficiency classification analyses.

This paper recommends a novel way to avoid such vulnerable conclusions by aggregating results from several efficiency analyses to achieve a robust efficiency classification. The methodology includes fitting multiple DEA models and comparing to outcomes from other efficiency classification procedures. Central to finding stable DEA classifications are sensitivity scores, which quantify the sensitivity of DEA classifications to changes in relative input-output variable values for particular reference sets and DEA models. Sensitivity scores can be used to cluster DMU's into groups that are efficient (E), inefficient (IE), or unstable (US). Thus, by implication, groups E and IE are stable with respect to DEA efficiency. Similarly, the methodology employs quantitative outcome measures from other efficiency analyses to cluster DMU's into stable or unstable groups. Finally, the disagreements in classification among different analytic procedures are tested for significance using Cochran's test for categorical outcomes and a rank based nonparametric analysis of variance for dependent sample design.

This paper unfolds as follows. The next section provides a background in related research. The subsequent sections layout the methodology and apply the procedure to Jordanian hospitals. Conclusions are discussed at the end of the paper.

METHODS OF EFFICIENCY CLASSIFICATION

Data Envelopment Analysis

DEA is a nonparametric linear programming procedure for determining relative efficiency of DMU's with multiple inputs and multiple outputs. Charnes, Cooper and Rhodes (1978) introduced data envelopment analysis with the CCR model, appropriate for constant-return-to-scale. Banker, Charnes and Cooper (1984) modified the original formulation to create the BCC model, appropriate for variable-return-to-scale. A DEA input-oriented formulation assigns an efficiency score less than one for inefficient units, meaning that a linear combination of other organizations in the sample could produce the same vector of outputs, using a vector of smaller inputs, or a vector of greater outputs, using the same vector of inputs.

The outcome of a DEA analysis provides useful information on how the inputs and the outputs can be adjusted in order to transform inefficient DMU's into efficient ones (Shafere and Bradford, 1995), but no measure of the relative vulnerability of efficient units. However, sensitivity analysis (Charnes *et al*., 1992, Charnes, Rousseau, and Semple, 1996, Seiford and Zhu, 1998) provides information about the relative stability of the classification, even for efficient units. Thus, meaningful rankings can result among all DMUs. For further results on stability of DEA efficiency, see (Anderson and Petersen, 1993, Zhu, 1996, Seiford and Zhu, 1998). Relevant early applications of DEA and recent applications of sensitivity analysis include (Aida *et al*., 1998, Boljuncic, 1998, Ozcan, 1992, Read and Thanassoulis, 2000, Rousseau and Semple, 1995, Valdmanis, 1992, Zhu, 2001). An extensive review on sensitivity analysis can be found in Cooper *et al*., (2001).

Cobb-Douglas Production Function

One of the best-known relations in economics is the relation between a single output and multiple inputs known as the production function. Many industries where output normally increases with input use the Cobb-Douglas model to estimate production and cost functions. The function determines the maximum producible output from the amount of input used in the production process (Allison and English, 1993). Cobb and Douglas (1928) formulated the original model:

$$Pi = bL_i^k C_i^{1-k} \varepsilon_i \tag{1}$$

where, P_i = Quantity of output,
L_i = Quantity of labor input,
C_i = Quantity of capital input,
ε_i = Error term
b, k = Parameters to be estimated, and
i = [1,…n], where n is the number of units.

For a given reference set, the values of b and k can be estimated using the least squares method or the maximum likelihood procedure, among others. In the illustration that follows, we use linear programming to:

$$\text{Minimize } \Sigma \, (\ln P_i - \ln Q_i) \tag{2}$$

such that

$$(\ln P_i - \ln Q_i) \geq 0 \tag{3}$$

Where Q_i is observed output to estimate the parameters of the production function (Giokas, 1991).

Efficiency scores are the ratio of the actual production to optimal production predicted by the model. Units with efficiency scores of one are technically efficient.

$$\text{Efficiency Score } E_i = Q_i / P_i \tag{4}$$

Ratio Analysis

Ratio analysis represents relationships between different specific input and output variables. Each ratio relates one output to one input. There are two main uses of ratio analysis. First is the traditional normative use whereby ratios are compared with a pre-set standard. The second is the use of ratio analysis for forecasting and predicting future variables with the aid of statistical models (Athanassopoulos and Ballantine, 1995). The vast majority of studies have used financial ratios (i.e., return on assets, return on equity, profit, and sales) in conjunction with statistical models (e.g., factor analysis, principal component factor analysis, and discriminant analysis) to evaluate the financial performance of hospitals. Managers better know ratio analyses, characterized by computational simplicity, than other techniques (Athanassopoulos and Ballantine, 1995).

Thanassoulis, Boussofiane and Dyson, (1996) found that ratio analysis and DEA closely agree on the performance of hospitals as a whole. The two methods, however, can disagree on the relative performance of individual hospitals. The authors also found in their study that ratio analysis, unlike DEA, is not suitable for setting targets for hospitals to become more efficient. This is because DEA takes simultaneous account of all inputs and outputs in assessing efficiency, while ratio analysis relates only one input to one output at a time. However, the two methods can complement one another in evaluating efficiency.

DEA Sensitivity Analysis

The sensitivity analysis in this study employs a technique developed by Charnes, Rousseau, and Semple (1996), which provides a single measure of the minimum magnitude of change required simultaneously in input-output variable values to reclassify a DMU. For each DMU this sensitivity measure (α) can be thought of as the radius of a "circle" of stability. Change of relative total magnitude less than α will leave the DEA efficiency classification unchanged. The linear programming formulation for sensitivity analysis follows.

CCR Model

Minimize α such that

$$\sum_{j=1}^{n} \lambda_j O_{rj}^{j0} + \alpha O_{j0} \geq O_{rj0}, \quad r = 1, \ldots, s; \text{ and} \tag{5}$$

$$\sum_{j=1}^{n} \lambda_j I_{ij}^{j0} - \alpha I_{j0} \geq I_{ij0}, \quad i = 1, \ldots, m, \tag{6}$$

where $\lambda_j \geq 0$ and α is unrestricted.

O_{rj}^{j0} is the output matrix with the tested unit's output vector removed.

I_{ij}^{j0} is the input matrix with the tested unit's input vector removed.

O_{j0} is the output vector of the tested unit.

I_{j0} is the input vector of the tested unit.

α is the radius (percentage) within which the DMU's classification remains unchanged.

λ_j are the dual variables associated with the constraints representing DMUj, j = 1, …, n, in the primary equation.

BCC Model

The essential difference between the BCC model and CCR Model is the addition of a new constraint to the linear program formulated in the CCR model. That constraint takes on the following expression:

$$\sum_{j=1}^{n} \lambda_j = 1; \qquad (7)$$

METHODOLOGY

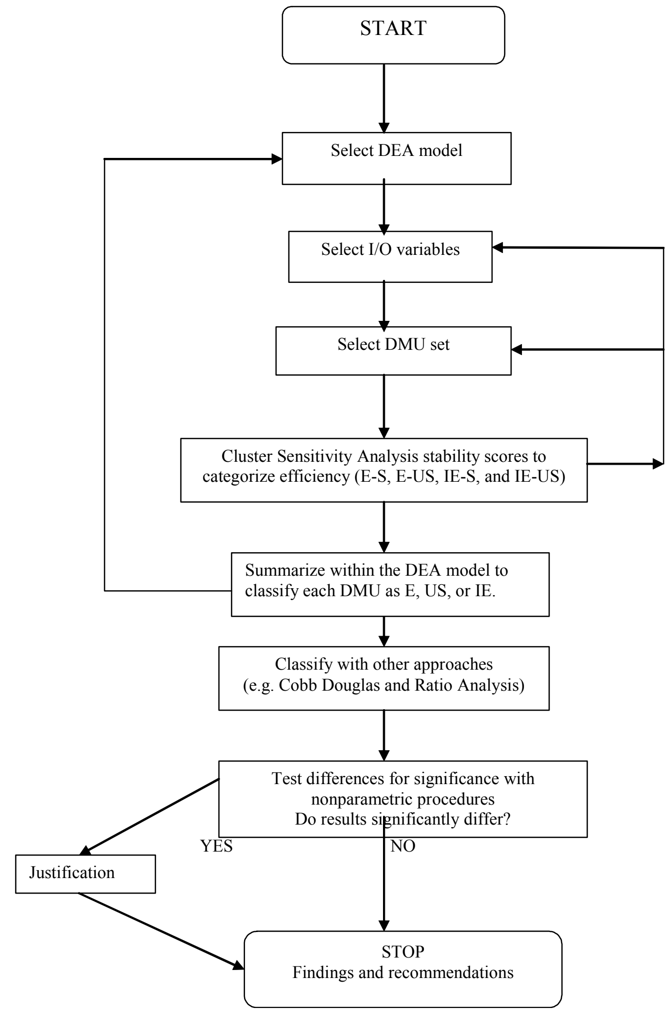
Figure 1 displays the proposed research framework for finding stable DEA classifications.

The methodology consists of two major phases. In the first phase the intent is to find a stable classification (or declare unstable) each DMU within each DEA model under consideration. In a particular application, it may be that the nature of the return to scale is sufficiently known that only one model need be solved. Consider the following design factors:

DEA models (m levels, $m \geq 1$.)
Input/output variable sets (v levels, $v \geq 1$),
Repeat multi-variate observations; i.e. reference sets, per DMU (r levels, $r \geq 1$),

From Figure 1, the iterations on Select DEA model, Select I/O variables, Select DMU set result in the analysis of each DMU m*v*r times via DEA. Each analysis yields a sensitivity score, α ($\alpha > 0$ is efficient, $\alpha < 0$ is inefficient). For each iteration, group efficient and inefficient DMU's separately. Then, for the two separate groups, perform univariate cluster analysis on the absolute value of the sensitivity scores α to create stable and unstable categories. It should be noted that that main idea of using the cluster analysis is to objectively obtain two categories (stable and unstable) for each efficient and inefficient group. Thus, the number of cluster was determined to be two in each case. The univariate cluster analysis, using NCSS Software Program, provides two clusters of the units. The first cluster is the stable group, which has high absolute value of sensitivity scores. The second cluster is the unstable group, which has low absolute value of sensitivity scores. These ranked efficiency classifications are efficient and stable (E-S), efficient but not stable (E-US), inefficient but not stable (IE-US) or inefficient and stable (IE-S). For each DMU, summarize the v*r categorizations within each DEA model by a single classification as efficient (E), inefficient (IE), or unstable (US) depending upon whether or not a clear majority of iterations yield either E-S or IE-S classifications.

Figure 1. Research Framework



The purpose of the second phase of the methodology is to compare efficiency classifications for all DEA models to Cobb-Douglas, ratio analysis or other efficiency classification results. Herein we consider CCR-DEA, BCC-DEA, Cobb-Douglas, and Ratio Analysis; but efficiency techniques to be compared will differ in particular applications.

Although extensions of the original Cobb-Douglas Model, such as a translog model (Christensen, Jorjenson, and Lau, 1971, Christensen, Jorjenson, and Lau, 1973) or seemingly unrelated regression (SUR) (Zellner, 1962), can be used to estimate the parameters when there is more than one dependent variable; Cobb-Douglas models, in this study, can only mimic DEA variable sets with a single output. Thus, repetitions of Cobb-Douglas efficiency analysis will not be entirely analogous to those for DEA. From each Cobb- Douglas analysis, again use the efficiency scores to group DMU's as efficient (scores of 1) or inefficient (scores < 1). Cluster the inefficient DMU's into stable and unstable groups. Since the Cobb-Douglas scores do not allow for the concept of unstable efficiency, the results do not exactly parallel those for DEA. Moreover, even the concept of efficiency is treated somewhat differently by the two procedures. It is this multiplicity of heretofore-incomparable methods that has led to such confusion in applying academic categorizations of efficiency to measuring productivity. If consensus regarding a DMU's efficiency can be derived despite these differences, then the categorization merits the designation of *stable*.

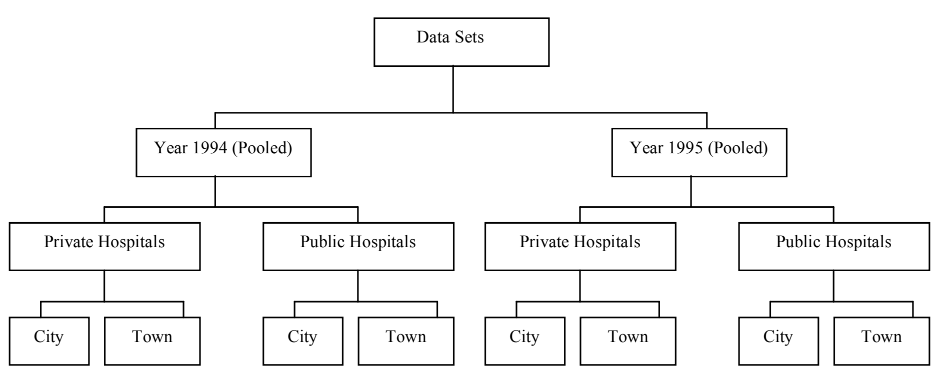
To obtain a single measure of efficiency from multiple ratios, normalize all ratio scores. Then, conduct pair-wise comparisons using Analytical Hierarchy Procedure (AHP) to assign a weight for each ratio (Anderson, Sweeney, Williams, 1994). Calculate the total score for each DMU by multiplying each ratio by its weight and summing. Based on the total scores, cluster DMU's into three groups; efficient, inefficient, and unstable.

Thus, each DMU has been categorized as efficient, inefficient, or unstable under each competing analysis. Several nonparametric procedures are available to test the significance of any observed disagreements in efficiency classifications. One such is the Cochran test for related observations with a categorical response. In addition, with the classes ordered (Inefficient < Unstable < Efficient), the Friedman (or Quade) test for dependent samples is appropriate. Conover (1999) describes the Cochran, Friedman, and Quade procedures.

APPLICATION: JORDANIAN HOSPITALS

An analysis of public and private Jordanian hospitals provides an illustration of the methodology proposed. The data, as shown in Figure 2, are the most recently available from the Ministry of Health in Jordan. For DEA analysis two reference sets (r=2 observations per DMU) are considered; Year = 1994 and Year = 1995. Figure 2 displays other possible subsets that could be used for relative efficiency classifications.

Figure 2: Data Sets



Hospital administrators in Jordan identified the most important input and output variables available for consideration as measures of hospital efficiency. Table 1 summarizes the v = 5 input and output variable sets selected. For example, the first model consists of one output (patient days) and two inputs (number of beds and total number of doctors and nurses). Thus, for each of the CCR and BCC models 10 (5x2) efficiency classifications and 10 stability scores are determined.

Table 1. Input-Output Combinations

Outputs	Model I	Model II	Model III	Model IV	Model V
Patient days	X	X	X	X	X
Occupancy rate					X
Inputs					
Number of beds	X	X			X
No. doctors and nurses	X		X		X
Number of doctors		X		X	
Number of nurses		X		X	
Admissions			X	X	

The resulting cluster analyses for DEA efficient and inefficient hospitals yield the initial categorizations displayed in Table 2. For instance, Hospital 1 is classified as inefficient using the CCR model with the 1994 reference set for the five input-output variable sets considered but stable for only one of these variable sets. Hospital 1 is classified as IE-US for all five variable sets when 1995 data provide the reference set. Using the BCC model and the 1994 reference set, Hospital 14 is efficient for all variable sets and stable for three. With the BCC model and the 1995 reference set, Hospital 14 is again efficient for the five variable sets but stable for only two. After summarizing across the 10 DEA results for each of the CCR and BCC models, place hospitals into final categories per model according to the following criterion:

if the hospital receives 6 (> 50%) E-S or IE-S (i.e. stable) categorizations,
classify accordingly as E or IE;
otherwise, classify as unstable, US.

Hospital 1 under CCR and Hospital 14 under BCC receive fewer than six stable ratings and are classified US for the respective DEA models.

The first four models of Table 1 (single output functions) are used to determine Cobb-Douglas efficiency for each hospital in each year (1994 and 1995). Parameters are estimated using constrained linear programming as previously described in the linear programming sets in (2) and (3).

Table 2. Efficiency-Stability Classification of Hospitals Using DEA Models Across Input-Output Models

	CCR 94				BCC 94				CCR 95				BCC 95			
	Efficient		Not-efficient		Efficient		Not-efficient		Efficient		Not-efficient		Efficient		Not-efficient	
Hospital	S	US	S	US	S	US	S	US	S	US	S	US	S	US	S	US
H1			1	4	1	4						5		5		
H2			1	4	1	1		3		1		4		2		3
H3			1	4				5				5			1	4
H4			1	4				5				5			2	3
H5			1	4				5		3		2		3		2
H6			1	4				5				5			2	3
H7			5				5				5				5	
H8			1	4				5		2		3		2		3
H9			1	4		4		1				5		5		
H10		2		3		3		2	1	2		2	1	3		1
H11			2	3			2	3		1	2	2		3	2	
H12			5				2	3			5				4	1
H13			1	4				5				5				5
H14	3	2			3	2			4	1			2	3		
H15			3	2	2			3			5		2		1	2
H16			3	2	2	3			2		3		2	3		
H17	2	1		2	3	2			2			3	1	3		1
H18			5	0		3		2			5	0			3	2
H19			5				1	4			3	2				5
H20			2	3			2	3			4	1			2	3
H21			1	4	5				1			4	5			
H22			2	3				5				5				5
H23			2	3				5				5				5
H24			2	3				5			2	3			1	4
H25			2	3				5				5				5
H26			4	1			3	2			4	1			4	1
H27			4	1			5				2	3			4	1
H28			2	3			1	4			5	0			4	1
H29			2	3				5				5				5
H30			2	3				5			1	4				5
H31			2	3			1	4			2	3			2	3
H32			2	3			2	3			2	3			2	3
H33			5	0			5	0			5	0			4	1
H34			4	1			2	3			5	0			4	1
H35			2	3			2	3				5				5
H36			5		3			2			5		3		2	

Table 3. Efficiency-Stability Classification of Hospitals Using Cobb-Douglas Models			
Hospital	**Efficient**	**Not-efficient**	**Not-stable**
H1	1		7
H2			8
H3			8
H4			8
H5	2	2	4
H6		1	7
H7		7	1
H8	1		7
H9		3	5
H10	2		6
H11		4	4
H12		8	
H13			8
H14	5		3
H15		8	
H16	2	6	
H17	2	4	2
H18		8	
H19		8	
H20		8	
H21	7		1
H22		1	7
H23			8
H24		3	5
H25			8
H26		7	1
H27		6	2
H28		5	3
H29		3	5
H30		3	5
H31		3	5
H32		4	4
H33		8	
H34		8	
H35		3	5
H36		8	

In equation (4), if the efficiency score (Q_i/P_i) is equal to one, then the hospital is technically efficient. If the efficiency score is less than one, then the hospital is technically inefficient. Since efficient hospitals could not be classified into stable and unstable (efficiency score =1), only inefficient hospitals were classified into two groups; inefficient stable and inefficient unstable using cluster analysis in the same manner it was employed in the DEA sensitivity analysis. Thus, each hospital is classified eight times (4 different sets of input variables x 2 different years) in one of three categories E, IE-US, IE-S. Table 3 displays these results. In a manner similar to the final DEA classification, Cobb-Douglas classification is stable only if 5 (>50%) of initial classifications are E or IE-S.

Ratio analysis was used in this study as another measure of hospitals' performance to be compared to DEA and Cobb-Douglas results. The following ratios were used in evaluating hospitals' efficiency: Average length of stay; patient days/bed; patient days/ number of doctors; patient days/number of nurses; occupancy rate; and bed turn over. Ratio analysis was performed for the pooled data as before and then repeated for public and private hospital reference sets separately for each year (resulting in two efficiency classifications, pooled and separate, per hospital per year). On average, private hospitals score better than public hospitals in patient days per doctor and patient days per nurse. Public hospitals score better in the other ratios.

Ratio analysis was performed according to the following steps:

1. Normalize all ratio scores.
2. Make pair-wise comparisons of ratios using Analytical Hierarchy Procedure (AHP) to assign weight for each ratio. Hospital administrators made these comparisons.
3. Calculate the total score for each hospital by multiplying each ratio by its weight and summing.
4. Rank hospitals according to their total scores to determine relative efficiency.
5. Classify hospitals based on their total scores, using cluster analysis, into three groups; efficient, inefficient, and unstable.

For the four cases (pooled 1994 and 1995, and separate 1994 and 1995), most hospitals have the same relative efficiency rank in each case. In the pooled case, more than 50% of the hospitals have the same classification in both years. Using separate sample cases, 94.4% of hospitals have the same classification in both years.

Finally, classify hospitals Efficient (E), Inefficient (IE), or unstable (US) as before using E or IE only for a clear majority. For example, H1 was classified as efficient four times (i.e., 100% efficient), therefore, classify as efficient.

Table 4 summarizes classifications across efficiency approaches. Cochran's statistic is used to test the hypothesis of no difference in efficiency classifications among the four approaches. (If a DMU is classified as E, then Cochran's score is 1; else Cochran's score is 0.)

Table 4. Classification of Hospitals across Approaches

Hospital	CCR	BCC	Cobb-Douglas	Ratio Analysis
H1	US	US	US	E
H2	US	US	US	E
H3	US	US	US	E
H4	US	US	US	US
H5	US	US	US	E
H6	US	US	US	US
H7	IE	IE	IE	IE
H8	US	US	US	E
H9	US	US	US	US
H10	US	US	US	E
H11	US	US	US	US
H12	IE	IE	IE	US
H13	US	US	US	US
H14	E	US	E	E
H15	IE	US	IE	US
H16	IE	US	IE	IE
H17	US	US	IE	US
H18	IE	US	IE	IE
H19	IE	US	IE	IE
H20	IE	US	IE	US
H21	US	E	E	E
H22	US	US	US	US
H23	US	US	US	US
H24	US	US	US	E
H25	US	US	US	US
H26	IE	IE	IE	US
H27	IE	IE	IE	US
H28	IE	US	IE	US
H29	US	US	US	E
H30	US	US	US	E
H31	US	US	US	E
H32	US	US	US	US
H33	IE	IE	IE	US
H34	IE	IE	IE	US
H35	US	US	US	US
H36	IE	E	IE	IE

The probability of the observed value of Cochran's statistic is less than .001; thus, the differences are significant among the four methods when classifying as either efficient or not. Similarly, the Friedman test (for ordered classes) yields a probability less than .001; indicating that the differences when classifying three ways: efficient, unstable, or inefficient also are significant. As anticipated, ratio analysis results in more DMU's being labeled efficient.

When the Cochran test is repeated for the two DEA models and the Cobb-Douglas method, removing the ratio analysis classifications, the observed (efficient or not) classes are not significantly different among these three methods. However, when the Friedman test is repeated without ratio analysis, the differences in the three-way classifications (E, US, and IE) remain significant (p-value = .006). CCR-DEA and Cobb-Douglas agree in efficiency classifications, but BCC-DEA differs from each of the others, with an observed bias toward classifying a hospital as unstable rather than inefficient. All told, the degree of agreement is striking among the three methods. For hospitals 7, 12, 16, 18, 19, 26, 27, 33, and 34, evidence of inefficiency is substantial. Hospitals 14 and 21 are arguably efficient. The remaining hospitals seem unstable with regard to an efficiency classification. The only clear contradictions are for Hospital 36.

CONCLUSIONS

This paper proposes a way to find stable DEA efficiency classifications. The technique provides researchers with a toolbox to use in specific applications that includes DEA sensitivity analysis, cluster analysis, and nonparametric tests of differences among several related samples with either categorical or ordinal response variables. Such a methodology is a powerful, practical antidote to the lack of well-developed stochastic theory for DEA.

The methodology is applied to data from public and private hospitals in Jordan, provided by the Minister of Health for that country. Despite significant differences in efficiency classifications among methods, considerable consensus emerges with DEA and Cobb-Douglas efficiency in classifying hospitals as efficient, unstable, or inefficient. It is interesting to note that efficiency classifications vary as much with differing DEA models as with different input-output variable sets. For example, the CCR and BCC models agreed on a final classification of efficient, unstable, or inefficient for 75% of the total number of hospitals, while the five input-output combinations showed initial efficient, not-efficient (whether or not sable) agreement of 94%, 86%, 78%, and 78% for each of the DEA models in each of the years considered. It can be argued that, in DEA applications, efficiency scores are more sensitive to the DEA model type (CCR versus BCC) than to input-output combinations.

In comparing the results of the DEA models to those for Cobb-Douglas and ratio analysis, observe that the concept of efficiency differs under each method. However, CCR and Cobb-Douglas models agreed on classification of 94% of the total number of hospitals. Interestingly, CCR, Cobb-Douglas, and ratio analysis converge for the stable hospitals. Their only clear area of difference in classification is the bias toward efficiency exhibited by ratio analysis. Sensitivity analysis with DEA provides the means for categorizing the stability of the evaluated units' efficiency.

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INVESTIGATION INTO THE HOME PAGE OF THE TOP 100 UNIVERSITY WEBSITES

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ABSTRACT

Many Universities provide information through their websites for users. The key to the successful utilization of the University website is to attract users' attentions and then to provide the users good impressions of the University through its websites. The home page, the first page of the university website, is vital for that purpose. We have investigated and evaluated home pages of the top 100 University Websites selected by U.S News and World Reports magazine. In order to evaluate the home pages, 12 evaluation criteria (i.e., critical features of an ideal website) are selected through literature reviews on the website design. Those are scrolling text, screen length, search box, number of colors, number of images, number of background colors, use of web mail, sequential appearance of text and then image, use of different fonts, use of capital letters, use of breathing space, and use of multiple headings.

We found that most universities use scroll text (83%), search box (90%), breathing space (84%), and multi headings (98%) but they use neither more than one font, size, or style (85%) nor capital letters only (97%). They do not use more than four colors per screen (84%). The other critical features of an ideal home page are used relatively frequently but in less degree. But not a single university's website satisfies all 12 evaluation criteria.

INTRODUCTION

As information technology has grown up, the Internet has been widely used in many academic areas. The World Wide Web (WWW) is providing huge information about universities through Internet. The university homepage is usually the first contact point for anybody who seeks information about the university on line. It is inevitable for the university to develop a dynamic homepage that captures its users' attentions and meets their informational needs. Nonetheless, many university home pages have inefficiencies, operational difficulties, and even defects that stop the users from conducting some critical functions. Thus, it may be worthwhile to investigate existing university home pages to find what the common critical features used (or not used) are. With these results from this study, it may be easier to determine whether or not the home page has sound structure, good content, and effective combination of colors. Thus, this study is an effort to develop a set of guidelines for the good design of home pages for the university.

The purpose of this paper is to investigate university home pages and to determine whether or not they employ selected principles of good home page design, structure, and content. These principles of good home page have been considered pivotal to the overall success of the website.

The remaining portion of this paper will be as followed. Literatures on principles of good home pages are reviewed to develop evaluation criteria for the university home page in the second section. Research methods are discussed in the third section, while evaluation results of university home pages are presented in the fourth section. The concluding remarks are made in the final section.

LITERATURE REVIEW

University home pages are the door through which the relationship starts between web users and universities. The home pages are seen as a key communication component of each website. The first look of the home page is so critical that users may decide whether to spend time exploring the website and/or engaging in other favorable behavior such as book marking the website based on their impressions of the home page [16]. Thus, the home page should provide the sufficient information content in the right way.

After reviewing a literature on the issue of the home page design [such as articles 1, 2, 3, 10, 11, & 23], twelve characteristics of the good home page which are critical evaluation criteria for the academic home pages are selected. The first 7 criteria are about general characteristics of the good home page, while the last five criteria are specifically about the content of the good home page. The general criteria are as follows.

Scrolling Text. Most users seek complete information satisfaction in the home page, which influences the overall feeling of satisfaction about the website as a whole. [12]. Because of this, scrolling text fields that have much hidden information are deemed to be distractive from the core content of the website and to slow down use process of the website [13].

Screen Length. Users want to see all core website content at once in the home page [18]. When the home page ventures into more than one screen, most users would not travel beyond the first screen [12]. Thus, it is a common agreement among users of websites that the fewer the number of screens in the home page, the better the home page is.

Search Box. The search box is one of the most important features for the university home page. Many users can save time in searching information they want by using the search box, because a search mechanism can take the user directly to wherever the information they need is located. [16] It is better to have this function in the home page.

Web Mail. The web mail, E-mail that is accessible via a standard web browser, is another important feature of the university home page, because this function may make it easier for users to access to their university email accounts and hence coerce them to visit the university website more frequently. [9]

Number of Color. Van Brakel et al. [18] found that more than four colors per screen excluding logos and other images are distractive for users. A limited of number of colors rather than too many colors in a screen make a home page more focused. [8]

Background Color. Van Brakel et al. [18] also recommended that light blue, white, or gray color be used for background of the home page, because the light colors such as those than the dark colors make the home page more conspicuous. It is better to use one of these colors than to use all three colors for the home page at the same time. [19].

Number of Image. The home page should not use more than three images per page. Excessive number of images causes long loading time and hence distracts rather than attracts the user from the web site. [5, 21]

The five content criteria are as follows.

Sequential Appearance of Text and Then Image. The home page should show the text, first, and then the image, because the image consists of lot more pixels than the text. In doing so, users can identify the content of the home page while images are being loaded. [21]

Use of Different Fonts. The home page should not use more than one font size or style except for titles to make the layout of the site consistent and user-friendly. [21]

Use of Capital Letters. The home page should not use all capital letters in the home page unless in page titles, page headings, or acronyms. It is because the home space may be wasted and the home page may be hard to read [21].

Use of Breathing Space. The home page should use white space, called "breathing space" between page elements, effectively to avoid a crowded home page [14, 15].

Use of Multiple Headings. A proper use of different headings such as title, sub titles, and sub-sub title is always beneficial to the efficient structure of the home page and hence makes it easy for the user to comprehend the home page. [6, 17].

METHODOLOGY

We investigate home pages of the top 100 university websites selected by the U.S News and World Reports magazine. The magazine has announced the top national universities every year and provides an online reference on home page URL's of these Colleges/Universities at http://www.usnews.com/usnews/edu/college/rankings/brief/natudoc/tier1/t1natudoc_brief.php. Due to the existence of multiple universities with the same rank, the total number of sample university websites investigated is 105.

The number of screens in a home page is measured as follows. First, the vertical length of the home page is measured. And then it is divided by the height of the viewable monitor screen of the computer which is used in this investigation. If the division produces an integer number only, then the integer number is the number of screens in the home page. If the division produces an integer number and remainder, the number of screens in the home page is one plus the integer number. For example, if a 17 inches monitor is used to investigate a home page that has 12 inches of the vertical length, the number of screens in the home page is two. Because the division of the vertical length, 12 inches, by the height of the monitor screen used, i.e., about 9 inches, produces one and one third.

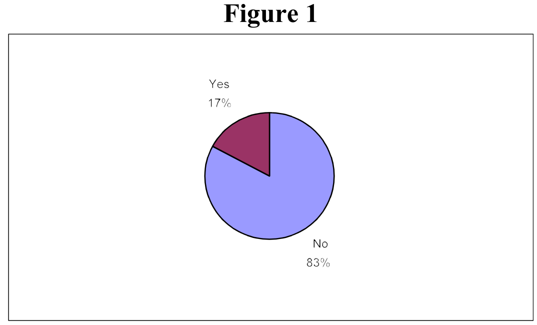
The latest version of Microsoft Internet Explorer, version 6.0, and Microsoft Windows XP operating System are used to examine all contents of the home page. Some contents of the home page can not be seen using the old operating system.

The sample university home pages are investigated and evaluated by the twelve afore-mentioned evaluation criteria.

DATA ANALYSES and DISCUSSIONS

After we are collecting each data of the top 100 College/University Websites, Microsoft Excel is used to analyze the data about the 105 sample university home pages. The Excel gives the analyzed data table using the spread sheet and their figures. The results from these analyses are as follows.

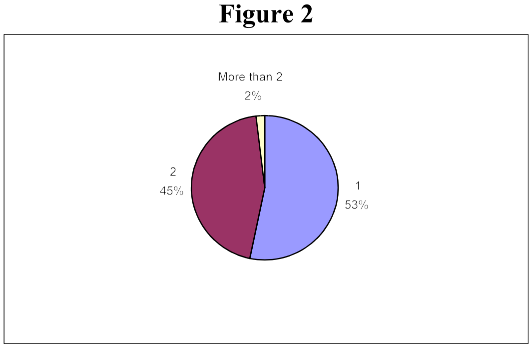
Figure 1



Scrolling Text. As shown on Figure 1, only 17% of the top 100 university home pages use scrolling text and hence the remaining 83% of them do not use it. It may be because scrolling text is relative outdated and impractical function in the contemporary home pages.

Single Screen. 53% of the home pages surveyed use a single screen to present their complete information, while 45% use 2 screens and 2% use 3 screens. (See Figure 2) The average number of screens in a home page is 1.50 with the standard deviation of 0.57.

Figure 2



Search Box. As shown on Figure 3, 90% of the sample home pages provide search box, while 10% neglect to provide the box. Most university home pages provide the search box to search information in the university web sites and/or WWW. The linked search file is also available in some sample university home pages. Among the university websites that do not have search boxes in their home pages, some websites provide search boxes in different pages than their home pages.

Number of Colors. We found that 19% of the sample university home pages use 2 colors in their home page, whereas 38% use 3 colors, 25% provide 4 colors, and 16% use more than 5 colors (see Figure 4). Thus, almost 84% do not use more than four colors per screen. The average number of colors is 3.41.

Figure 3

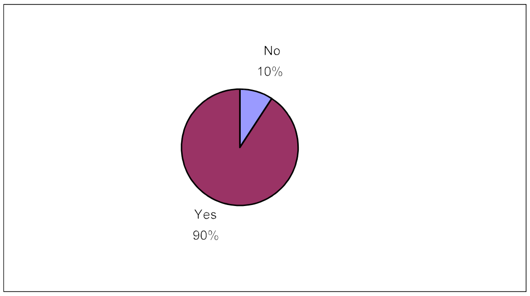
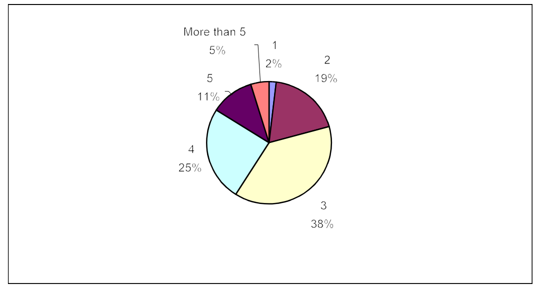


Figure 4



Number of Images. 20% of the home pages analyzed have a single image in their home pages, whereas 22% have 2 images, 19% have 3 images, and 37% have more than 3 images. Only 2% do not have any image in their home pages. (See Figure 5) In sum, 63% of the sample home pages have no more than three images. One sample home page uses eight images which is the highest number of images used by the sample home pages. The average number of images is 3.18.

Number of Background Colors. We find that 54% of the sample home pages use a single back ground color in their home pages, while 39% use 2 back ground colors, and 7% use more than 3 back ground colors (see Figure 6). The average number of back ground color is 1.53. In addition, 77% of the home pages use white back ground color, of which 46% use only white color and 35% use another color like blue, green, or gray with white. It is because some university home pages use different back ground colors for menu functions than for their content.

Figure 5

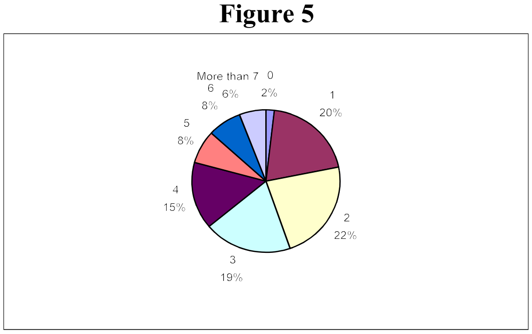
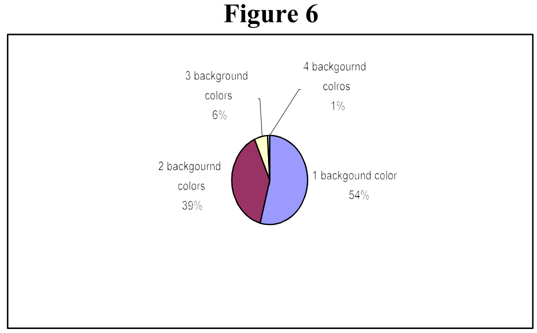


Figure 6



Web Mail. Only 18% of the sample home pages provide the web mail function, while 82% neglect to provide the function. Amongst the university websites that do not have the web mail function in their home pages, some provide the web mail function in a different page than the home page in their web sites.

Contents. 7% of the sample home pages analyzed provide texts, first, and then images, while 93% do not show texts and then images, sequentially. Most of the sample university home pages provide their texts and images, simultaneously. This may be due to the improved computer speed as well as the network speed.

85% of the sample university home pages use more than one font, size, or style, where 15% use only one. Most sample university home pages use a different font, size, or style for the menu functions than their content.

It is discovered that 97% of the sample home pages do not use capital letters only unless in page title, page heading, or acronyms, while 3% use capital letter only.

We find that 84% of the sample home pages have the breathing space between elements, while 16% do not. It means that most sample home pages use the breathing space, effectively.

With regard to the use of multiple headings, 98% of the sample home pages categorize their content using at least one of the following headings: topic headings, subtopic headings, or horizontal lines. Figure 7 shows a summary of content evaluations. None of the sample home pages meet all twelve afore-mentioned criteria.

Figure 7

Content Criteria	Yes	No
Provide text, first, and then image?	7%	93%
Use more than one font, size, or style?	15%	85%
c. Use capital letters only unless in page titles, page heading, or acronyms?	3%	97%
d. Give the breathing space between elements?	84%	16%
e. Use multiple headings?	98%	2%

CONCLUSIONS

We have investigated and evaluated home pages of the top 100 University Websites selected by U.S News and World Reports magazine. In order to evaluate the home pages, 12 evaluation criteria (i.e., critical features of an ideal home page) are selected through literature reviews on the website design. Those are scrolling text, screen length, search box, number of colors, number of images, number of background colors, use of web mail, sequential appearance of text and then image, use of different fonts, use of capital letters, use of breathing space, and use of multiple headings.

We found that most universities use scroll text (83%), search box (90%), breathing space (84%), and multi headings (98%) but they use neither more than one font, size, or style (85%) nor capital letters only (97%). They do not use more than four colors per screen (84%). The other critical features of an ideal home page are used relatively frequently but in less degree. But not a single university's website satisfies all 12 evaluation criteria.

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PRICING CONGESTION: MATHEMATICAL MODEL AND ALGORITHM FOR ESTIMATION

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ABSTRACT

Congestion is becoming a problem all over the world and physical expansion of road networks is becoming not the best option due to cost and other reasons. This paper considers some option of a congestion pricing model and explains its rationale and parametric estimation. An algorithm is being proposed for the suggested model parametric estimation and price determination. A case of a city is exposed to reflect on the potentials of data collection mechanisms and public participation and awareness. A simulation of the case of a city is used as a basis to show how the parameters of the model would be estimated.

INTRODUCTION

The relatively successful road-pricing scheme in Singapore has encouraged transportation planners and urban policy makers throughout the world to consider charging for the use of the road as an attractive alternative to deal with growing urban congestion problems (Rex Toh (1992)). With the increasingly tightened public budgets and the growing environmental concern of traffic pollution, physical measures to expand the network of roads seem neither politically feasible nor socially desirable. There are both pricing and non-pricing options to reduce traffic. The non-pricing options include: banning or restricting access to the road (e.g. high occupancy vehicle lanes policy (HOV)) or to a specific area, restricting car ownership, and transit fares subsidy. The pricing options include: parking fees, gasoline tax, and per mile charge per access charge congestion fees. Among the pricing options the congestion fee is the only one that directly targets congestion but also the most politically difficult to enact .

CONGESTION FEES: EFFICIENCY, EQUITY AND IMPLEMENTATION CONCERNS

Economists were earlier convinced that congestion is a type of a user-user externality and that the only way to ration congestion is to charge the road user the full marginal social cost of his trip (Iman, R. (1978), Bordman, A. and Lave, L. (1977), Henderson, J. V. (1974) and Evans, A. W. (1992)). This marginal social cost includes both the private marginal cost incurred by taking the trip and the additional cost imposed on the other users . The cost imposed on the other users is the forgone value of their incremental travel time caused by the speed delay due to the presence of the last user. A parking fee or gasoline taxes are inefficient because they do not charge the user the exact social cost of his/her trip. The only method that charges the user the full cost of his trip is the congestion fee. Kraus, M. (1989) found that the congestion fee increases the household welfare gains by 40% higher than the gains from a revenue-equivalent gasoline tax.

A widely held argument against congestion fees and congestion pricing in general is that they are regressive in the sense that they favor the rich more than the poor. Because the rich has a higher marginal value of time, the rich benefits more from congestion pricing; while on the cost side , as a percentage of income , the poor is hit harder by the congestion fee. A recent study by Kanninen, B. (1995) on the distributional impacts of a proposed congestion pricing program in Twin Cities showed that the fee is indeed regressive and favors both the rich and the urban dwellers against the poor and the rural commuters. This not an argument against the efficiency of the congestion fees but rather a distributional issue that the policy maker has to be aware of when enacting such a policy. Since almost every enacted policy has winners and losers, on a Kaldor efficiency ground, such a policy should be enacted if the winners could compensate the losers in such way that no body is worth off.

Two possible methods suggested by the literature for handling the equity resulting from a congestion pricing are: to use the proceeds from the congestion fees to subsidize buses and improve road services or to use them to reduce other distortionary taxes, e.g., income tax, property tax, or sale tax (Alberini, A., et al (1994)).

The second argument against enacting a congestion fee is the cost associated with installing and operating the monitoring systems required for implementing such a fee. Although the current costs of implementing a large scale highly sophisticated monitoring systems appear economically unjustifiable, a simple small scale implementation seems both technologically feasible and economically viable (Evans, A. W. (1992)).

The actual implementation of the congestion fee depends on whether the proposed scheme is a per-access or a per-distance fee. The monitoring systems of an area fee include two types. Area License Scheme (ALS): in which the regulator issues entry permits and sell them to the public . There is also the Automatic Vehicle Identification (AVI) system: in which cars are equipped with electronic identifiers whose signals are read by road scanners at the point of entry to the restricted zone. In the ALS scheme the permit value is the congestion fee. The entry points to the restricted area are monitored by security officers and private cars are not allowed in unless showing the permit. In the AVI scheme the signals, coded by the vehicle registration number, are then communicated to a central computing facility which bills the cars owners periodically. Alternatively the cars may be equipped with smart debit cards containing microprocessor-based chips that automatically deduct the fee as the car pass over a detector buried at the entry point.

Monitoring of distance fees is considerably difficult and costly compared to that of an area fee. For this reason a distance fee has never been implemented to date. However, at the present rate of progress in research relating to this field, at least a limited scale application of a distance fee seems technologically possible in the near future (Kanninen, B. (1995)). The systems, so far suggested to monitor a distance fee include the Intelligent Vehicle Highway Systems (IVHS): these systems are capable of electronically identifying vehicles as they enter and leave pass ways or a zone area. They also include the Satellite Systems that track vehicles movement and charge owners for the distance traveled within the restricted area or road. A third type of a distance fee system is the Metering System: in which autos are equipped with electronic meters that drivers can activate and deactivate manually. The meters use electrolytic timers which are sold at specified outlets at price set by the city in accordance with the congestion fee. The timer expires after specified number of miles and the driver has to buy a new one. These electronic meters are detectable by the roadside police within the restricted zone.

THE ECO-ENGINEERING MODEL

Congestion can be viewed as the outcome of the number of users and the attributes of the road and can have the following general functional form;

$$C = C(N, R, \varepsilon), \qquad \frac{\partial C}{\partial N} < 0 \tag{1}$$

where :
C : the congestion indicator measured as the speed (mph)
N : the number of cars moving per unit of time
R : vector of road characteristics e.g. number of lanes, surface condition, etc..
ε : unobserved inputs in the traffic system.

For all practical reasons we shall consider C as if a function of N only (treating R as given). The generalized cost of moving N identical users one mile on a road is given by:

$$T_c = N(k + v/C) \tag{2}$$

where:
k : is the maintenance plus the gas cost per mile
v : is \$ per hour value of user time
v/C : is the user opportunity cost of traveling one mile.

The additional cost inflicted on the society by the N^{th} user joining the traffic, the social marginal cost (SMC), is given by:

$$SMC = \frac{\partial Tc}{\partial N} = (k + v/C(N)) + N(\frac{v}{C^2(N)}\frac{\partial C(N)}{\partial N})$$

$$= (k + v/C) + (v/C) * E_{NC} \quad (3)$$

where the term ($k + v/C$) is the user private marginal cost per mile (pmc) and the last term the user opportunity cost in a mile multiplied by E_{NC} which is the positive of the speed-flow elasticity.

Efficiency requires each user bears the full cost of his travel as given by the right-hand-side of (3). Since the user pays only his pmc, to achieve efficiency a per mile pigouvian tax (A Pigouvian Tax is a tax on "external activities" for example pollution or traffic congestion) equivalent to the second term on the right-hand-side of (3) should be levied on users. The higher the elasticity E_{NC} of speed-flow the higher the tax for a given user opportunity cost. This tax is the per mile congestion fee and it depends on congestion supply relation in (1).

Let P(N,C) define the efficient price (i.e. the mpc plus the per mile congestion fee) for flow N and speed C . Now consider a household preference over x^h, a numariare good, and n^h, the number of trips taken, given by the utility function :

$U^h = U^h(x^h, n^h)$

For simplicity assume that:

i) at any given time a household has a choice of either making a trip or not, i.e. $n^h = 0$ or 1 respectively.
ii) all households use the same road and each has H hours to allocate between labor and travel.
iii) the hourly wage rate is w and each household takes the price P(N,C) as given.

The planner's problem can be stated as :

$$\text{Max } W=W(U^1(x^1, n^1), U^2(x^2, n^2), ..., U^h(x^h, n^h), ...) \quad (4)$$

subject to: $w\Sigma(H - n^h d^h / C(N)) = X + P(N,C)\Sigma n^h d^h$
$S x^h = X$
$S n^h = N$

where d^h is the number of miles traveled by household h. Solving (4) for N , yields a total demand for taking trips as a function of the speed C and per mile price P:

$$N=N(C,P) \tag{5}$$

N^* is then determined by solving simultaneously the demand equation (5) and the congestion supply function from (1) with the price determined from (3) .

PARAMETERS ESTIMATION

The congestion technology or the flow-speed relationship is usually estimated from the road engineering data. Different functional forms are used to fit such a relationship e.g. exponential, parabolic, hyperbolic, and the different Cox-Box transformation functions (see, for examples, Iman, R. (1978), Bordman, A. and Lave, L. (1977), Henderson, J. V. (1974) and Evans, A. W. (1992)).

The parameter k in (2) and (3) is obtained or estimated from the market data , while the user value of time ,v , is generally imputed from the average wage rate.

The demand function in (5) can be estimated from the households travel diaries or from specifically designed households surveys (e.g. see for examples, Kanninen, B, (1995) and Small, K. (1983)).

The optimal flow, N^*, can be computed iteratively from (1), (3) and (5). The following iterative algorithm is described in Kanninen, B, (1995):

1- Fix the congestion fee at an arbitrary value and compute the user price P.
2- Fixing the speed at C_0, pass P in (5) and compute N, say N_1.
3- Use N_1 in (1) and compute the speed C_1 .
4- Use N_1 and C_1 to compute a new congestion fee from (3) .
5- Use the new fee and C_1 in (5) to compute N_2 .
6- Iterate steps 2 to 5 until demand and supply converge to an equilibrium. The equilibrium N is the optimum N^* .

IMPLEMENTATION ASPECTS OF A CONGESTION PROGRAM: DATA AND ESTIMATION ISSUES

Given the physical constraints facing urban planners and the growing environmental awareness among urban population and city dwellers, a supply-side engineering solution may no longer be the appropriate response to meet the urban demand for traffic. Indeed, policy makers are increasingly pressed upon to consider measures and policies that directly restraint traffic. Various cities around the world therefore have considered implementing some sort of congestion reduction programs during the 1980s and 1990s with the objective of balancing the limited supply with the growing demand for traffic. A primary step in implementing such programs is to conduct baseline household travel inventory surveys to estimate household demand for travel and/or to provide the city administration with feedback on the effectiveness of the already installed traffic reduction programs. In these surveys, each participant in the study is asked to keep a diary of his/her trip during a randomly assigned day. For every trip made , the participant records the origin and the destination of the trip, the travel mode used, the time of the day, the number of people in the vehicle, and the number of miles or blocks traveled. In addition , the participants are asked to complete a survey on the socio-economic and travel characteristics of their household's adult members.

The following are statistics generated from the 1994 travel behavior inventory survey conducted by the city of Boulder, Colorado. The travel characteristics reflected by this survey we believe are widely shared by many modern cities in the world. The survey had a sample of 1864 households; of these 1196 had completed and returned their travel diaries and the attached socio-economic survey implying a 64% response. The mode choices and the trip purpose for the participants are summarized in table 1:

Table (1): Boulder Valley Travel Inventory 1994

	Modal choice and Trip purpose		
Mode	work	non work	total
car alone	7.49	28.61	36.1
car pool	1.21	23.29	24.5
bus	0.69	2.61	3.3
other	3.11	32.99	36.1
total	12.5	87.5	100.0

Source: City of Boulder Co. "Modal Shift in Boulder Valley 1990-1994" Center for Policy and Program Analysis Office of the City Manager Boulder Feb. 1994 tables 1, 8, 9.

The reported statistics seem to indicate a markedly high preference among Boulder residence for car transportation (60.6%) compared to a very low preference for buses (3.3%). Among the 60.6% auto users , 36.1% prefers driving alone to sharing a ride . The break down of the trips between work and non-work purposes indicates that only 12.5% of the trips taken are work trip , and that the dominant mode for work trips is driving alone . The results from the accompanied survey revealed travel behavior patterns for other households' members very similar to those observed for the participants . In particular , 57.7% of the work trips made by the other household members who work in Boulder are single occupancy vehicle ones . Together , these results would suggest that policies that shift travel mode from SOV to car pooling and transit are needed if any reduction in traffic is to be achieved.

A solution to a such situation would be : to get people individually change their behavior, when the old behavior is deemed socially not optimal, just make them face the full cost or the correct price of their individual behavior i.e. in this case just correctly price the use of road. i.e., pricing congestion is the most efficient way to make people change their travel behavior . Other policies that may ease the shift but which are not sufficient by themselves to guarantee the shift are bus subsidies, improvements of transit services , and HOV lane policies. The pricing policies could be a congestion fee, a gas tax, and/or an increase in parking fees. Which policy or policies package to enact may depend on the administrative feasibility of the option and the political process involved.

The travel inventory data generated from the household diaries can be exploited to estimate a travel behavior model. Since these surveys have data on household trip, mode, time, and destination choices, a nested logit model (McFadden, 1974) can be estimated. From such a model, demand for trips as well as compensating variation measures of consumer surplus associated with a congestion fee or a gas tax can be obtained. These measures may provide the basis for judging which pricing policy to choose. In addition the impact of the pricing policy on mode, time, and trip destination pattern can also be assessed from the estimated model parameters.

If engineering data on road characteristics, traffic flow, and traffic speed are available, a congestion supply function can be estimated. This supply function could then be combined with the demand function discussed above to estimate the optimal traffic flow . Given the optimal flow, a decision regarding the areas, roads, and/or the time when congestion is a problem can be made.

If a congestion fee is desired, the optimal flow and speed together with a suitable estimate of user value of time are sufficient to compute such a fee from the equation system of (1)-(5).

CONGESTION PRICING: A NUMERICAL EXAMPLE

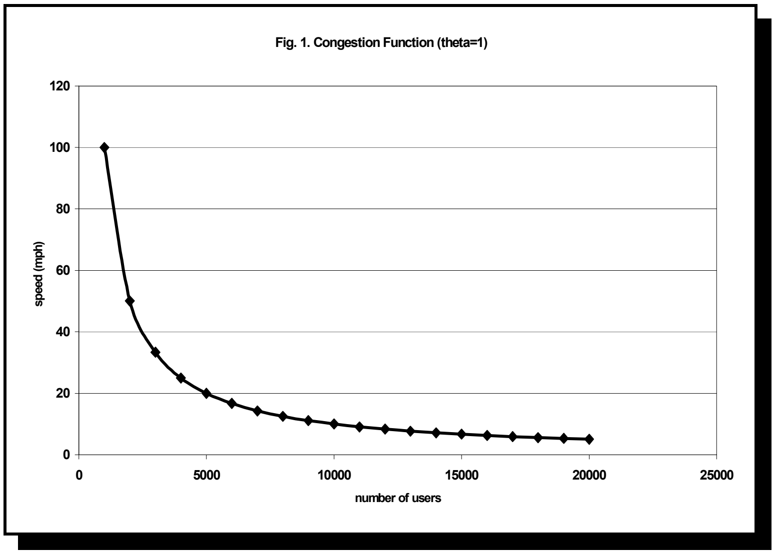
To provide a flavor to the above discussion, this section simulates numerically a simple congestion pricing example along with an attempt to tie it up to the Boulder city situation. For Boulder, the statistics reported by Boulder Community Network (BCN) indicate that there were more than 250,000 cars registered and more than 170,000 employees who commute daily to work by 2002 (http://bcn.boulder.co.us) with the speed of traffic dropping down sometimes to the range 10-15 mph in some parts of the city during the rush hours. Taking this into account we benchmark our example on an initial speed rate of 10 mph and an initial traffic flow volume of 10,000 users at a time during the rush hours.

The speed-flow relationship of equation 1 is modeled for simplicity as a constant-elasticity function of the form:

$$C = C0\left(\frac{N0}{N}\right)^{\theta}$$

where C0 and N0 are respectively the initial speed and the initial traffic flow and is the speed-flow elasticity, with a low value of 0.5, a medium value of 1.0, and a high value of 1.5.

Such a function for the medium elasticity value is depicted on Figure 1.



Based on the AAA club assessment of car ownership and operation costs for 2002, we estimate the maintenance plus the gas cost per mile (k) of equations 2 and 3 to be 0.2 US\$. The per hour value of user's time (v) is assumed to be 10US\$ and accordingly the initial user price per mile (P0) is (0.2+10/10=1.2 US\$). For any policy simulation the efficient user price (P) is provided by equation 3. The demand function in 5 , for simplicity, is also modeled as a constant elasticity function with speed elasticity of demand for travel of (and a price elasticity of demand for travel (of values 02 for low, 0.5 for medium, and 1 for high [Thomson (1970), Varlaki and Lesley (1986), Kanninen (1995)]. The exact functional form used for 5 is then,

$$N = N0\left(\frac{C}{C0}\right)^{\beta}\left(\frac{P0}{P}\right)^{\alpha}$$

A graphical representation of the demand function for lower elasticity is provided in Figure 2.

The calibrated system of equations (1) –(5) is simulated numerically following the iterative algorithm suggested in the previous section (the GAMS code is provided in Appendix). Table 2 presents the simulation results for the example, in which we show respectively the number of iterations took the algorithm to converge, the predicted demand for travel (number of users), the congestion indicator (speed mph), the efficient price (social marginal cost), the corresponding demand and flow-speed elasticities, and the congestion fee expressed as \$/mile.

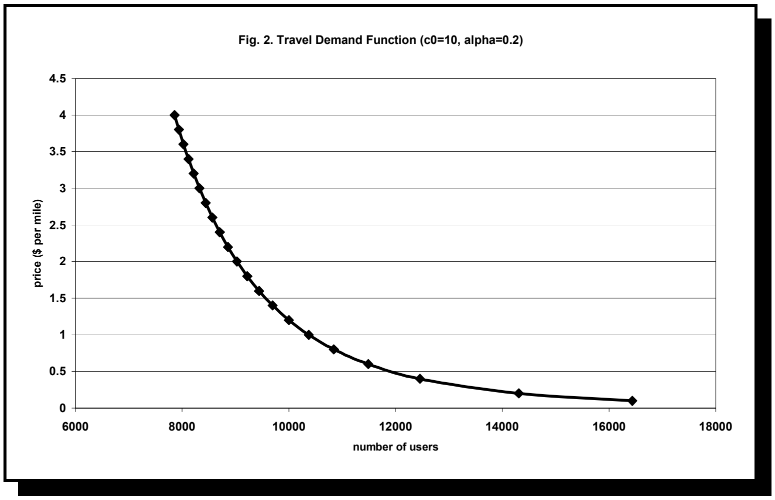


Table 2: Simulation Results of a Hypothetical Congestion Pricing Example						
Iterations to converge	# users	speed (mph)	price	Demand.	Supply	congestion fee
	N	C	smc (P)	elas. ?	elas. ?	$/m
10	9430	10.298	1.657	0.2	0.5	0.486
15	8763	10.682	1.604	0.5	0.5	0.468
25	7963	11.199	1.539	1	0.5	0.446
10	9159	10.917	2.032	0.2	1	0.916
40	8322	12.016	1.865	0.5	1	0.832
20	9022	11.669	2.342	0.2	1.5	1.285
465	8153	13.583	2.040	0.5	1.5	1.104
700	7634	13.990	1.727	1	1.5	0.763

To show how the model works the numerically simulation above showed that the algorithm converges quickly when the flow-speed elasticities are low but takes more cycles to converge when both the flow-speed and the price elasticity of demand are high.

It is also obvious that pricing congestion correctly reduces demand for driving which is a positive aspect of this model.

The traffic externality imposed by the extra user on the network will depend on the flow-speed characteristics of the network – the higher the flow-speed elasticity the greater the extent of the externality and hence the greater the tax (fee) needed to correct it.

The greater the user responsiveness (α) to the travel price the lower the congestion fee needed to induce the user to change his/her travel behavior and the greater the effect on the traffic flow and the network speed.

In addition to congestion relief, we know that congestion pricing also has effects on gas consumption, urban pollution, and road maintenance and investment.

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APPENDIX

GAMS code for simulating the congesting pricing example

```
set
s       simulation iterations /1*1000/,
l       supply elasticity level /low, med, high/,
d       demand elasticity level /low, med, high/;
parameter
c       congestion indicator (speed mph),
n       traffic flow demand (number of road users),
p       user price (social marginal cost)
beta    the speed demand elasticity
theta(l)   supply speed-flow elasticity
        /low 0.5, med 1, high 1.5/,
alpha(d)   flow demand elasticity
        /low 0.2, med 0.5, high 1/;
parameter
rc      reported speed for the simulation,
rn      reported number of users demanded for simulation,
tax     tax in dollars per mile,
rp      reported smc per mile;
beta=0.2;
scalar
k maintenance plus gas cost per mile in dollars /0.2/,
v user time cost per hour in dollars /10/,
p0      initial private marginal cost per mile /1.2/,
n0      initial flow (number of users) /10000/,
c0      initial speed (mph) /10/;
c=c0;
n=n0;
loop(d,
loop(l,
loop(s,
   p=(k+v/c)+(v/c)*theta(l);
tax(s) = (v/c)*theta(l);
   n=n0*(p0/p)**alpha(d)*(c/c0)**beta;
   c=c0*(n0/n)**theta(l);
rc(s,l,d)=c;
rn(s,l,d)=n;
rp(s,l,d)=p;
);
);
);
display rc,rn,rp,tax;
```

FORECASTING KEY STRATEGIC VARIABLES IN THE CASINO TOURISM INDUSTRY

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ABSTRACT

We examine the issues of forecasting industry gross revenue models in the casino gaming industries of Nevada, Mississippi and Atlantic City. Industry gross revenues are used as benchmarks for casino performance, a major source of state tax collection, an important part of a state's tourism industry and an important point of consideration for states contemplating legalizing gambling. Our model divides the time-series forecasts into two separate components, seasonality and trend. The results show all three states have distinctly different monthly seasonal patterns. Trend forecasting models and the presence of interventions such as September 11 are also shown to vary by region. In Mississippi, September 11 had an insignificant effect on casino gaming revenues. The effects of the September 11 intervention vary by region in Nevada. Six of the eight regions within Nevada do not conform to the overall Nevada state model. Aggregating time series data between states or within Nevada will lead to more complex, less accurate forecasts. The results indicate that in most cases aggregated or pooled time-series data should not be used in estimating models centered on forecasting revenues for casino and gaming establishments.

INTRODUCTION

Forecasting revenues in the casino gaming industry runs into the intrinsic problem of dealing with aggregating multiple time-series data sets. Time series data from three of the largest gaming regions in the United States, Atlantic City, Mississippi and Nevada, will be used to compare seasonal estimation and trend estimation in forecasting models. Finally, similar tests will be conducted focusing on the aggregated and pooling of multiple time series data on a state and national level.

Since 1988, when only Nevada and New Jersey (Atlantic City) offered casino gambling, the casino industry experienced explosive growth and became a significant source of state and local tax revenues. As of 2000, thirty-three states allowed more than 600 casinos to operate legally ("Legalized gambling," 2000). Roehl (1994) suggested that growth in legalized gambling was fueled by state governments wanting to create employment opportunities (ex: Indiana, Louisiana, and Mississippi), capture additional tax revenues and tourism monies. These along with a changing attitude toward gambling facilitated the boom in the casino industry. Surveys show that 92% of Americans approved of casino entertainment, 62% find casino gambling acceptable for anyone, and approximately 52% had played a lottery within the past 12 months ("Report indicates," 1997; Cabot, 1996).

Prior to World War II, Atlantic City ("The World's Favorite Playground") was a popular entertainment choice. After World War II, its popularity began to decline. The deterioration was attributed to the availability of air travel during the 1950s, the economical and social problems that urban cities faced during the 1960s, and a westward migration of the population. Since Atlantic City's economy was dependent on tourism, the decision was made to legalize gambling in 1976.

In 1978, Atlantic City reported 700,000 yearly visitors. In the same year Resorts International, Atlantic City's first casino opened. Over the next ten years a dozen casinos were built, and by 1988 the number of yearly visitors increased to over 30 million. In 1990 one of Atlantic City's biggest gaming establishments, the 51-story Taj Mahal, opened. The Taj Mahal broke from the "traditional-style" casino, offering grand-style design items such as crystal chandeliers and Italian marble. The Taj Mahal also offers over 5,000 slot machines and over 200 table games. The new, bigger more upscale casino has become an Atlantic City norm, including three 5-Star Diamond hotels one of which is the Trump Plaza. The Mirage, Harrah's Entertainment Inc., and Hilton International, some of the largest companies in the casino industry, now market themselves more as entertainment and resort destinations than casinos (Ben-Amos, 1997). In December 2002, the historic Claridge Casino Hotel and Bally's Atlantic City merged creating the largest casino resort in Atlantic City.

Most of the capital needed to build a casino comes from high-yield public market and bank loans. Financing a casino project is a moneymaker for both lenders and underwriters (Darsa, 1997). During the casino building boom of the 1990s, more and more banks became willing to finance casinos and gaming companies. In 1993 only eight fiduciary institutions were actively involved in the casino and gaming business, by 1996 that number soared to 26 (Ben-Amos, 1997). Currently, the Trump Plaza, Trump's Castle and the Taj Mahal are the only casinos in Atlantic City not publicly owned. The casino and gaming industry accounts for almost 90% of Atlantic City's total revenue. In comparison, Las Vegas' gaming industry generates approximately 60% of their city's total revenue (Lucas, 1996).

Construction and remodeling projects in Atlantic City declined after the terrorist attacks of September 11, 2001. The downturn in Atlantic City's economy and the loss in revenues in New York since 9-11 has prompted the state of New York to consider legislation allowing gambling in six locations around the state. However, Atlantic City is expecting major growth since the opening of the Atlantic City Convention Center and a new connector expressway over to the Marina casinos (Turpin, 2002).

In 1990, legislation in Mississippi authorized gaming on its navigable waterways. In mid-1992 the first casino opened. While many categorize Mississippi casinos as a form of riverboat gambling (Roehl, 1994), the large facilities with their adjoining hotels, restaurants, and entertainment facilities generate most revenues today. Mississippi currently ranks as the third largest casino market in the United States. The 2003 Mississippi Gaming Commission updated a study from Meyer-Arendt, 1995 and estimated more than 50 million people have visited the state's casinos each year since 1995. Furthermore, of the more than 50 million people, who patronize Mississippi's casinos annually, approximately 65% come from Mississippi or adjoining states, and at least 80% come from the southeastern U.S. (Mississippi Gaming Commission, 2003).

Mississippi's gaming commission consistently regulates casino operations, facilitating time-series analysis (Russell, 1997). During the period of 1992 to 2003, Mississippi annual casino gaming revenues increased from $121 million to over $2.7 billion, and the number of casinos grew to approximately 30 (Mississippi Tax Commission, 2004). Casino space in Mississippi now exceeds 1.4 million square feet.

The gaming commission casino gross revenues report divides the state into two regions, the river region and the gulf coast region. The river region is predominately casinos around Tunica, Mississippi, with the majority of these casinos located close to Highway 61 just south of Memphis, Tennessee. The gulf coast region is centered in Biloxi, Mississippi.

Tunica's proximity to Memphis allows it to offer higher profile events, such as heavyweight boxing matches, which helps to attract more day-gamblers along with vacationers. Biloxi's location on the Gulf of Mexico allows the casinos to package the natural attractions of the gulf along with a large number of golf courses with gambling.

Gambling in the state of Nevada starts with Las Vegas. Las Vegas was founded as a city in 1905 and the first gambling licenses were issued in 1931. Corporations entered the casino business in the 1960's and since have acquired most of the casinos. This corporate involvement signaled a makeover in industry strategy ("The history," n.d.). In 2001 alone, more than 35 million people visited Las Vegas (Las Vegas Convention and Visitors Authority, 2002). Studies show that 86 percent of Las Vegas visitors gamble while there, each with an average gambling budget in excess of $600. Air travel is important to the health of the Las Vegas casino industry as 48% of the cities visitors arrive by air. The events of September 11, 2001 had a dramatic impact on the airline industry and also affected the gambling industries in Nevada (Moss, Ryan, and Parker, 2004). In the first twelve months following September 11, Las Vegas gaming revenues declined $298 million from the prior twelve months.

The state of Nevada reports casino gaming revenues in eleven geographic regions, with the Las Vegas Strip being the largest revenue generator. Due to the size of the Las Vegas Strip relative to the other casino regions in Nevada, it is easy to overlook areas such as South Lake Tahoe or the Boulder Strip. Nine of the eleven geographic reporting regions in Nevada are identifiable regions, such as the Las Vegas Strip, and two are catch-all categories for casinos that do not fall in the other nine regions. This paper analyzes the eight largest regions in Nevada as measured by casino gross revenues.

SEGMENTATION AND FORECASTING STRATEGIC VARIABLES

Strategic variables such as, market size, segmentation, and growth rate, are important parts of strategic planning models. Capon and Palij (1994) assert that proper market definition and selection of a firm's market segment will increase the model's ability to produce accurate forecasts of strategic variables. Capon and Palij further show that increased accuracy in long-term forecasts of key strategic variables results in increases in a firm's performance relative to its competitors.

Effective market segmentation occurs when quantifiable differences between segments are observed (Mo and Havitz, 1994). Diaz-Martin et.al., 2000 asserts the importance for firms, within the tourism industry, to find groups of customers with homogeneous characteristics. Moreover, Diaz-Martin et.al., 2000 used a Chow test to segment data based on customer expectations. By identifying these groups of customers a market segment can be defined and a more effective strategy can be developed. This study will analyze geographic destination regions where customers have homogeneous behavior in terms of season-visiting selection and market growth patterns.

Forecasts are also used in planning, employee scheduling and staffing (Preez and Witt, 2002), revenue projection studies for government agencies (state gaming and tax commissions), both national and regional tourism organizations, and by the individual casinos or suppliers of facilities (Sheldon and Var, 1985).

The ability to identify the existence or non-existence of seasonality or the appropriate seasonal patterns is essential to successful forecasting. Butler (1994) concludes that problems in staffing, obtaining capital, and capacity are attributed to seasonality. Butler further asserts that little research has been conducted on the topic of seasonality in tourism data. Regional differences also play a role in tourism seasonality. Both Hunsaker (2001) and Moss et. al (2004) used quarterly and monthly data when testing seasonality patterns in casino gaming revenues. Preez and Witt (2003) hypothesize that time series data can be aggregated across regions to increase sample size and to improve forecasting accuracy data. Reece (2001) noted that the regional and seasonal affects of Las Vegas and Atlantic City-Cape May change with the level of aggregation in the data. Moreover, when heterogeneous regions are aggregated or pooled results become misleading, forecasting accuracy diminishes, and the models have to be more complex.

By examining two separate time-series forecasting components for each casino gaming revenue series we test the degree of homogeneity amongst geographic regions. Seasonality and trend patterns help to determine to what degree data can be aggregated or pooled.

DATA

Monthly time-series casino gaming-revenue data from the Atlantic City, Mississippi and Nevada regions are analyzed in this research. In all three regions casino gaming-revenues represent the amount a casino wins from gaming operations and not the revenues from other sources such as restaurant or hotel operations. New Jersey's Casino Control Commission provided monthly casino gaming revenues from December 1996 through December 2003 (in 2003 the annual casino gaming revenue was $4.489 billion) for the 13 individual casinos operating in Atlantic City.

The Mississippi casino gaming revenue series is for all casinos (excluding Indian Gaming) operating in the state of Mississippi between August 1992 and December 2003 (in 2003 the annual casino gaming revenue was $2.705 billion). The data is divided between two geographic regions, the River Region and the Gulf Coast Region. Data was collected from the Mississippi State Tax Commission, Miscellaneous Tax Bureau and Casino Gross Gaming Revenues reports.

Nevada is the biggest revenue generator and has the most geographic gambling regions. The data, November 1996 through November 2003, for Nevada casino gaming revenue is available to the public and was collected from the State of Nevada, Gaming Control Board, Tax License Division, and Monthly Win and Percentage Fee Collection reports. Annual casino gaming revenue for Nevada was $9.634 billion as of November 2003. Table 1 lists the different geographic regions within Nevada used in this study.

Table 1: Nevada Revenue by Region

Nevada's Gaming Regions	% Revenue by Region
Las Vegas Strip (LVS)	49.2%
Downtown Las Vegas (DLV)	7.5%
North Las Vegas (NLV)	2.3%
Washoe	11.7%
Laughlin (LL)	5.9%
Boulder Strip (BS)	6.4%
Elko	2.4%
South Lake Tahoe (SLT)	3.6%

METHODOLOGY

We use a general-to-specific methodology. This approach has three advantages in tourism forecasting. First, the model does not require extensive data mining, because the independent variables are time lags of the dependent variable with dummy variables representing important calendar events. Second, we avoid the multiple specification problems associated with specific-to-general models where time dependency becomes a problem. Third, we avoid spurious correlation problems (Song and Witt, 2003).

We analyze eleven time series which all exhibit trends (a non-stationary series) and seasonality. In the first part of the research we use an ANOVA model to estimate the seasonality effects for each series and then to compare seasonal patterns between geographic regions both intrastate and interstate. Seasonality is estimated with a ratio to centered moving methodology (Bowerman & O Connell, 1993; Moss et al., 2003).

In the second part of the research, we will use an autoregressive model for panel time series data to estimate trend patterns and interventions. Witt, Song, and Louvieris (2003) assert that VAR models yield unbiased and highly accurate two to three year forecasts, while Preez and Witt (2003) conclude that univariate ARIMA models produce the most accurate tourism forecasts.

We deseasonalize each panel series with the appropriate seasonal indices prior to VAR estimation. For series with the same seasonal patterns the raw seasonal indices are pooled into one set. Deseasonalizing the series prior to estimating the trend model maintains the full series length versus seasonal differencing and seasonal lags. In addition, this approach substantially reduces the model complexity (Moss, Ryan and Parker, 2004).

Using Doan's (1996) approach after each state's model is estimated we perform a Chow test using dummy variables designating sub-samples making it possible to test the stability across the individual panel series and to correct for heteroscedasticity. Because we have equal sample sizes, the Chow test for equality of linear regression models is well behaved when the linear regression models exhibit heteroscedasticity (Ghilagaber, 2004). Finally, because estimation models of the states may have similar structural forms, we use the Chow test to test for model equality between states.

RESULTS

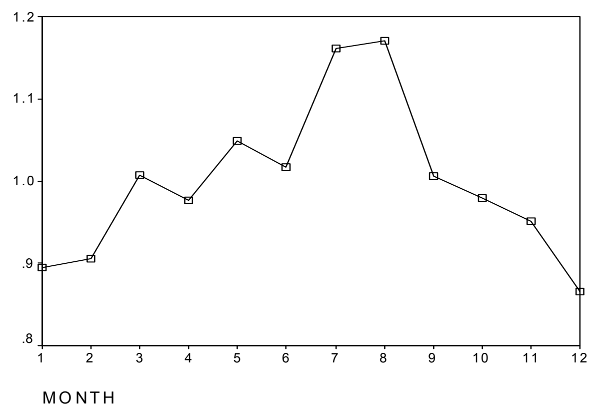
Seasonal patterns for the geographical reporting areas within each state are estimated. The raw seasonal monthly indices are calculated with a ratio-to-moving average methodology (an index representing the percentage of yearly average attributed for each month within the year). A seasonal index below one indicates a lower than average month. If the seasonal indices for a region do not deviate significantly from one then there is no seasonality in the time series. The ANOVA model reveals if monthly deviations are significant and if the geographic reporting areas within the state interact with the monthly seasonal patterns. Table 2 represents the results of the only geographic region for Atlantic City.

Table 2: Atlantic City Seasonality

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	73.447	12	6.121	5072.752	.000
MONTH	73.447	12	6.121	5072.752	.000
Error	0.007	61	0.012		
Total	73.521	73			

The model shows that Atlantic City does exhibit a seasonal pattern as the seasonal indices are significantly different from one. Figure 1 depicts the seasonal patterns. Figure 1 shows Atlantic City's busiest months are July and August and the lowest revenue months are January, February, and December.

Figure 1
Atlantic City Seasonal Pattern

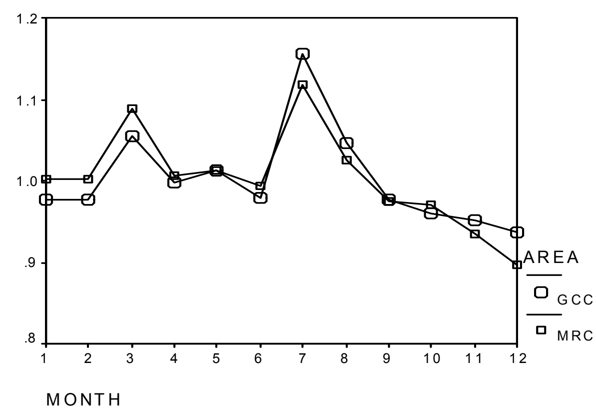


The results for the two Mississippi regions reveal a significant monthly seasonal pattern. Since the interaction term is insignificant we infer that Mississippi's two geographic regions are not significantly different from each other, see Table 3 and Figure 2. This makes it possible to deseasonalize the two Mississippi regions with one set of seasonal indices.

Table 3: Mississippi Seasonality

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	234.773	24	9.782	2794.669	.000
Inter	0.031	11	0.003	0.803	.637
MONTH	0.719	11	0.065	18.663	.000
AREA	0.000	1	0.000	0.000	.997
Error	0.732	209	0.004		
Total	235.505	233			

Figure 2
Mississippi Seasonal Pattern

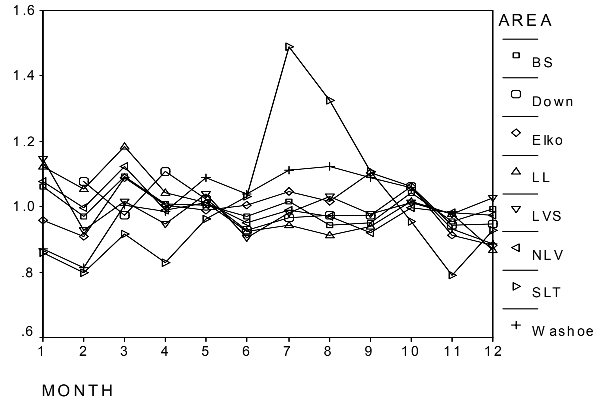


With eight geographic regions Nevada's model is more complex. The estimated model, shown in Table 4, supports the presence of a monthly seasonal pattern. Moreover, the interaction between Nevada's geographic regions is significant, thus there is an indication that seasonal patterns vary by geographic reporting area. Figure 3 shows South Lake Tahoe has the most extreme seasonal pattern within Nevada, with up to a 49% monthly deviation. All eight of the Nevada regions have months where the seasonal index significantly deviates from one, which indicates seasonality in all the time series. Since none of the eight Nevada geographic regions follow the same seasonal patterns aggregating or pooling the regions would result in inaccurate seasonal indices. By aggregating or pooling regions with dissimilar seasonal patterns, seasonal indices may offset one another resulting in an inadequate estimation of the true seasonal variation. Therefore, we deseasonalize each region individually.

Table 4: Nevada Seasonality

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	589.050	95	6.201	1819.186	.000
MONTH	1.057	11	0.096	28.182	.000
AREA	0.006	7	0.000	0.027	1.000
Inter	4.409	76	0.058	17.021	.000
Error	1.667	489	0.003		
Total	590.717	584			

Figure 3
Nevada Seasonal Pattern



Because the Nevada regions have inconsistent seasonal patterns, we use the Las Vegas Strip, Nevada's largest revenue reporting area, for the purpose of comparison with Atlantic City and Mississippi. Table 5 and Figure 4 show significantly different seasonal patterns between the three areas. Table 6 compares all 11 regions; Nevada's eight regions, Mississippi's two regions, and Atlantic City.

Table 5: Comparison of Atlantic City, the Las Vegas Strip, and Mississippi

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	272.351	36	7.565	4030.002	.000
MONTH	0.651	11	0.059	31.539	.000
AREA	0.003	2	0.001	0.076	.927
Inter	0.635	22	0.029	15.380	.000
Error	0.441	235	0.018		
Total	272.792	271			

Figure 4
Comparison of Atlantic City, the Las Vegas Strip and Mississippi

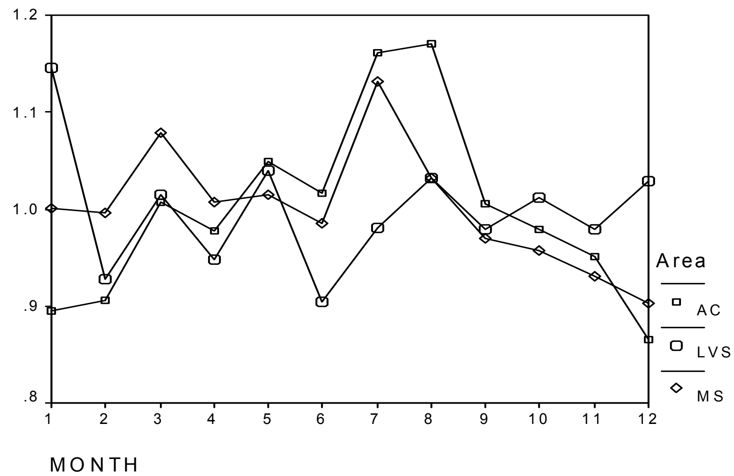


Table 6 Seasonal Indices										
Mon.	AC	MS	BS	Down	Elko	LL	LVS	NLV	SLT	Washoe
1	0.90*	0.99	1.06*	1.08*	0.96	1.12*	1.15*	1.08*	0.86*	0.87*
2	0.91*	0.99	0.97	0.97	0.91*	1.05*	0.93*	1.00	0.80*	0.82*
3	1.01	1.07*	1.09*	1.11*	1.09*	1.19*	1.01	1.12*	0.92*	1.01
4	0.98	1.00	1.01	1.01	1.00	1.04	0.95*	0.99	0.83*	0.99
5	1.05*	1.01	1.00	1.03	0.99	1.01	1.04	1.01	0.96	1.09*
6	1.02	0.99	0.97	0.93*	1.00	0.92*	0.90*	0.95*	1.03	1.04
7	1.16*	1.14*	1.02	0.96	1.05*	0.94*	0.98	0.99	1.49*	1.11*
8	1.17*	1.04*	0.94*	0.97	1.02	0.91*	1.03	0.97	1.33*	1.12*
9	1.01	0.97	0.95*	0.98	1.10*	0.94*	0.98	0.92*	1.11*	1.09*
10	0.98	0.97*	1.04	1.06*	1.06*	1.02	1.01	1.00	0.96	1.06*
11	0.95*	0.94*	0.95*	0.94*	0.91*	0.98	0.98	0.98	0.79*	0.93*
12	0.87*	0.92*	0.99	0.95*	0.88*	0.87*	1.03	0.97	0.93*	0.89*
* significant at the 5% level.										

Part two of this research focuses on forecasting trend models for each of the geographic regions, both inter-and-intrastate. A first difference transformation is used prior to estimating the forecasting model because the deseasonalized series are all non-stationary. Table 7 reveals the resulting forecasting model for Atlantic City. The residuals of this model are verified to be white noise by observing the Ljung-Box Q-Statistics, auto-correlation function, and partial auto-correlation function. The model has an R2 (which in this case is for the trend portion of the transformed time series) of 45%. The R2 for the trend portion of the non-transformed time series is approximately 54%. An intervention variable for September 11, 2001 is found to be significant and negative in the Atlantic City forecasting model. The implication is that Atlantic City casino gaming revenues were negatively affected as a result of September 11.

Table 7: Trend model for Atlantic City

Variable	Coeff	T-Stat	Signif
Constant	1626342.284	1.067	0.286
AR lag 1	-0.823	-9.772	0.000
AR lag 2	-0.340	-3.433	0.001
911	-10218711.072	-6.425	0.000
Differencing = 1 Series = 1 R2 = 45%			

Table 8 shows the estimated model (AR2) for Mississippi's two regions. The September 11, 2001 intervention variable was tested and found insignificant in Mississippi.

Table 8: Trend model for Mississippi

Variable	Coeff	T-Stat	Signif
Constant	1099993.717	3.475	0.001
AR lag 1	-0.693	-11.151	0.000
AR lag 2	-0.444	-6.409	0.000
Differencing =1 Series = 2 R2 = 38%			

A Chow test is used to determine if there is a difference between the two Mississippi geographic reporting regions. Table 9 reveals the results of the Chow test, indicating no difference between Mississippi's two geographic reporting regions. Implying both regions conform to the overall estimated model, shown in Table 8, or pooling/aggregating is possible.

Table 9: Mississippi Chow Test			
Variable	Coeff	T-Stat	Signif
Constant	1504258.357	3.031	0.002
AR lag 1	-0.745	-10.058	0.000
AR lag 2	-0.473	-5.072	0.000
Gulf Coast			
GC	-806859.726	-1.285	0.199
GC*AR lag 1	0.145	1.136	0.256
GC*AR lag 2	0.073	0.562	0.574
Chi-Squared(3)= 2.952 with Significance Level 0.399 Differencing = 1 R2 = 38%			

The eight regional Nevada series are also transformed with first differencing to obtain stationary series prior to estimation of the trend model. An additional problem arises within the Nevada series in the fact that the Las Vegas Strip gaming revenues are much greater than the other geographic regions in the state. To avoid scaling problems the eight first differenced series are standardized prior to estimation of the trend model. Table 10 displays the resulting model.

Table 10: Trend model for Nevada			
Variable	Coeff	T-Stat	Signif
Constant	0.007	0.242	0.808
AR lag 1	-0.840	-21.059	0.000
AR lag 2	-0.654	-11.990	0.000
AR lag 3	-0.336	-6.133	0.000
AR lag 4	-0.260	-6.411	0.000
AR lag 9	0.091	2.942	0.003
911	-0.468	-2.320	0.020
Differencing = 1 Series standardized Series = 8 R2 = 47%			

A complexity problem within the AR model occurs when a complex lag structure is needed to obtain a white noise residual series. Since each of the eight Nevada regions contribute to the model, the complexity arises from each individual region having its own and different lag structure. The Chow test shown in Table 11 reveals the different lag structures.

Table 11: Chow Tests for Nevada

Variable	Coeff	T-Stat	Signif
Boulder Strip R2 = 49%			
BS	-0.008	-0.131	0.895
BS * AR lag 1	-0.311	-2.929	0.003
BS * AR lag 2	-0.376	-2.354	0.019
BS * AR lag 3	-0.058	-0.359	0.719
BS * AR lag 4	-0.096	-0.834	0.405
BS * AR lag 9	0.285	3.528	0.000
BS * 911	0.743	2.743	0.006
Chi-Squared(7)= 71.677 with Significance Level 0.000			
Down Town Las Vegas R2 = 48%			
DTL	-0.057	-0.690	0.490
DTL * AR lag 1	-0.077	-0.658	0.510
DTL * AR lag 2	-0.100	-0.688	0.492
DTL * AR lag 3	-0.287	-2.000	0.046
DTL * AR lag 4	-0.094	-0.789	0.431
DTL * AR lag 9	-0.285	-3.689	0.000
DTL * 911	-0.484	-1.846	0.065
Chi-Squared(7)= 26.567 with Significance Level 0.000			
Elko R2 = 47%			
Elko	0.030	0.314	0.754
Elko * AR lag 1	0.147	1.160	0.246
Elko * AR lag 2	0.007	0.048	0.961
Elko * AR lag 3	-0.019	-0.106	0.915
Elko * AR lag 4	-0.004	-0.035	0.972
Elko * AR lag 9	-0.007	-0.067	0.946
Elko * 911	-0.240	-0.812	0.417
Chi-Squared(7)= 2.127 with Significance Level 0.952			

Table 11: Chow Tests for Nevada			
Variable	Coeff	T-Stat	Signif
Laughlin R2 = 48%			
LL	0.028	0.293	0.769
LL * AR lag 1	0.249	2.146	0.032
LL * AR lag 2	0.018	0.135	0.893
LL * AR lag 3	-0.040	-0.328	0.743
LL * AR lag 4	-0.027	-0.235	0.814
LL * AR lag 9	0.102	1.169	0.242
LL * 911	0.878	-3.340	0.001
Chi-Squared(7)= 18.874 with Significance Level 0.009			
Las Vegas Strip R2 = 48%			
LVS	-0.023	-0.244	0.807
LVS * AR lag 1	0.162	1.486	0.137
LVS * AR lag 2	0.268	1.620	0.105
LVS * AR lag 3	0.285	1.756	0.079
LVS * AR lag 4	0.232	2.030	0.042
LVS * AR lag 9	-0.202	-2.247	0.025
LVS * 911	-0.927	-3.215	0.001
Chi-Squared(7)= 38.498 with Significance Level 0.000			
North Las Vegas R2 = 48%			
NLV	0.006	0.073	0.942
NLV * AR lag 1	-0.166	-1.478	0.139
NLV * AR lag 2	-0.039	-0.217	0.828
NLV * AR lag 3	0.189	1.136	0.256
NLV * AR lag 4	0.190	1.393	0.163
NLV * AR lag 9	0.160	1.711	0.087
NLV * 911	0.897	2.687	0.007
Chi-Squared(7)= 18.135 with Significance Level 0.011			

Table 11: Chow Tests for Nevada			
Variable	Coeff	T-Stat	Signif
South Lake Tahoe R2 = 48%			
SLT	0.026	0.312	0.755
SLT * AR lag 1	-0.061	-0.664	0.506
SLT * AR lag 2	0.050	0.326	0.744
SLT * AR lag 3	-0.249	-1.846	0.065
SLT * AR lag 4	-0.151	-1.453	0.146
SLT * AR lag 9	-0.130	-1.787	0.074
SLT * 911	1.030	4.986	0.000
Chi-Squared(7)= 51.062 with Significance Level 0.000			
Washoe R2 = 47%			
WAS	0.010	0.123	0.902
WAS * AR lag 1	0.007	0.056	0.955
WAS * AR lag 2	0.024	0.170	0.865
WAS * AR lag 3	0.037	0.216	0.829
WAS * AR lag 4	-0.043	-0.406	0.685
WAS * AR lag 9	0.080	1.103	0.270
WAS * 911	0.086	0.306	0.760
Chi-Squared(7)= 2.626 with Significance Level 0.917			

Table 11 also reveals significant and dramatic differences in trend equations between the eight geographic regions. We use a Chow test, for Nevada, in which dummy variables and interaction terms are tested one geographic region at a time. The number of lags required and the coefficients for the lag terms differ by geographic reporting area. The September 11, 2001 effect also differs within the geographic reporting areas. In Boulder, North Las Vegas and South Lake Tahoe the estimated negative effect of September 11 (as shown in the overall model) is reversed within the Chow test. For Downtown Las Vegas, Laughlin, and the Las Vegas Strip the estimated negative impact of September 11 is shown to have a greater negative impact than estimated in Nevada's overall model, shown in Table 10. Elko and Washoe are the only two regions that do not differ significantly from the overall forecasting model estimated for Nevada in either the impact of September 11 or autoregressive terms.

Finally, we use a Chow test to determine if the Mississippi series and the Atlantic City series can be combined to estimate a single model. Recall, since prior analysis indicated differences in forecasting models within the state, Nevada was excluded from this part of the analysis. The Chow test, shown in Table 12, indicates that the models for the two states are different. The difference arises from the impact of September 11 on the gaming revenues. In Mississippi, September 11 did not have a significant impact on casino gaming revenues, whereas, in Atlantic City, the impact was significant and negative. Other than September 11 both states gaming revenues follow a two lag auto-regressive model with no significant coefficient difference.

Table 12: Chow test for Atlantic City/Mississippi.

Variable	Coeff	T-Stat	Signif
Constant	935608.308	2.295	0.022
AR lag 1	-0.737	-10.352	0.000
AR lag 2	-0.472	-5.786	0.000
911	468690.366	0.471	0.638
Atlantic City			
AC	690733.976	0.438	0.661
AC * AR lag 1	-0.086	-0.778	0.437
AC * AR lag 2	0.133	1.038	0.299
AC * 911	-10687401.438	-5.696	0.000

R2 = 44%
Differencing = 1
Series = 3
Chi-Squared(4)= 153.062 with Significance Level 0.000

CONCLUSIONS

Industry gross revenues are forecasted for Nevada, Mississippi and Atlantic City's casino gaming industry. These revenues are a benchmark for individual casino performance and an important planning and strategic variable when dealing with capacity constraints. Casino gaming revenues are also important for state forecasts of potential tax revenues. For example, the casino gaming revenue tax accounts for as much as 10% of Mississippi's total tax collections. Trend and seasonal patterns are an important consideration for states considering legalizing casino gaming as a means of increasing tax collections. States use forecasts and past collection data from regions where existing casino gaming is already legal to estimate potential future tax collections.

This research divided time series forecasts into two components, seasonality and trend. We avoid the temptation of increasing sample size by pooling multiple time series data into a single panel model; even though it has been argued that the larger pooled samples may lead to more accurate forecasting models (Preez and Witt 2003). Our results show that, in general, multiple time series should not be aggregated or pooled when forecasting casino gaming revenues.

All three states are found to have distinctly different monthly seasonal patterns. The states with multiple geographic reporting regions, Mississippi and Nevada, had conflicting seasonality results. The two regions in Mississippi have no significant differences in seasonal patterns. Nevada's eight reporting regions, on the other hand, all follow different monthly seasonal patterns. These findings require that Nevada seasonality be addressed at the individual region level, while Mississippi and Atlantic City can be analyzed at the aggregate state level. If a panel was constructed combining the individual Nevada regions or the aggregate Nevada state data with Mississippi and Atlantic City erroneous seasonal patterns would result. For example, January in Atlantic City has a seasonal index of .9, whereas January on the Las Vegas Strip has a seasonal index of 1.15. Combining area specific seasonal indices would offset one another resulting in a forecast with a gross underestimation of seasonal fluctuations.

Trend forecasting models and the presence of interventions such as September 11 are also shown to vary by region. In Mississippi, September 11 had an insignificant effect on either regions casino gaming revenues. The effects of the September 11 intervention vary by region in Nevada. Six of the eight regions within Nevada do not conform to the overall Nevada state model. Aggregating time series data between states or within Nevada will lead to more complex, less accurate forecasts.

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DYNAMIC LOT SIZING FOR DISCRETE AND CONTINUOUS SHIPPING

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ABSTRACT

Managing inventories has gained more significance today as managing an entire supply chain has become increasingly important. This study examines the structure of the general Wagner-Whitin (WW) dynamic lot sizing (DLS) model from a practical standpoint. Through mathematical model formulation and inventory curve graphs, we show that the general WW model does not always exactly represent DLS situations in practice. For those cases, we formulate two general DLS models with discrete and continuous shipping. For both discrete and continuous dynamic lot sizing (DDLS, CDLS) models, we analyze optimal properties of the zero inventory production (ZIP) policy related to Wagner-Whitin theorem 1 and 2 (i.e., no simultaneous ordering or production and prior inventory carryover and coverage of integer period demands) and show that the ZIP policy is not always optimal unlike the general WW model. And we develop an optimal dynamic programming approach to the DDLS and CDLS models satisfying ZIP conditions. Through numerical examples, we show a potential problem of blindly applying the WW approach to the DDLS and CDLS situations in practice.

INTRODUCTION

The dynamic lot sizing (DLS) model, often referred to as Wagner-Whitin (WW) model (Wagner & Whitin, 1958) in its basic form, concerns determining undiscounted cost-minimizing lot sizes of a product in a single uncapacitated system with dynamic demands for discrete-time, multiple periods in a finite planning horizon. This problem has received much attention, since it has served as a basis for analyzing more complex production and inventory systems. Particularly, previous studies have focused on 1) extending Wagner-Whitin's planning horizon theorem for more general cases (Blackburn & Kunreuther, 1974; Eppen, Gould, & Pashigian, 1969; Zabel, 1964), 2) developing a forecast horizon concept and procedure (Chand & Morton, 1986; Chand, Sethi, & Proth, 1990), 3) developing efficient optimal algorithms (Evans, 1985; Federgruen & Tzur, 1991; Lundin & Morton, 1975; Wagelmans, Hoesel, & Kolen, 1992), and 4) developing fast heuristic procedures and conducting comparative studies (Berry, 1972; Karni, 1985; Vollmann, Berry, & Whybark, 1992 to name a few]. For a more detailed review of relevant research, readers are referred to Federgruen and Tzur (1991).

This study revisits this classic problem from a different perspective. Unlike the previous studies, its main focus is on problem structuring related to the Wagner-Whitin's theorem 1 and 2 (i.e., no simultaneous ordering or production and inventory carryover from a prior period and integer period coverage of meeting dynamic demands). Specifically, we explore what dynamic lot sizing situations in practice are or are not exactly represented by the general Wagner-Whitin model. Through mathematical model formulation and inventory curve graphs, we show that the general WW model is an exact representation of some DLS situations, but only an approximation of other DLS cases. And for those approximate situations, we develop two general DLS models by explicitly considering the timing of satisfying demand or shipping requirements, i.e., discrete shipping and continuous shipping.

In detail, the general WW model differs from the proposed models in terms of handling demand shipping timing, holding costs, and production rates. In the WW model, inventory holding costs are based on period ending inventories and production rates are implicitly assumed to be infinite with simultaneous shipping or usage at the beginning of the instantaneous ordering or production period (see Blackburn & Kunreuther, 1974; Chand & Morton, 1986; Chand, Sethi, & Proth, 1990; Eppen, Gould, & Pashigian, 1969; Evans, 1985; Federgruen & Tzur, 1991; Lundin & Morton, 1975; Wagelmans, Hoesel, & Kolen, 1992; Wagner & Whitin, 1958; Zabel, 1964). On the contrary, the discrete (shipping version of the) DLS (DDLS) model reflects DLS situations in which inventories are accumulated at finite production rates until demand shipping occurs at the end of each time period and holding costs are captured by the area under the inventory curve. Many production and inventory systems in reality are based on this discrete shipping, including a single stage or flexible assembly system (FAS) such as Ford's tail lamp assembly plant (see Kim & Mabert, 2000; Kim, Mabert, & Pinto, 1993) and a final stage in a multi-stage repetitive manufacturing environment, and an MRP system in a job shop environment (see Vollmann, Berry, & Whybark, 1992). And the continuous (shipping version of the) DLS (CDLS) model represents situations in which production occurs at finite rates and demands are met or shipped out continuously during each period as in the classic economic production quantity (EPQ) model (see Hax & Candea, 1984). Thus, this model can also be viewed as a multiple-period, finite-horizon, dynamic demand extension of the EPQ model, which is also an extension of Schwarz's (1972) single-period, finite-horizon, constant demand EPQ model. This continuous shipping situation is typically found in component manufacturing, subassembly, and just-in-time (JIT) continuous-flow repetitive manufacturing systems in practice (see Vollmann, Berry, & Whybark, 1992). Further, in terms of the problem or model structure, it should be noted that our study examines finite production rates for its generality over infinite rates and even without finiteness, the above three DLS models are different as evident from inventory curves in Figure 1 and model structure presented next.

Due to these differences, when we directly apply the Wagner-Whitin based approach to these new DLS situations, the optimal solution is no longer guaranteed. Further, this blind application can cause more detrimental impact on an entire supply chain inventory costs. Therefore, we investigate optimal zero inventory production (ZIP) properties of the DDLS and CDLS models. The analysis reveals that in these cases the ZIP policy is not always optimal and instead the non-ZIP policy can be optimal in some situations. We also develop an optimal dynamic programming (DP) algorithm for the special cases satisfying ZIP conditions. Through numerical examples, we exemplify the cost difference among the WW, DDLS, and CDLS models. The rest of the paper is organized as problems and model formulation, optimal properties and solution approach, and numerical examples, followed by conclusions.

PROBLEMS AND MODEL FORMULATION

Both the general Wagner-Whitin (WW) dynamic lot sizing (DLS) model and the proposed discrete and continuous DLS (DDLS, CDLS) models are concerned with finding undiscounted cost-minimizing (production) lot sizes of a single product in a single uncapacitated facility with dynamic demands for discrete-time, multiple periods in a finite planning horizon. In this section, we examine structural differences of the models through mathematical model formulation and inventory curve graphs. To facilitate the discussion, we use the following notation:

t = discrete time period index
Q_t = *(production or ordering) lot size for period t*
f_t = *binary {0 if* Q_t*=0, 1 if* Q_t*>0} setup variable in t*
I_t = *inventory at the end of t*
d_t = *demand or shipping requirements for t*
p_t = *production rate in t*
a_t = *cost per setup (or order) in t*
c_t = *unit production (or purchase) cost in t*
h_t = *unit inventory holding cost in t*

The General Wagner-Whitin (WW) Dynamic Lot Sizing (DLS) Model

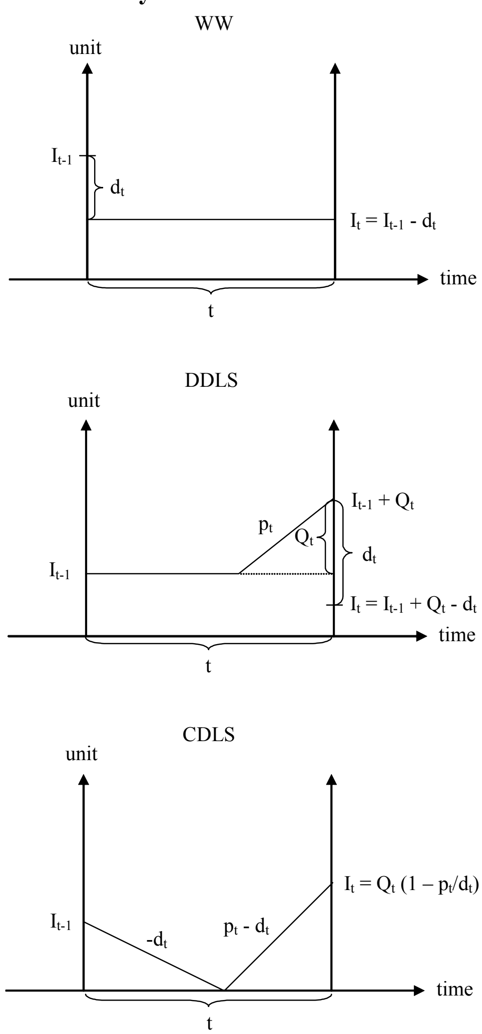
$$\text{Min} \quad \sum_t (a_t f_t + c_t Q_t + h_t I_t) \tag{1}$$

$$\text{s.t.} \quad I_{t-1} + Q_t - d_t = I_t \qquad \forall t \tag{2}$$

$$f_t = \{0, 1\} \qquad \forall t \tag{3}$$

Note that the general WW model is based on the implicit assumptions that demand for period t (d_t) is satisfied either by inventory carried over from a prior period (I_{t-1}) or by order or production lot size received or produced instantaneously at the beginning of t (Q_t) and that the period ending inventory I_t is used in calculating inventory holding cost for period t, i.e., h_tI_t (see Blackburn & Kunreuther, 1974; Chand & Morton, 1986; Chand, Sethi, & Proth, 1990; Eppen, Gould, & Pashigian, 1969; Evans, 1985; Federgruen & Tzur, 1991; Lundin & Morton, 1975; Wagelmans, Hoesel, & Kolen, 1992; Wagner & Whitin, 1958; Zabel, 1964). Therefore, when we closely examine the general WW model, we can find two important points. First, as easily seen from the inventory curve in Figure 1, this model is an exact representation of the situation where the lot size for period t is instantaneously received or produced at the beginning of t and demands or shipping requirements are met at the same time. Second, this model is an approximate representation of the situations where the production rate for period t is finite and demands or shipping requirements are 1) met at the end of period t as in the discrete DLS (DDLS) model or 2) met continuously during t as in the continuous DLS (CDLS) model presented next as similar to the economic order quantity (EOQ) or economic production quantity (EPQ) models.

Figure 1
Inventory Curves for the DLS Models



The Discrete Dynamic Lot Sizing (DDLS) Model

$$\text{Min} \quad \Sigma_t\, [a_t\phi_t + c_tQ_t + h_t(I_{t-1} + 0.5Q_t^2/p_t)] \qquad (4)$$
$$\text{s.t.} \quad (2) - (3)$$

This DDLS model accurately describes the first approximate situation of the DLS. That is, in this model, the production for period t occurs during t at a finite rate and demands or shipping requirements are satisfied at the end of period t (see Figure 1). Due to the finiteness of production rate, holding cost is calculated by the area under the inventory curve. Observe the difference in model formulation between I_t in (1) of the general WW model and $I_{t-1} + 0.5Q_t^2/p_t$ in (4) above. Also, observe that in the ordering or purchasing situation, $0.5Q_t^2/p_t$ in (4) approaches 0, as pt approaches infinity, which is still different from the general WW model in terms of the timing of inventory holding cost calculation.

The Continuous Dynamic Lot Sizing (CDLS) Model

$$\text{Min} \quad \Sigma_t\, [a_t\phi_t + c_tQ_t + 0.5h_t(I_{t-1}^2 + Q_t^2(1 - d_t/p_t) - I_t^2)/d_t] \qquad (5)$$
$$\text{s.t.} \quad (2) - (3)$$

In this model, the production Q_t occurs during period t at a finite rate and demands or shipping requirements d_t is satisfied continuously during period t (see Figure 1). Given the general assumption of uncapacitated lot sizing, production rate is assumed to be far greater than demand rate and setup is assumed to be done not more than once per period and production is not continued in the next period with the current setup, although the case of multiple setups can also be easily incorporated by redefining t as a non-negative integer (0,1,2,). And holding cost is calculated by the area under the inventory curve. Observe the difference from the general WW and DDLS models, even in the ordering situation where d_t/p_t in (5) approaches 0 as pt approaches infinity. Further, this model can also be viewed as a dynamic demand extension of the EPQ model for multiple periods in a finite planning horizon (see Hax & Candea, 1984; Schwarz, 1972).

OPTIMAL PROPERTIES AND SOLUTION APPROACH

One of the important findings in Wagner-Whitin (1958) is that the zero inventory ordering or production (ZIP) policy (i.e., no simultaneous ordering or production and inventory carryover from a prior period from theorem 1 and the coverage of integer period requirements from theorem 2) is optimal to the DLS problem. In this section, we analyze whether optimal properties of the ZIP policy hold true for discrete and continuous dynamic lot sizing (DDLS, CDLS) models and develop an optimal dynamic programming (DP) based solution approach satisfying the ZIP policy. To facilitate the discussion, we define the following:

i,j = period indices where $i < j$
$j1,j2$ = partitioned partial period indices of j such that $d_{j1} + d_{j2} = d_j$ where $j1 < j2$
$d_{i,j} = d_i + \ldots + d_j$
$h_{i,j} = h_i + \ldots + h_j$
TC_1 = non-ZIP (NZIP) based total cost from period i to j when there is production in period i and j, covering $d_{i,j1}$ and d_{j2}, respectively
TC_2 = ZIP based total cost from period i to j when there is production in period i and j, covering $d_{i,j-1}$ and d_j, respectively
TC_3 = ZIP based total cost from period i to j when there is production in period i only, covering $d_{i,j}$
$\Delta_{12} = TC_1 - TC_2$
$\Delta_{13} = TC_1 - TC_3$

Then, for the optimal properties of the ZIP and NZIP policies, we need to make comparisons of only Δ_{12} and Δ_{13}.

Optimal Properties of the DDLS Model

From (4) in the DDLS model, we obtain the following total costs:

$$TC_1 = a_i + c_i(d_{i,j-1} + d_{j1}) + 0.5h_i(d_{i,j-1} + d_{j1})^2/p_i + h_{i+1}(d_{i+1,j-1} + d_{j1}) + \cdots + h_{j-1}(d_{j-1} + d_{j1}) + a_j + c_jd_{j2} + h_jd_{j1} + 0.5h_jd_{j2}^2/p_j,$$
$$TC_2 = a_i + c_id_{i,j-1} + 0.5h_id_{i,j-1}^2/p_i + h_{i+1}d_{i+1,j-1} + \cdots + h_{j-1}d_{j-1} + a_j + c_jd_j + 0.5h_jd_j^2/p_j, \text{ and}$$
$$TC_3 = a_i + c_i(d_{i,j-1} + d_j) + 0.5h_i(d_{i,j-1} + d_j)^2/p_i + h_{i+1}(d_{i+1,j-1} + d_j) + \cdots + h_{j-1}(d_{j-1} + d_j) + h_jd_j.$$

Then, after solving and rearranging the terms of $\Delta_{12} = TC_1 - TC_2$ and $D_{13} = TC_1 - TC_3$, we obtain

$$\Delta_{12} = 0.5(h_i/p_i + h_j/p_j)d_{j1}^2 + [(h_id_{i,j-1}/p_i - h_jd_j/p_j + h_{i+1,j}) - (c_j - c_i)]d_{j1} = 0.5H_2d_{j1}^2 + (H_1 - C)d_{j1} \text{ and} \quad (6)$$
$$\Delta_{13} = 0.5(h_i/p_i + h_j/p_j)d_{j2}^2 + [(c_j - c_i) - \{(h_id_{i,j-1}/p_i - h_jd_j/p_j + h_{i+1,j}) + (h_i/p_i + h_j/p_j)d_j\}]d_{j2} + a_j = 0.5H_2d_{j2}^2 + (C - H)d_{j2} + a_j, \quad (7)$$

where $0 < d_{j1},d_{j2} < d_j = d_{j1} + d_{j2}$, $H_1 = h_id_{i,j-1}/p_i - h_jd_j/p_j + h_{i+1,j} > 0$, $H_2 = h_i/p_i + h_j/p_j > 0$, $H = H_1 + H_2d_j = h_id_{i,j}/p_i + h_{i+1,j} > 0$, and $C = c_j - c_i \leq$ or ≥ 0 for $i < j$ and $j1 < j2$. (8)

Theorem 1. The ZIP policy is always optimal to the DDLS, if one of the following is true:

a. *$C \leq H_1$, i.e., $(c_j - c_i) \leq h_id_{i,j-1}/p_i - h_jd_j/p_j + h_{i+1,j}$,*
b. *$C \leq 0$, i.e., $(c_j - c_i) \leq 0$ for $i < j$ (i.e., unit production cost is non-increasing),*

c. $C \geq H$, i.e., $(c_j - c_i) \geq h_i d_{i,j}/p_i + h_{i+1,j}$,

d. $H - (2H_2a_j)^{0.5} \leq H_1$, i.e., $h_i d_{i,j}/p_i + h_{i+1,j} - (2(h_i/p_i + h_j/p_j)a_j)^{0.5} \leq h_i d_{i,j-1}/p_i - h_j d_j/p_j + h_{i+1,j}$, or $H_2 d_j \leq (2H_2a_j)^{0.5}$, or $d_j \leq (2a_j/(h_i/p_i + h_j/p_j))^{0.5}$, or

e. $H - (2H_2a_j)^{0.5} \leq C < H$, i.e., $h_i d_{i,j}/p_i + h_{i+1,j} - (2(h_i/p_i + h_j/p_j)a_j)^{0.5} \leq (c_j - c_i) < h_i d_{i,j}/p_i + h_{i+1,j}$, where 1b is a subset of 1a, and 1c and 1e are combined as $C \geq H - (2H_2a_j)^{0.5}$. (9)

Theorem 2. The non-ZIP (NZIP) policy is optimal to the DDLS, if $H_1 < C < H - (2H_2a_j)^{0.5}$, i.e., $h_i d_{i,j-1}/p_i - h_j d_j/p_j + h_{i+1,j} < (c_j - c_i) < h_i d_{i,j}/p_i + h_{i+1,j} - (2(h_i/p_i + h_j/p_j)a_j)^{0.5}$. (10)

Proof. By inspection of (6) and (7), $\Delta_{12} > 0$ if $H_1 - C \geq 0$ (theorem 1a) or $C \leq 0$ (theorem 1b) and $\Delta_{13} > 0$ if $C - H \geq 0$ (theorem 1c). Now, suppose $H_1 < C < H$. Let $f = (C - H)^2 - 2H_2a_j$, i.e., the square root term of (7). Then, $\Delta_{13} \geq 0$ if $f \leq 0$, i.e., $H - (2H_2a_j)^{0.5}$ £ C. If $f > 0$, i.e., $C < H - (2H_2a_j)^{0.5}$, then (7) has two roots, say, $(R_2,R_1) = ((H - C) \pm f^{0.5})/H_2$. Therefore, $\Delta_{13} \geq 0$, if $H - (2H_2a_j)^{0.5} \leq H_1$ (theorem 1d). Otherwise (i.e., if $H - (2H_2a_j)^{0.5} > H_1$), $\Delta_{13} > 0$, if $H - (2H_2a_j)^{0.5} \leq C < H$ (theorem 1e), which in turn implies that $\Delta_{13} < 0$, if $R_1 < d_{j2} < R_2$ or $H_1 < C < H - (2H_2a_j)^{0.5}$ (theorem 2). □

Therefore, unlike the Wagner-Whitin DLS model, the ZIP policy is *not always* optimal to the DDLS.

Optimal Properties of the CDLS Model

Similarly from (5) in the CDLS model, the total costs are

$TC_1 = a_i + c_i(d_{i,j-1} + d_{j1}) + 0.5h_i[(d_{i,j-1} + d_{j1})^2(1 - d_i/p_i) - (d_{i+1,j-1} + d_{j1})^2]/d_i + 0.5h_{i+1}[(d_{i+1,j-1} + d_{j1}) + (d_{i+2,j-1} + d_{j1})]$ + MBOL215\f"Symbol"\s12·· $+ 0.5h_{j-1}[(d_{j-1} + d_{j1}) + d_{j1}] + a_j + c_j d_{j2} + 0.5h_j[d_{j1}^2 + d_{j2}^2(1 - d_j/p_j)]/d_j$,

$TC_2 = a_i + c_i d_{i,j-1} + 0.5h_i[(d_{i,j-1})^2(1 - d_i/p_i) - (d_{i+1,j-1})^2]/d_i + 0.5h_{i+1}[(d_{i+1,j-1}) + (d_{i+2,j-1})] + \cdots + 0.5h_{j-1}[(d_{j-1}) + 0] + a_j + c_j d_j + 0.5h_j[d_j^2(1 - d_j/p_j)]/d_j$, and

$TC_3 = a_i + c_i(d_{i,j-1} + d_j) + 0.5h_i[(d_{i,j-1} + d_j)^2(1 - d_i/p_i) - (d_{i+1,j-1} + d_j)^2]/d_i + 0.5h_{i+1}[(d_{i+1,j-1} + d_j) + (d_{i+2,j-1} + d_j)] + \cdots + 0.5h_{j-1}[(d_{j-1} + d_j) + d_j] + 0.5h_j[d_j^2]/d_j$.

Then, after solving and rearranging the terms of Δ_{12} and Δ_{13}, we obtain

$$\Delta_{12} = 0.5[(h_j/d_j - h_j/p_j) + (h_i/d_j - h_i/p_i)]d_{j1}^2 + [\{h_i(1 - d_{i,j-1}/p_i) + h_{i+1,j-1} - h_j(1 - d_j/p_j)\} - (c_j - c_i)]d_{j1} = 0.5H_2 d_{j1}^2 + (C - H_1)d_{j1} \text{ and} \quad (11)$$

$$\Delta_{13} = 0.5[(h_j/d_j - h_j/p_j) + (h_i/d_j - h_i/p_i)]d_{j2}^2 + [(c_j - c_i) - \{h_i(1 - d_{i,j}/p_i) + h_{i+1,j}\}]d_{j2} + a_j = 0.5H_2 d_{j2}^2 + (C - H)d_{j2} + a_j, \quad (12)$$

where $0 < d_{j1}, d_{j2} < d_j = d_{j1} + d_{j2}$, $H_1 = h_i(1 - d_{i,j-1}/p_i) + h_{i+1,j-1} - h_j(1 - d_j/p_j) \leq or \geq 0$, $H_2 = (h_j/d_j - h_j/p_j) + (h_i/d_j - h_i/p_i) \leq or \geq 0$, $H = H_1 + H_2 d_j = h_i(1 - d_{i,j}/p_i) + h_{i+1,j} > 0$, *and* $C = c_j - c_i \leq or \geq 0$ *for* $i < j$ *and* $j1 < j2$. *(13)*

Theorem 3. The ZIP policy is always optimal to the CDLS, if one of the following is true:

a. $0 \leq H_2 \leq 2a_j/d_j^2$, *i.e.,* $d_j \leq \min\{2h_i/(h_j/p_j + h_i/p_i), (2a_j/\{(h_j/d_j - h_j/p_j) + (h_i/d_j - h_i/p_i)\})^{0.5}\}$

b. $H_2 > 2a_j/d_j^2$ *and* $C \leq H_1$ *or* $C \geq H - (H_2 d_j/2 + a_j/d_j)$, *or*

c. $H_2 < 0$ *and* $C \leq H + (-H_2 d_j/2 - a_j/d_j)$ *or* $H - (-H_2)d_j/2 \leq C \leq H_1$. *(14)*

Theorem 4. The non-ZIP (NZIP) policy is optimal to the CDLS, if one of the following is true:

a. $H_2 > 2a_j/d_j^2$ *and* $H_1 < C < H - (H_2 d_j/2 + a_j/d_j)$ *or*

b. $H_2 < 0$ *and* $H + (-H_2 d_j/2 - a_j/d_j) < C < H - (-H_2)d_j/2$ *or* $C > H_1$. *(15)*

Proof. Consider the following four possible cases of Δ_{12} in (11). $\Delta_{12} = 0$ if $d_{j1} = \{0, R =: 2(C - H_1)/H_2\}$. (i) If $H_2 \geq 0$ and $R \leq 0$ (i.e., $C \leq H_1$), then $\Delta_{12} \geq 0$. (ii) If $H_2 \geq 0$ and $R > 0$ (i.e., $C > H_1$), then $\Delta_{12} \geq 0$ iff $d_{j1} \geq R$. However, since $\min\Delta_{12} < 0$ at $d_{j1} = \min\{R/2, d_j - \varepsilon\}$ where ε is an infinitesimal value, $\Delta_{12} < 0$. (iii) If $H_2 < 0$ and $R \leq 0$ (i.e., $C \leq H_1$), then $\Delta_{12} < 0$. (iv) If $H_2 < 0$ and $R > 0$ (i.e., $C > H_1$), then $\Delta_{12} \geq 0$ iff $d_{j1} \leq R$. Thus, if $d_j \leq R$ (i.e., $C \geq H_1 + H_2 d_j/2$), then Δ_{12} BOL179\f"Symbol"\s12 0. Otherwise $\Delta_{12} < 0$.

Now consider the following four possible cases of Δ_{13} in (12). $\Delta_{13} = 0$ if $d_{j2} = \{R_1 =: ((H - C) - f^{0.5})/H_2,\ R_2 =: ((H - C) + f^{0.5})/H_2\}$ where $f = (H - C)^2 - 2H_2 a_j \geq 0$, and $\Delta_{13} \neq 0$ if $f < 0$. (v) If $H_2 \geq 0$ and $f \leq 0$ (i.e., $H - (2H_2 a_j)^{0.5} \leq C \leq H + (2H_2 a_j)^{0.5}$, then $\Delta_{13} \geq 0$. (vi) If $H_2 \geq 0$ and $f > 0$ (i.e., $C < H - (2H_2 a_j)^{0.5}$ or $C > H + (2H_2 a_j)^{0.5}$), then a) If ($R_1 <$) $R_2 < 0$ (i.e., $C > H$), then $\Delta_{13} > 0$ and so the ZIP condition for C is $C > H + (2H_2 a_j)^{0.5}$. b) If ($R_2 >$) $R_1 > 0$ (i.e., $C < H$), then $\Delta_{13} > 0$, iff $d_j \leq R_1$ (i.e., $C \geq H - (H_2 d_j/2 + a_j/d_j)$, and so the ZIP condition is $H - (H_2 d_j/2 + a_j/d_j) < C \leq H - (2H_2 a_j)^{0.5}$, since $(H_2 d_j/2 + a_j/d_j) - (2H_2 a_j)^{0.5} = ((H_2 d_j/2)^{0.5} - (a_j/d_j)^{0.5})^2 \geq 0$. (vii) The condition of $H_2 < 0$ and $f < 0$ does not exist, since $f = (H - C)^2 - 2H_2 a_j > 0$ if $H_2 < 0$. (viii) If $H_2 < 0$ and $f \geq 0$ (i.e., $H - (2H_2 a_j)^{0.5} \leq C \leq H + (2H_2 a_j)^{0.5}$), then regardless of the two possible cases depending upon the sign of $d_{j2} = (H - C)/H_2 >$ or < 0 which maximizes Δ_{13}, $\Delta_{13} \geq 0$ iff $d_j \leq R_2$ (i.e., $C \leq H + (-H_2)d_j/2 - a_j/d_j$), since $R_1 < 0$ and $R_2 > 0$.

Therefore, we obtain theorem 3a (i.e., $0 \leq H_2 \leq 2a_j/d_j^2$) from (i), (v) and (vi), theorem 3b (i.e., $H_2 > 2a_j/d_j^2$ and $C \leq H_1$ or $C \geq H - (H_2 d_j/2 + a_j/d_j)$) from (i), (v) and (vi.b), theorem 3c (i.e., $H_2 < 0$ and $C \leq H + (-H_2 d_j/2 - a_j/d_j)$ or $H - (-H_2)d_j/2 \leq C \leq H_1$) from (iv) and (viii), and theorem 4a and 4b from the complementary set of theorem 3b and 3c, respectively. □

Therefore, again unlike the Wagner-Whitin DLS, the ZIP policy is *not always* optimal to the CDLS.

Solution Approach

For the situations where any of the ZIP properties in Theorem 1 and 3 is satisfied, we can obtain the optimal solution to the DDLS and CDLS by readily applying the Wagner-Whitin type dynamic programming (DP) recursion algorithm. For the situation where the non-ZIP policy in Theorem 2 and 4 is optimal, the ZIP policy based DP recursion can serve as an efficient heuristic approach. The optimal algorithm presented below is for the cases satisfying the ZIP conditions, developed by modifying the Evans' (1985) forward DP algorithm. Now let:

F_j = *minimum cost for periods 1 through j when* $I_j = 0$ *and*
$M_{i,j}$ = *cost incurred by producing in period i, covering* $d_{i,j}$ *for* $i \quad j$.

Then the forward DP recursive relations are constructed as

DP recursive relations for the DDLS model

$$F_j = \min_{1 \leq i \leq j}[F_{I-1} + M_{i,j}] \quad \forall j, \text{ where } F_0 = 0,$$

$$M_{i,j} = a_i + c_i d_{i,j} + 0.5 h_i d_{i,j}^2/p_i + \Sigma_{t=i+1,j} h_t d_{t,j},$$

$$= M_{i,j-1} + d_j(c_i + h_{i+1,j}) + 0.5 h_i (2d_{i,j-1} + d_j) d_j / p_i \text{ for } i \leq j,$$

DP recursive relations for the CDLS model

$$F_j = \min_{1 \leq i \leq j}[F_{I-1} + M_{i,j}] \quad \forall j, \text{ where } F_0 = 0,$$

$$M_{i,j} = a_i + c_i d_{i,j} + 0.5 h_i (d_{i,j}^2 (1 - d_i/p_i) - d_{i+1,j}^2)/d_i + 0.5 \Sigma_{t=i+1,j-1} h_t (d_{t,j} + d_{t+1,j}) + 0.5 h_j d_j \text{ for } i \leq j$$

$$= M_{i,j-1} + d_j(c_i + 0.5 h_{i+1,j-1} + 0.5 h_j) + 0.5 h_i \{(d_{i,j}^2 - d_{i,j-1}^2)(1 - d_j/p_i) - (d_{i+1,j}^2 - d_{i+1,j-1}^2)\}/d_j, \text{ and}$$

$$M_{i,i} = a_i + c_i d_i + 0.5 h_i d_i (1 - d_i/p_i) \quad \forall i,$$

where $h_{i+1,j} = h_{i+1,j-1} + h_j$ *and* $d_{i,j} = d_{i,j-1} + d_j$ *for* $i \leq j$.

NUMERICAL EXAMPLES

In order to illustrate a potential problem of blindly applying the Wagner-Whitin (WW) to the DDLS or CDLS situations, we compared total costs among the WW, the DDLS, and the CDLS approach, using the twelve-period demand data in Wagner and Whitin (1958). For the comparison, we generated 20 replications for non-decreasing unit holding cost per period from the uniform distribution (0, 10] with the constant unit production cost per period for simplicity, hence directly satisfying the optimal properties of the ZIP policy. Table 1 summarizes the data and solution. These examples showed some total cost difference of the DDLS (CDLS) from the WW approach for the average and the worst case being 29.53% (0.29%) and 123.47% (3.33%) deviations, respectively. Also, in 3 (14) out of 20 replications, the WW approach yielded the optimal solutions to the DDLS (CDLS). As is apparent from the computation results, the WW approach performed quite poorly in the DDLS situation than in the CDLS.

Table 1: Numerical Examples and Solutions

Data set:
Number of periods = 12,

Demand rate = {69, 29, 36, 61, 61, 26, 34, 67, 45, 67, 79, 56} units/period,
Production rate = 280 units/period,
Unit production cost per period = constant,
Unit holding cost per period = generated from the uniform distribution (0, 10],
Setup cost to unit holding cost ratio = 10, and
Number of replications = 20.

Average and Worst Case Statistics between Wagner-Whitin (WW) and DDLS Approach:

	Average Statistics			Worst Case Statistics		
Approach	WW	DDLS	% difference	WW	DDLS	% difference
Setup Cost	526.65	611.32	-13.85%	300.19	513.18	-41.50%
Holding Cost	692.13	329.63	109.97%	1,510.67	297.15	408.39%
Total Cost	1,218.78	940.95	29.53%	1,810.86	810.33	123.47%

same solutions 3 out of 20 replications
For the worst case,
lot size (WW) = {69, 29, 97, 0, 61, 26, 34, 112, 0, 146, 0, 56}
lot size (DDLS) = {69, 29, 36, 61, 61, 26, 34, 67, 45, 67, 79, 56}

Average and Worst Case Statistics between Wagner-Whitin (WW) and CDLS Approach:

	Average Statistics			Worst Case Statistics		
Approach	WW	CDLS	% difference	WW	CDLS	% difference
Setup Cost	526.65	534.77	-1.52%	258.32	255.96	0.92%
Holding Cost	1,335.70	1,322.27	1.02%	700.90	672.31	4.25%
Total Cost	1,862.36	1,857.04	0.29%	959.22	928.27	3.33%

same solutions 14 out of 20 replications
For the worst case,
lot size (WW) = {69, 29, 36, 61, 61, 26, 34, 67, 112, 0, 79, 56}
lot size (CDLS) = {98, 0, 36, 61, 61, 26, 34, 67, 45, 67, 79, 56}

Note that solution figures are subject to rounding errors and that total costs consist of only setup and holding costs since unit production costs are constant and thus irrelevant for comparison.

CONCLUSIONS

In this study, we investigated the structure of the general Wagner-Whitin (WW) dynamic lot sizing (DLS) model. Through a thorough examination, we showed that the WW model is not always an exact representation of real-world DLS situations with discrete and continuous shipping. For these approximate situations, we presented new discrete and continuous DLS (DDLS, CDLS) models and explored optimal properties of the zero inventory production (ZIP) policy, along with the development of an optimal dynamic programming solution approach. The analysis revealed that the ZIP policy is not always optimal and the non-ZIP policy can be optimal in some situations. And through examples, we illustrated a potential problem of blindly applying the WW approach to the DDLS and CDLS.

This study intended to provide a new insight into the DLS problem in terms of problem structuring, which can serve as a basis for more complex discrete and continuous DLS situations. Due to the practical significance of the developed models in many real production and inventory systems, it is desired that future research focuses on further analysis of developing an efficient algorithm for non-ZIP policy cases and for more complex situations dealing with limited capacity, multiple products, and/or multiple stage.

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SELF CONFLICT RESOLVING INTERACTIVE WEB-BASED CLASS SCHEDULING SYSTEM

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ABSTRACT

This paper explores the possibility of an interactive web-based class schedule management system, which includes automatic conflict resolution functions. This system utilizes the automatic conflict resolution capability to solve tardiness and complexity of class scheduling problems and to save time consuming in the scheduling for both instructors and administrators. The system allows instructors to enter their class schedules to the system directly and solve most of the conflicts with other classes by the criteria already set in the system. The system finalizes each scheduling when the conflicts are solved by the set rules, and administrators intervene to the scheduling process only when the system cannot solve the conflicts even after applying all the criteria. In this case, involved instructors and administrators receive a message from the system to have further adjustment. Through this process, the system provides efficient and powerful means to instructors to set up their class schedule by themselves every semester in timely manner without sacrificing all the stakeholders' interest. By replacing a primarily paper-based work process and utilizing web-based on line scheduling system, both instructors and administrators can use all the scheduling information saved in database and update it whenever they use the system. This practice may save time and cost in class scheduling tremendously for all sort of educational institutions.

INTRODUCTION

With the advancement of information technology, many colleges/universities use Web-based registration systems in which course schedules are offered to & selected by students and then students' course selections are registered with the colleges/universities.[1] For the effective use of Web-based registration systems, Institutions should have a well-organized class schedule system in place before they offer course schedules in their Websites. Having a good schedule is not that easy job in most institutions, because instructors have conflicting preferences on such issues as day, time, classroom, building, and lab [7]. Therefore, there are class conflicts almost all the time in most institutions.

Conventional Web-based class scheduling systems in many universities [2, 4, 5] do not have automatic conflict resolution functions that can solve incompatible and inconsistent class schedules raised by all the instructors in the universities. Department administrators usually have to take actions to resolve not only systematic conflicts but also unsystematic conflicts manually, although systematic conflicts can be resolved automatically in the system. Conventional systems also utilize paper-based work processes or e-mails to interact and/or communicate each other. Conventional systems work but are neither efficient nor convenient in terms of time and process. The motivation of the proposed system is to replace conventional off-line conflict solution processes with automatic resolution processes using a group of pre-set criteria to reduce time and effort for upcoming class scheduling.

The purpose of this paper is to explore the possibility of an interactive web-based class schedule management system, which includes automatic conflict resolution functions. To accomplish this objective, this study provides an essence of the proposed system development to show how it was developed, what it looks like, how it can be used, and what are the criteria used in the PHP programming. The study also provides a few captured screens of the user-friendly interfaces of the system. The proposed system provides an efficient and user-friendly Web-based interface to the instructors, too. It also responds immediately to any course scheduling requests with conflicts. The system resolves the conflicts automatically whenever it finds any applicable pre-set criteria for the conflict.

METHODOLOGY

Three important steps in coding class schedule management systems are: creating tables in MySQL, creating HTML pages, and embedding PHP codes into HTML tags. We download PHP [3, 6, 10] and configure PHP to run on personal computer and test the PHP script, first. Then we install and configure MySQL [8, 9], which is followed by a coding of HTML pages. In order to publish the webpage and run it on a web server that supports PHP & MySQL, we gained an access to a DATAFLAME web server supporting PHP and MySQL. Once we learn how to administer the web server, we begin to create tables in database and load the tables with data. PHP files for HTML pages are coded as shown in Figure 1. This figure shows that what kind of information instructors can enter into the program and what kind of view the program produces in response using PHP coding.

The database for this application is developed using MS Access that is widely used for the small database. This database is linked with the web pages in this application. We design nine tables for instructors and administrators: Login_info, Courses_Offered, Semester_Description, Room_Assignment, Bldg_Description, Time_Slots, Requested_Schedule, Instruction_Description, and Conflict_Description

Figure 1. PHP Coding (instr_view.php)

```
<?php
session_start();          //Starting a session where empid is a session variable i.e reading the empid
from current session
$_SESSION[empid];    // and when user logs in, it is stored like a global variable
$connection = mysql_connect("localhost", "ujtjxwc_110", "BABA") or die ("Couldn't connect to
server.");

$db = mysql_select_db("ujtjxwc_c5633s3g25", $connection) or die ("Couldn't select database.");
$sql_query1      =      "SELECT      TM.COURSE_RUBRIC,TM.COURSE_NUMBER,R.
SECTION_ID,E.LNAME,E.FNAME,RM.BLDGDESC,R.ROOM1,T.day,T.time
        from requested_schedule R,  semester_desc S, courses_offered TM, login_info L,
emp_desc E,
        room_assignment RM, timeslot T
        where                  R.SEMESTER_ID=S.SEMESTER_ID                  and
TM.CLASS_NUMBER=R.CLASS_NUMBER  and   L.EMPLOYEEID=R.EMPLOYEEID  and
E.EMPLOYEEID=R.EMPLOYEEID       and       RM.BLDG_ID=R.BLDG_ID1        and
RM.ROOMNO=R.ROOM1  and  T.TID=R.TID  and  S.SEMESTER_ID=L.SEMESTER_ID  and
R.employeeid=$empid";
$sql_result_query1 = mysql_query($sql_query1,$connection)   //executes the query & stores the
data in                                          //$sql_result_query1
        or die ("Couldn't run query!");
?>

//instructor_view.php continued
  while ($row1 = mysql_fetch_array($sql_result_query)) {  //passing the results of the query in to
an array
        //called row1 which consist of multiple entities & then we are breaking those entities in to
different variables.
   $title1 = $row1["COURSE_NAME"];       //picking up course name from array & storing it in
title1
   $title2 = $row1["COURSE_NUMBER"];
   $title3 = $row1["SECTION_ID"];
   $title4 = $row1["LNAME"];
   $title5 = $row1["FNAME"];
   $title6 = $row1["BLDGDESC"];
   $title7 = $row1["ROOM1"];
   $title8 = $row1["day"];
   $title9 = $row1["time"];
echo"
 <tr>
   <td width=10%  align=center>$title1</td>  //This prints out on screen the data according to the
following alignment
   <td width=10%  align=center>$title2</td>
        …….
        …….
   <td width=10%  align=center>$title8</td>
   <td width=10%  align=center>$title9</td>
</tr>";
```

Login_info table - It stores the login information such as User ID and password. First name, last name and email address of the user are also stored in this table. Users can be department administrators, facility administrators or instructors who want to register for teaching courses.

Courses_Offered table - This table has the basic information about the courses being offered in a particular semester of a year. Instructors choose from amongst these courses. And his choices are populated in the Requested_Schedule table. It shows course identification numbers, credit hours and the semester and the year in which the course will be offered.

Semester_Description table - It stores the descriptions of the semester codes that are being used in the Course_info and Requested_Schedule tables.

Room_Assignment table - This table shows the room number, building number and the capacity of the room.

Bldg_Description Table - This is another description table of the building codes that are being used in Room_Assignment and Requested_Schedule table.

Time_Slots table - This table shows the day and time available for the slot.

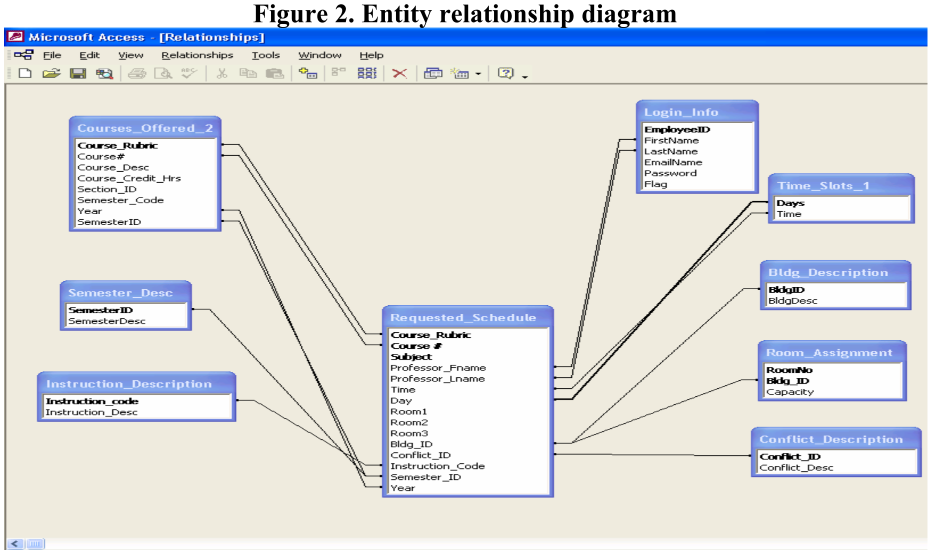
Requested_Schedule - This table gets populated when the instructor chooses course ID, room No, time and other information related to the class that he/she wants to teach. As the relationship window illustrates, this table is getting values from the others tables.

Instruction_Description - This table shows the descriptions of codes for instruction methods. For example code 0 means that instruction method is face to face and code 1 means that it's a web course.

Conflict_Description Table - This table shows the description of codes for different class scheduling conflicts.

Considering the above-addressed typical tables of this application, we design the entity relationship (ER) diagram that is a logical representation of the data as shown on Figure 2. The database reflects the principal information system of basic functionalities. The tables are accessed by primary key(s), which are bold, and they are interconnected by foreign key(s) from other tables. All tables are linked by the Requested_Schedule table which shows instructors' offering courses.

Figure 2. Entity relationship diagram



IMPLEMENTATION

The class schedule management system is based upon a client-server architecture. The client side is any Internet browser capable computer with an access to the university network. Instructors and administrators enter class-scheduling information through the system. The interface is developed using HTML and the communication protocol is based upon HTTP. The users can access to the system by logging into their pre-established accounts, which is verified and validated by the system. The users' requests are posted to and processed on the university server via HTTP protocol. Then the system updates the database with the new requests.

This interactive Web-based class schedule management system has two primary users: instructors and administrators. Instructors should be able to perform the following functions in the system:

1. Add classes to their schedules with specific requests for time and location of instruction;
2. Modify class information in the schedule;
3. Delete classes from their schedule;
4. View the schedule;
5. Request new classes with specific requests for time and location of instruction.

The administrator should be able to perform following functions in the system:

1. View un-resolved conflicts;
2. Add new courses;
3. Drop courses not complying with the institution's policy.

This Web-based class schedule management system is a program that enables instructors to schedule classes by applying the pre-set criteria in the system. The system saves all class scheduling requests in the data repository, based on which appropriate reports are produced. The system provides a simple means of class scheduling through a user-friendly Web-based interface. The system will produce the final class schedules if all conflicts in the scheduling requests are resolved automatically by the system. For those un-resolved conflicts, the system sends notices to corresponding instructors and administrators for the necessary actions to resolve the conflicts off-line. This Web page contains hyperlinks to such features as add class, modify class, delete class, show instructor schedule, request a new course addition, modify user preference, home, and logout. Instructors select their class schedules after they choose the 'add class' button.

The screen in Figure 3 shows that instructors can add one or more of pre-selected classes stored in the system to their schedules. The pre-selected classes are classes approved by the administrators before they are entered into the system. Instructors select time and locations of instructions considering such factors as available time slot, enrollment cap, teaching method, and available classrooms. Instructors modify, delete, and see their schedules. They also can request new courses after they choose the proper main menu buttons as shown in Figure 4. Then, instructors can choose their preferred days, time of the days, and classrooms on the menu.

Figure 3. Add class menu for an instructor

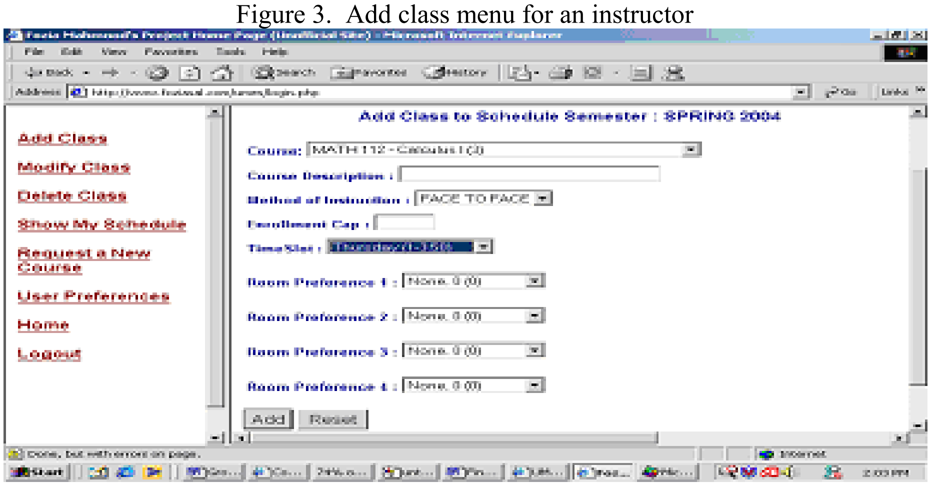
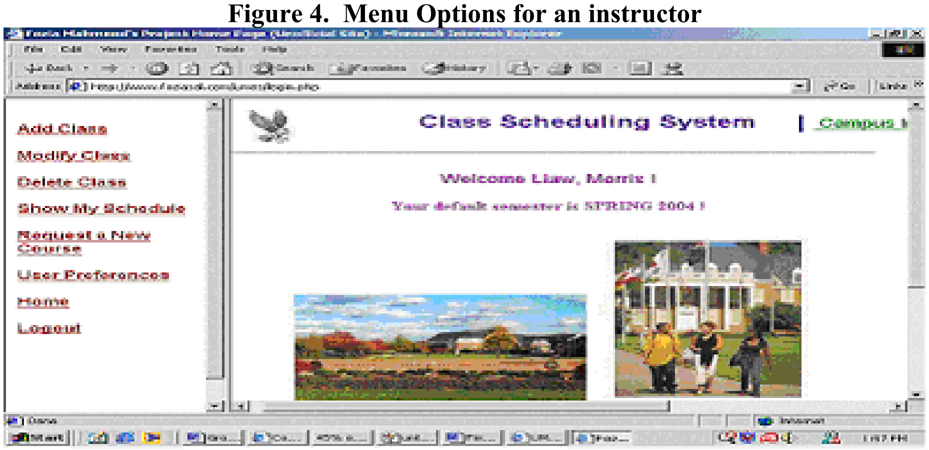


Figure 4. Menu Options for an instructor



Administrators are supposed to enter classes to be offered to the students and pre-approved classes for each instructor. However, administrators' roles in resolving schedule conflicts are very limited in this class schedule management system. They participate in the conflict resolution process only if there are unresolved scheduling conflicts by the system after applying all applicable conflict resolving criteria.

RESOLVING CONFLICTS IN THE WEB-BASED CLASS SCHEDULE MANAGEMENT SYSTEM

Conflicts occur when more than one instructors request for the same classroom and the same time slot or when more than one instructors teaching different required classes request for the same time slot. These conflicts will be resolved in the web-based class schedule management system using the following criteria.

Criterion 1: the required course has a preference over the elective course, which means scheduling requests for the required course should be granted, first, between the required course and the elective course.

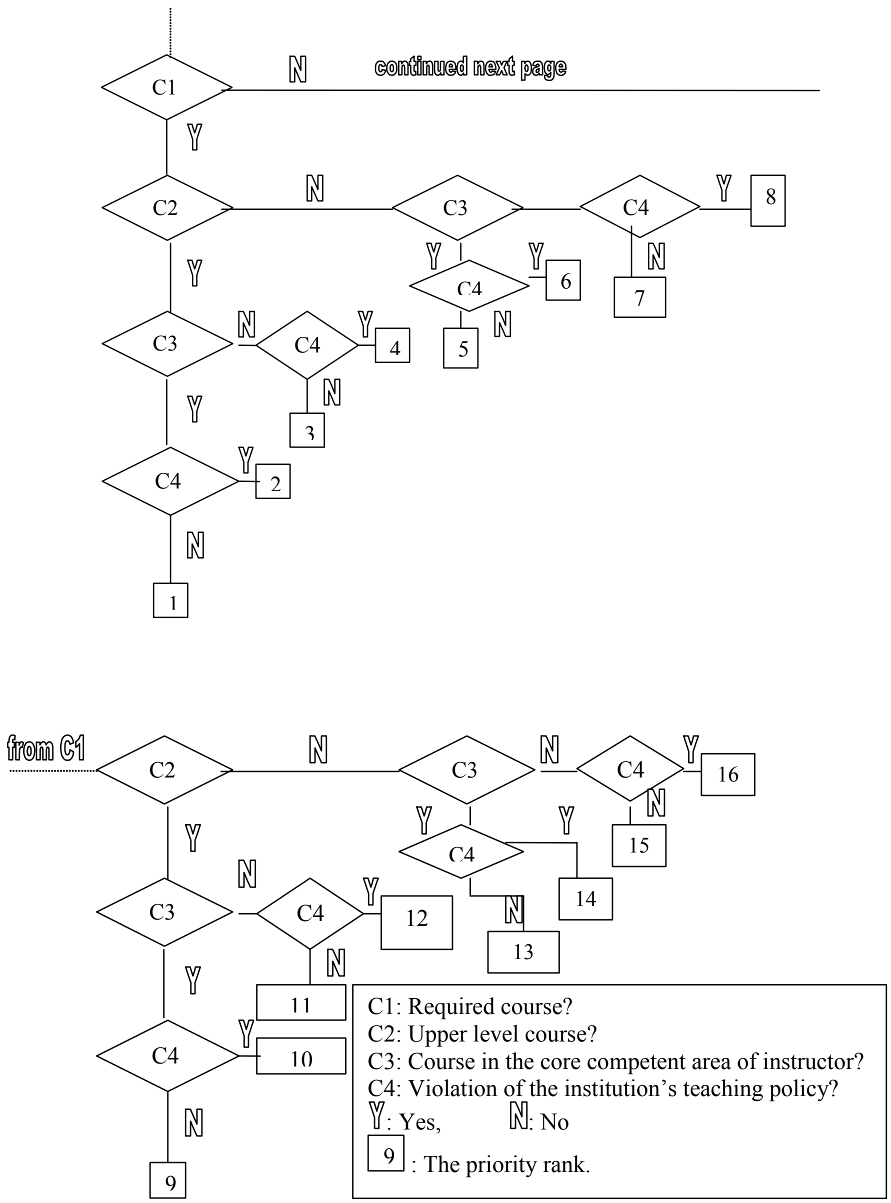
Criterion 2: the upper level course has a preference over the lower level course. The upper level course is a course offered to the upper class students, while the lower level course is to the lower class students. For example, among advanced level course, intermediate level course, and introductory level course, scheduling requests for advanced level courses should be granted, first, then intermediate level courses, and introductory level course, last.

Criterion 3: the course in the core competent area of the instructor has a preference over the course in the non-core competent area of the instructor. For example, schedule requests for MIS classes by instructors with MIS expertise should be granted before the approval of schedule requests for MIS classes by instructors without MIS expertise for the benefit of students.

Criteria 4: scheduling requests that cause violations of the institution's teaching policy, if not granted, have preferences over the other class scheduling requests that do not. Suppose that an instructor's teaching schedule will violate the institution's teaching policy that prohibits any instructor from teaching more than 3 days a week, if his or her course scheduling request is not granted, his or her course scheduling request should be granted, first.

The above-mentioned 4 criteria should be applied in the same order as they are presented. In other words, apply the criteria in the order of criterion 1, 2, 3, and then 4. It is necessary to apply the immediate subsequent criterion, only if the immediate preceding criterion does not resolve the conflict in the scheduling requests. If all four criteria do not resolve the conflict, the system informs the requesting instructor that he or she must contact the administrator to resolve the conflict.

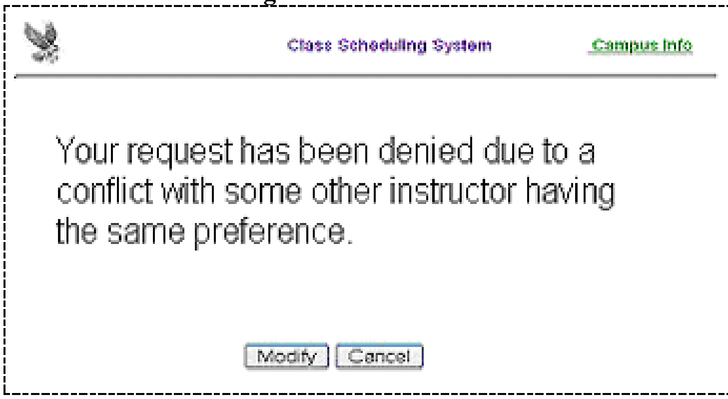
Figure 5. Flow Chart Of The Online Conflict Resolution Function



If all conflicts are resolved by the system, the approved course schedule of an instructor will appear in the monitor screen. On rare occasions where there be any unresolved course scheduling conflicts, both the requesting instructor and the administrator will receive e-mails regarding them.

This request needs further attention of the administrator and will be finalized off line. And the following message shown in Figure 7 will appear in the monitor screen,

Figure 6. Alert Screen



CONCLUSION

This paper explores the possibility of an interactive web-based class schedule management system, which includes automatic conflict resolution functions. This system utilizes the automatic conflict resolution capability to save time and effort consumed in the scheduling process for both instructors and administrators. The system allows instructors to enter their class schedules to the system directly and solve most of the conflicts with other classes by the criteria already set in the system. The system finalizes each scheduling request when the conflicts are solved by the pre-set criteria, while administrators intervene to the scheduling process only when the system cannot solve the conflicts even after the system applies all the criteria. In this case, involving instructors and administrators receive a message from the system to have further adjustment.

Through this process, the system provides efficient and powerful means to the instructors to set up their class schedules by themselves every semester in timely manner without sacrificing any stakeholders' interest. By replacing a primarily paper-based work process with a web-based scheduling system, both instructors and administrators can use all information saved in database of the system and update the database whenever they use the system. This practice may save time and cost in class scheduling tremendously for all sort of educational institutions.

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THE CASE FOR MEASURING SUPPLIER SATISFACTION

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ABSTRACT

Many organizations struggle in their efforts to establish supplier partnerships, and many such partnerships fail to live up to their potential. This paper examines why partnerships do not deliver the hoped for results, and proposes supplier satisfaction surveys as a possible remedy to this situation. Drawing upon empirical studies in the supply chain management literature, the paper establishes that (i) successful partnerships require trust to develop between organizations; (ii) such trust requires open, two-way communication; and (iii) despite the recognition of the importance of communication, a significant and persistent perception gap exists between buyers and suppliers within many such partnerships. The cause of this perception gap is then traced to a communication imbalance between buyers and suppliers. While buyers generally communicate expectations and provide feedback to suppliers, there is little evidence that expectations and feedback flow the other direction (i.e., from suppliers to buyers). The paper makes the case that buyers can use supplier satisfaction surveys to correct this imbalance and eliminate the perception gap impeding the development of effective buyer-supplier partnerships.

INTRODUCTION

Supply chain management theory and practice has evolved over the last twenty years from a focus on transaction processes based on arms-length agreements with suppliers to a focus on collaborative processes based on mutual trust and information sharing (Ghosal & Moran, 1996; Hoyt & Huq, 2000). Organizations are increasingly trying to work much more closely with their suppliers to try to optimize the performance of their supply chain, and many of these organizations now describe their relationship with their suppliers as partnerships. Research indicates that when well executed, these collaborative, partnership-like relationships with suppliers can lead to improved firm performance (Tracey & Vonderembse, 2000; Jones et al., 1997; Liedtka, 1996; Handfield & Nichols, 1999).

For these types of collaborative partnerships to be successful, however, buying organizations must implement fairly radical changes to their own organizational processes and structures to support them (Liedtka, 1996; Mariotti, 1999). Further, the processes and methods needed to really achieve such partnerships are still being developed, understood and refined. As a result, many organizations struggle in their effort to implement partnerships (Mariotti, 1999; Spekman et al., 1998). Many buyer-supplier partnerships do not live up to their potential, and many are not true "partnerships" in any real sense of that term.

Saying one has partnerships with their suppliers is quite easy, but actually transforming one's approach to how one works with and manages their suppliers to achieve real partnerships with one's suppliers is significantly more complex. As Spekman et al. (1998) characterize it, most organizations that claim to have partnerships with their suppliers have simply achieved some level of cooperation whereby the firms "exchange bits of essential information and engage some suppliers/customers in longer-term contracts" (p. 55). True partnerships, however, are built on a foundation of trust and commitment that goes well beyond mere cooperation. Partners collaborate with each other to develop shared goals and to integrate their processes into their major customers' processes. Such firms recognize and act on the fact that their long-term success is dependent on their weakest supply chain partner. Many companies, however, never reach this stage of true partnership and collaboration (Spekman et al., 1998).

This paper proposes a means to help move organizations toward true partnerships with their suppliers – supplier satisfaction measurement. It proposes that buyers need to think of their suppliers more like they think about their customers, and only when this occurs will organizations really begin to view their suppliers more like partners and less like traditional suppliers. The paper begins with a look at the prerequisites of successful partnerships – inter-organizational trust and communication. After establishing the role of trust and communication, the paper focuses on the significant gap that exists between buyers and their suppliers regarding their expectations and assessments of performance in buyer-supplier partnerships. This gap creates a significant barrier to the development of trust in the relationship. It is then proposes that measuring suppliers' expectations and perceptions regarding their relationship with buying organizations is the simplest way to overcome this perception gap and move the relationship closer toward a true partnership. Finally, it is proposed that the underlying cause of the perception gap relates to the highly directional view that most organizations hold relative to their supplier chains, and that in reality buying organizations should view their suppliers in a similar way that they view their immediate customers in the supply chain.

SUCCESSFUL PARTNERSHIPS ARE BUILT ON COMMUNICATION & TRUST

Many theorists propose, and empirical studies seem to confirm, that success of supplier partnerships depend, at least in part, upon the level of trust and cooperation that can be achieved between the organizations and upon the extent and quality of information sharing that occurs between the organizations. Ellram (1995) collected data from 80 matched pairs of buyers and supplier organizations in order to assess what factors led to successful partnerships. Ellram found that for both buyers and suppliers, that communication, trust, strategic direction and shared goals were the critical factors in creating and maintaining successful supplier partnerships. Monczka et al. (1998) found similar results by looking at survey data from 84 buying organizations. Monczka et al. measured partnership success in terms of the buying company's satisfaction with the partnership, the performance improvement experienced by the buying company as a result of the partnership, and the extent to which the partners were able to work together (e.g., how flexible the partners were to requests made by the other and whether partners met their commitments within the partnership). The researchers found that trust, interdependence, information quality, information sharing, information participation (i.e., the extent to which partners engage in joint planning & goal setting activities) and joint problem solving efforts all contributed to more successful supplier partnerships.

Krause and Ellram (1997) collected data from 520 buying organizations in order to investigate the related issue of supplier development efforts. Using a split sample approach, they found that the organization's that were satisfied with the results of their supplier development efforts tended to take a more proactive approach to supplier performance (e.g., trying to anticipate supplier performance problems and viewing suppliers as extensions of their own organization), put more effort and resources into their supplier development efforts (e.g., supplier evaluation & feedback, training of supplier personnel, and recognition of outstanding suppliers), and exhibited greater willingness to share information with their suppliers. While this last study focused on supplier development as opposed to supplier partnerships, it is relevant here given many organizations efforts to form supplier partnerships have roots in their efforts at supplier development.

Repeatedly, then, large sample studies have found that communication and trust play a pivotal role in the establishment of partnership relationships between buyers and suppliers. Other researchers (e.g., Henriott, 1999; Mariotti, 1999; Yuva, 2001) have also argued that the information sharing is really a prerequisite for the development of trust, and subsequent studies focused on trust between buying and supplying organizations confirm the importance of communication to the development of trust and relationship quality. Parsons (2002), for example, investigated the determinants of buyer-supplier relationship quality, measuring relationship quality as the buying organizations' assessment of the trust that existed within the relationship in addition to the buying organizations' general level of satisfaction with the relationship. Based on survey results from 368 organizations, Parsons found that both the interpersonal relationships between the individual buyers and salespeople and the relationship between the companies in terms of the existence of mutual commitment, goals and relationship benefits contributed to higher relationship quality. Communication plays a significant role in both the interpersonal relationships as well as in the organizations identifying and developing mutual goals and commitment.

In another study looking at trust in buyer-supplier relationships, Cousins and Stanwix (2001) looked at the management of supplier relationships among automobile manufacturers operating in the U.K. in an effort to identify those factors that contributed to a high trust relationship. Results indicated that manufacturers found 17 factors contributed to high trust relationships, including full and open communication, consistency from all personnel, full cost transparency, receptiveness to supplier ideas, and providing help to suppliers with 'no strings attached'. Interestingly, the Japanese vehicle manufacturers in the study reported that these contributing factors were fairly easy to implement, while non-Japanese manufacturers found such activities to be harder to implement. The authors of the study concluded that the Japanese vehicle manufacturers tended to view 'relationship development' as what supply chain management was all about – it was simply an integrated part of what they did. Non-Japanese vehicle manufacturers, on the other hand, seemed to think more in terms of 'supplier development' rather than 'relationship development' and viewed supplier development as an extra responsibility of their work (as opposed to an integrated part of it).

Cousins and Stanwix's (2001) finding that many organizations fail to view the relationship development component as central to the supply chain management function is consistent with the more general finding that buying organizations struggle to achieve true partnerships with their suppliers and that many continue to manage suppliers based on more of an arms-length relationship approach (Maniotti, 1999). It is also consistent with the findings of Spekman et al. (1998), who studied the practices of buyers and sellers in 22 aggregate supply chains, and found that "buyers tend to embrace the notions of collaboration less than sellers and appear to fear the close ties that are required for integrated supply chain management" (p 59). For example, Spekman et al. found that buyers were less willing to devote extra effort to their supply chain relationships and were less likely to view their suppliers as irreplaceable and essential to their business than their immediate customers in the supply chain. So while communication and trust seem to be part of the foundation upon which supplier partnerships are built, the evidence suggests that many organizations struggle to really achieve these goals. This difficulty in achieving trust appears to be based in part on the fact that buyers and suppliers perceptions of their partnership arrangements differ significantly.

BUYERS AND SUPPLIERS DO NOT PERCEIVE PARTNERSHIPS THE SAME

Ellram (1995) and Blancero and Ellram (1997) carried out one of the first supplier partnership studies dealing with the perceptions of both buyers and suppliers. Ellram and Blancero used data collected from 80 matched pairs of buyers and their corresponding suppliers to compare the perceptions of buyers and suppliers in terms of which factors were the most important contributors to successful supplier partnerships (Ellram, 1995) and in terms of what was happening in these relationships (Blancero & Ellram, 1997). In terms of factors contributing to a successful partnership, both buyers and suppliers agreed that communication and trust were critical. Suppliers, however, consistently saw the relationship aspects of the partnership (e.g., relationships among top management teams, the existence of multiple relationships between the organizations, the personal relationship between the buyer and salesperson) as more significant to the success of the partnership than did the buying organization. In terms of what was happening in these relationships, buyers and suppliers frequently did not share the same perceptions. Further, where there were differences in perceptions, the buying organization in every case perceived that their own behavior was more supportive of the relationship than the suppliers perceived their behavior. The buying organization perceived that they met with the suppliers top management more, that they more regularly communicated forecasts, production schedules and proprietary information, that they worked more with suppliers on cost reduction and quality improvement efforts, and that they involved suppliers early in the design process more than suppliers perceived these activities occurring.

Subsequent studies investigating the perceptions of both the buying and supplying organization confirm Ellram (1995) and Blancero and Ellram's (1997) finding that perceptions between buyers and suppliers differ. Campbell (1997), for example, conducted a study in the European packaging industry, collecting data on the relationship between 45 buying organizations working with three large packaging suppliers. Data was collected from 28 salespeople from the three suppliers and 114 purchasing agents from the 45 buying organizations. Campbell found that the buyer and salesperson shared the same expectations about the partnership in only 42 of the 114 relationships (37%). Further, no correlation was found between a buyer's trust in the supplier and the corresponding supplier's trust in the buyer, nor did the suppliers' perceptions of the extent of proprietary information disclosed by the buying organization match the buying organizations perceptions on the extent of proprietary information disclosed. In another study of a Korean semiconductor manufacturer and its key suppliers, Kim et al. (1999) found significant perception gaps existed between buyer and suppliers. Like Ellram's (1995) study, Kim found that suppliers perceived relational characteristics like communication, familiarity and long-term goals to be more important to the effectiveness and success of the relationship than did the buying firms. Further, Kim found that this perception gap had a negative impact on inter-firm trust.

In fact, no studies could be found that indicated that buyers and suppliers consistently shared the same perceptions regarding their expectations for and/or the subsequent behaviors realized in buyer-supplier partnerships. The evidence suggests that the vast majority of buyers do not have an accurate picture of their suppliers' perceptions of the partnership – either in terms of expectations or performance. It is difficult to understand how an organization can truly claim to have a partnership with suppliers when such a situation exists. Rather, the ongoing perception gap would appear to provide a plausible explanation for why so many organizations do not realize the full potential from their partnerships.

Wagner, Macbeth and Boddy's (2002) in-depth case study on the relationship between a buying organization and one of its suppliers that it was attempting to develop a partnership relationship with provides a good example of what can happen when organizational perspectives on the relationship differ. In early stages of the partnering process, the supplier felt a continuing and significant imbalance of power in favor of the buying organization. Among the supplier's personnel, this created the impression that improvement ideas would only be considered and accepted by the buying organization if there was minimal impact and disruption for the buying organization. Whether or not this perception was justified was unclear to the researchers, but what was clear was that it greatly limited the range of ideas put forth by the supplier. As trust and commitment grew, and as the buying organization moved more toward treating its supplier more like a partner and less like a traditional supplier, the supplier became more comfortable communicating to the buying organization things that the buying organization could be doing differently to help the supplier.

THE ROOT CAUSE OF THE PERCEPTION GAP: ONE DIRECTIONAL THINKING

This paper has established three facts so far about the current state of buyer-supplier relationships based on the supply chain management literature. First, buying organizations increasingly face the competitive need to establish partnership-like relationships with their suppliers in an attempt to optimize performance of the value chain for their end customers. Second, communication and the establishment of trust between buying organizations and their suppliers are consistently found to be key components to the establishment of successful partnerships. Finally, there is strong evidence that a perception gaps exits between buying organizations and their suppliers; despite the recognition of the importance of communication in such efforts, most organizations' communication efforts seem to fail. Such differing perceptions are likely to generate underlying conflict in these relationships and impede the development of trust, which is so critical to the success of such partnerships. As such, buying organizations and suppliers attempting to establish or maintain partnership-like relationships need to find a way to overcome this perception gap in order to advance the relationships toward true partnerships where they can produce maximum operational and strategic benefit to the firms.

Before discussing the proposed solution to this perception gap, it is worth considering the underlying cause of this perception gap. The cause would seem to relate to the fact that information sharing in most buyer-supplier arrangements, even many of those that the buying organization calls partnerships, is limited and somewhat one dimensional, focusing primarily on the performance of the supplier (Campbell, 1997). Buying organizations now routinely communicate detailed expectations to their suppliers - both specific expectations (e.g., we want our supplier to perform this service, and this is how we want it performed) and general expectations (e.g., we expect suppliers to be proactive in working with our company). Buying organizations are also increasingly providing their suppliers with regular, detailed feedback on how the suppliers are meeting these expectations. But there is little evidence that buying organizations are asking for, or are typically receiving, the reverse information. That is, buying organizations are not in general, asking their suppliers what their suppliers expect from them, nor are they typically asking their suppliers for feedback on how they, the buying organizations, are performing. This limited view that most buying organizations take to information sharing, amounting really to information giving, appears to create the perception gaps revealed in the literature and hinders many of these arrangements from developing into true partnerships that lead to improved firm performance.

This one directional flow of information appears to be symptomatic of a broader, entrenched view that supply chains have an inherent directional focus to them. That is, when organizations think about their supply chains, they think first about the flow of goods and services from raw material supplier toward end customer (i.e., constantly moving downstream) and second about the flow of information in the supply chain from end customer backward toward raw material supplier (i.e., constantly moving upstream). There is also a power component to this linear thinking, whereby organizations downstream tend to have more power, while organizations upstream have less power based on the fact that customers have the power to "choose" a different supplier, while suppliers are not in the same position of simply being able to "choose" a different customer.

As a result of this linear thinking, organizations tend to treat downstream members of the supply chain very differently than they do upstream members of the supply chain. Organizations will do whatever it takes to be the preferred supplier of their immediate customer, but rarely will they approach their upstream suppliers with the attitude of doing whatever it takes to be their suppliers' preferred customer. In fact, more typically, organizations expect their suppliers to do whatever it takes to be their preferred supplier. This fails to optimize the performance of the supply chain, however, because each upstream member of the chain must work within the constraints, both explicitly stated by the downstream member and perceived by the upstream organization, and optimize within these set of constraints. True optimization of the supply chain requires these constraints to be examined and in many cases modified through collaboration among the upstream and downstream members of the supply chain.

What is needed is for organizations to see beyond the directional orientation that they have toward their supply chains. A significant advancement in the supply chain management literature along these lines is the use of the term "networks" – either described as supply networks or demand networks. Being a member of a demand network implies much less directionality to relationships than does a supply chain. Ultimately, competition is between these networks of companies working together to satisfy the final customer, not between individual companies. That is, the competitive success of an individual firm has as much to do with what its partners do as it does with what it does. If an important partner in such a network fails to perform its function well, the whole network of organizations suffers because end customers switch to an alternative network of companies to purchase from. Further, it largely doesn't matter whether that organization that fails to perform is an upstream or downstream organization, the network itself suffers as a result. Given this state of competition, firms need to be working more to insure that their actions support the actions of all members of the network, regardless of whether they are upstream or downstream. It is suggested that firms take what they know about serving downstream organizations, and apply that to better serving upstream organizations.

THE SOLUTION: MEASURING SUPPLIER SATISFACTION

The simplest solution to insuring that differences in perceptions between buyers and suppliers doesn't restrict the gains from supplier partnerships is for buyers to measure supplier perceptions and determine their expectations for the partnership, their expectations of the buyer in the partnership, and their perceptions of the buyer's performance in the partnership. In essence, buyers need to measure supplier satisfaction in the same way that their firm would measure customer satisfaction. Such measurement would allow firms to begin to bridge the perception gap in their relationships with suppliers, allowing relationships to advance toward true collaboration and partnership. With a more accurate understanding of its role in the partnership, the buying firm is then in a position to change its behaviors to better allow the supplier to meet the buying firm's needs.

Roberts (2001) has recently proposed that supply chain management/purchasing departments should begin to survey their internal customers – the marketing, production and engineering functions within the firm – as a basis for evaluating and improving its performance. Roberts suggests that surveying internal customers will help purchasing managers better understand their customers and their customers to better understand them. It also signals to internal customers that the purchasing group cares about their needs and as such helps promote trust between the purchasing group and its customers. Communication of survey results back to respondents, along with action plans for improvements based off the surveys, represents an opportunity to further develop trust and enhance the relationship with internal customers. Such communication shows internal customers that the purchasing group is responsive to their concerns and needs. What is suggested in this paper is that this approach be extended to the organization's suppliers, since the same need for trust and a working relationship exists. Roberts proposes such a survey because the purchasing department serves these other departments in the firm. In the similar way, the purchasing group provides a service to the supplier. That is, one role of the purchasing department is to facilitate the interactions between suppliers and the rest of the organization. It would make sense for the purchasing department to ask how well it was meeting both sides' needs in this role. The survey proposed in this paper, however, would go beyond simply measuring supplier satisfaction with the purchasing department (although a more limited survey like this might provide a good starting point) and also look at the suppliers' satisfaction with the overall performance of the firm.

Measuring suppliers' expectations of the buying organization and suppliers' perceptions of the buying organization's performance represents a very concrete process aimed at maintaining and strengthening partnerships with suppliers. Landeros et al. (1995) found that many buyer-supplier partnerships fail because partners lack an established process to maintain the relationship. The researchers argued that an important part of such a maintenance process was to be able to understand how problems can enter a relationship. Further, Landeros et al. found that differences between expectations & performance, more than absolute performance, drove successful buyer-suppler relationships. According to Landeros et al. (1995, p. 10), "The partners expectations and perceptions of each other's performance generally appear to be the primary factors in the development and maintenance of a sound buyer-seller partnership." Given the importance of both expectations and perceptions of performance, a servqual-like instrument might be an appropriate starting point for developing an appropriate survey. This is also the type of survey methodology that Roberts suggested was needed when working with internal customers. Interestingly, while Landeros et al. (1995) argued that successful buyer-supplier relationships depended on the fulfillment of mutual expectations, their recommendation focused solely on the buyer developing expectations for the supplier and measuring the supplier's performance against those expectations, and did not deal at all with creating expectations for the buying organization or measuring the buying organization's performance relative to those expectations.

Approaches other than a formal supplier satisfaction survey might also be used to evaluate the buying organization's performance vis-à-vis its suppliers – the point is more generally that buying organizations need to get feedback from their suppliers on how well they believe that the buying organizations are performing in the relationship. Vokurka (1998), for example, describes one company's successful supplier partnership program that included a supplier advisory council that was initiated to create a mechanism to foster continuous improvement in how the company managed supplier partnerships. The council consisted of either the president or division head of six major material suppliers along with the company's own president and its directors of manufacturing, engineering and purchasing. The council's purpose was "to review current and proposed purchasing policies and practices with the overall goal of making the company the best customer it can be." (Vokurka, p. 33). Most organizations do not approach their relationship with suppliers with the goal of being the best customer possible. However, it is this underlying change in attitude that is necessary to truly optimize performance in the supply chain.

CONCLUSIONS

This paper has attempted to make the case that buying organizations should be treating suppliers more like customers and specifically need to begin to seek supplier feedback on the buying organization's performance. Empirical evidence clearly indicates that (i) buying organizations are attempting to establish more partnership like relationships with their suppliers, and that when successfully implemented, such relationships lead to improved firm performance and competitive standing; (ii) successful partnerships require trust to develop between organizations, and such trust requires open, two-way communication; and (iii) despite traditional communication efforts between buyers and suppliers, a significant and persistent gap exists between buying organizations and their suppliers in terms of their expectations and their perceptions of the their partners performance.

These three results, taken together, indicate a significant shortcoming in the management of an organization's supply chain. It is proposed that the root cause of this problem stems from thinking about supply chains as having a dominant directional component. Treating suppliers a little more like customers should help to overcome this mentality, allow firms to eliminate the significant perception gap that impedes development of a true partnership approach, and promote real optimization of performance across an organizations supply chain. The proposed first step is for buying organizations to ask their suppliers for feedback on how well they are performing in the relationship. This information should put buyers in a much better position to truly optimize performance of the supply chain.

It could be argued that the analysis and proposals put forth in the latter half of this paper are off the mark because suppliers are different from customers and can generally be replaced more easily than customers (assuming that another supplier exists that has the necessary capacity and capabilities to meet the buyer's needs). This argument, however, misses the point. Organizations that think about their suppliers as easy to replace are almost certainly not treating their suppliers like partners. The point is that organizations need to begin to view their key suppliers as invaluable as their key customers, and begin to treat them as such. Measuring suppliers' satisfaction with the buying organization's performance and responding to supplier concerns raised through such a process strengthens the network of companies that the buying organization competes within, ultimately benefitting the buying organization.

In closing, it should be noted that thinking about suppliers more like customers certainly does not preclude the buying organization from saying "no" to a supplier request or even switching suppliers if it becomes apparent over time that the supplier-partner is no longer an asset to the supply chain. What it does is provide the buying organization with much needed information about how their suppliers view them as a customer, which can help overcome the perception gap in the relationship, which would seem to help significantly in the establishment of trust that so many organizations report as critical for successful buyer-supplier relationships. Likewise, it provides a means to uncover opportunities at the boundaries in the supply chain for true supply chain optimization to occur.

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PRODUCTION & OPERATIONS QUALITY CONCEPTS: DEFICIENT DIFFUSION INTO THE SERVICE SECTOR

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ABSTRACT

Over the past 25 years, America has migrated from an industrial economy toward information, technology and service. The shift is well documented by various statistics regarding the declining balance of manufacturing exports-to-imports, declining manufacturing employment and declining direct labor content within goods, as well as through the transformation of the Dow Jones Industrial Average components.

The production/operations management discipline has been slow to respond. Since 1992, only the smallest percentage of academic articles in the leading production/operations management journals have been devoted to service operations. Textbook content reveals only the weakest trend to alter the classic manufacturing paradigm toward services.

Accordingly, this paper hypothesizes that basic quality concepts embedded within the production/operations management body of knowledge have been slow to transfer into the service sector. The survey instrument, involving 126 service corporations across 32 industries, enjoyed a 91% response rate. The results find that the overall degree of knowledge in the service sector is very low. Many of the resulting means placed within the lowest quartile of the Likert scale. The authors hope that this paper and evidence will effectively serve as a call for production & operations management academics to more aggressively shift their discipline perspective toward services.

THE RISE OF SERVICE AND THE DISCIPLINE PERSPECTIVE

Over the past twenty-five years, America has migrated from an economy based upon industrial and manufacturing activity toward an economy, to great extent, based upon information, technology and service—in agreement with the prophetic 1980 perspective of futurist Alvin Toffler (1980). There is little doubt that the service sector has now all but replaced the dominance of the manufacturing sector within the American economy. By 1990, service accounted for 72% of U.S. Gross National Product (U.S. Bureau of Economic Analysis, 1991) and accounted for 70% of American employment (Schmenner, 1995). Employment in the manufacturing sector began a rapid decline during the late 1990s, with 3 million jobs lost between 2000 and 2003, that being one-sixth of the total manufacturing sector (Anonymous, 2003a, 2003b) , while the number of Americans employed in service continues to increase (Stevenson, 1996). The American economic shift away from manufacturing toward service is also well documented with various other economic statistics regarding the declining balance of manufacturing exports-to-imports, declining manufacturing employment and declining direct labor content within goods.

Perhaps even more persuasive evidence of the American economic shift from manufacturing toward service in the last twenty-five years is found within the composition of the thirty component corporations of the Dow Jones "Industrial" Average (DJIA); during that time, the component basis of the DJIA has steadily moved toward service. Table 1 displays a number of significant changes evidencing the trend (Dow Jones & Company, 2004; Shell, 2004).

According to a recent USA Today article (Shell, 2004), the 1999 changes represented the point at which "the stodgy index that once tracked the smokestack economy went ‘new economy.'" The article also states that International Paper "was expelled because basic materials matter less in today's information-based economy." In addition, other long-standing DJIA component corporations such as IBM and Honeywell have clearly shifted a significant percentage of their core business into the service sector. With similar perspective, Fortune magazine stopped distinguishing between service and manufacturing within its Fortune 500 list during the 1990s.

The rise of service is also evidenced throughout much of the industrialized world as well, representing nearly 70% of the civilian labor force in Canada, Australia, France and the Netherlands and nearly 50% in Germany, Japan and Italy (U.S. Bureau of Economic Analysis, 2002).

Table 1
DJIA Component Replacements Toward Service Content

New Component	Replaced Component	Year
American Express	Manville Corporation	1982
McDonalds	General Foods	1985
Disney	U.S. Steel	1991
J. P. Morgan Chase	American Can	1991
Citigroup	Westinghouse	1997
Wal-Mart	Woolworth	1997
Microsoft	Chevron	1999
SBC Communications	Union Carbide	1999
Home Depot	Sears, Roebuck	1999
American International	International Paper	2004
Verizon	AT&T	2004
Pfizer	Eastman Kodak	2004

The academic perspective regarding production & operations management, however, remains stubbornly focused upon its manufacturing paradigm "roots" rather than shifting toward services. The authors reviewed 217 abstracts from Journal of Operations Management, generally recognized as the discipline's leading journal (Barman, Hanna, & LaForge, 2001; Barman, Tersine, & Buckley, 1991; Soteriou, Hadjinicola, & Patsia, 1999; Vokurka, 1996). The review, which included the articles published from 1993 through 2001, found no more than seven articles (3.2% of the total articles) squarely focused upon the topic of service operations (Heineke, 1995; Karmarkar & Pitbladdo, 1995; Kellogg & Nie, 1995; Miller, Craighead, & Karwan, 2000; Narasimhan & Jayaram, 1998; Soteriou & Chase, 1998; Stank, Goldsby, & Vickery, 1999) and no more than 18 articles with some significant degree of service operations content. In contrast, 68 articles (31.3% of the total articles) were found to have "classic" topics such as planning, scheduling, forecasting and production control intended for the manufacturing environment.

Even the most cursory longitudinal examination of production & operations textbooks reveals only the weakest trend to alter the classic manufacturing perspective or to add service content. For example, the index of the 1996 edition of the best-selling production & operations management textbook (Stevenson, 1996) identifies only 17 of its 897 pages (1.9%) as pertaining to services; the index of the 2005 edition (Stevenson, 2005) identifies only 35 of its 871 pages (4.0%) as pertaining to services. In 2003, a major production/operations textbook (Heizer & Render, 2003) did adopt a predominant service theme in its seventh edition, threading its examples through a case based upon the Hard Rock Café. For the most part, however, the production & operations management discipline persists in perceiving service operations as distinct from the production & operations discipline, as evidenced by brand-new textbooks dedicated solely to service operations such as Davis & Heineke (2003) as well as continuing editions of dedicated service operations textbooks such as Fitzsimmons & Fitzsimmons (2004).

There is even earlier evidence of the discipline's resistance to service issues. During the 1980s and early 1990s, much (though certainly not all) of the significant service operations research was actually conducted within the discipline of marketing, by researchers such as Martin Bell (1986), Mary Jo Bitner (1992), John Bowen (1990) and Christopher Lovelock (1980; 1983; 1984; Maister & Lovelock, 1982). Many of the articles authored by these researchers are still considered "service classics" and continue to strongly influence, and comprise no small portion of, the production/operations management body of knowledge with respect to services. The term "service factory" provides one example. The term, which refers to how service operations such as McDonalds are similar in nature to a traditional manufacturing operation, was popularized within the production & operations discipline by a Harvard Business Review article titled "The Service Factory," written by two productions & operations management academics possessing a special interest in services (Chase & Garvin, 1989). However, the term "service factory" actually appeared six years earlier in the marketing literature within an article authored by marketing professor Christopher Lovelock (1983). Another example involves the "classic" list of characteristics that differentiate manufactured goods from services, a list typically found in recent production & operations management textbooks;

that list is essentially derived from a Lovelock services marketing text published twenty years ago (1984).

HYPOTHESES

Based upon this delay in the conversion of the production & operations management academic perspective from that of manufacturing operations toward service operations, the authors hypothesize that:

H1: The degree of production & operations discipline concepts diffused into the practice of service operations is relatively low.

Since we suspect that there is little "formal" diffusion of these concepts, much of any existing diffusion is expected to be "informal" in nature. Under such informal diffusion, concepts that are easier for practitioners to conceptualize—or to transfer easily by "word of mouth"—may well possess higher degrees of diffusion into the service sector. Accordingly, the authors additionally hypothesize that

H2: Differences in diffusion exist between production & operations discipline concepts transferred into the practice of service operations.

The final hypothesis concerns industry effect. All service operations and industries differ substantially, and in similar fashion, from that of traditional manufacturing operations, hence no industry effect is anticipated:

H3: There is no industry effect upon the degree of production & operations discipline concepts diffused into the practice of service operations.

METHOD

The participants in this study were individuals selected from 126 service corporations across 32 service industries. With minimal exception, the corporations surveyed have significant national presence and were surveyed via a local unit operating within thirty miles of a specific medium-sized mid-Atlantic state university. One individual, in most cases an individual with some degree of managerial experience, was surveyed at each corporation. Table 2 presents the 32 service industries surveyed, each noted with the number of companies surveyed within that industry.

The survey employed nine-point Likert-style scales to capture self-reported degrees of knowledge regarding 24 major quality concepts (including three service quality concepts) commonly found within the production & operations management body of knowledge. The specific concepts measured are listed within Table 3 (displayed in the first Data Analysis section).

While the sample is intended to be representative of the population of all units of all the 126 service corporations, it is important to note that the selection of the participants in this study was based upon convenience sampling. According to Kerlinger (1986), in convenience sampling, probably the most frequent form of sampling, selection is based upon ease of accessibility. Such sampling is not truly random and therefore may impact generalizability, however, it often leads to intellectual insights not otherwise easily afforded and is generally acceptable in exploratory work. In this case, the convenience is the geographic proximity of the business establishments. Indeed, Babbie (1995) presents a specific example regarding how geographic proximity can easily result in a non-representative sample.

Table 2
Service Industries Surveyed

Accounting & Tax Services (2)	Consumer, Food & Beverage (28)
Automobile Rental (4)	Furniture/Appliance Rental (3)
Automobile Repair (non-dealer) (4)	Groceries (5)
Automobile Sales, New (7)	Home Furnishings, Retail (2)
Automobile Supplies, Retail (3)	Home Improvement, Retail Sales (2)
Banking (3)	Hospitality (7)
Books, Retail Sales (2)	Insurance, Consumer (3)
Cable a/o Internet Provider (2)	Letter & Package Delivery (3)
Clothing, Retail Sales (5)	Office Supplies, Retail Sales (2)
Consumer Loans (Non-Bank) (3)	Optical Goods, Retail (2)
Department Stores (5)	Real Estate Sales (3)
Drug & Sundries, Retail (5)	Retail, Miscellaneous (2)
Duplication and Binding (2)	Stock Brokerage (4)
Electronics, Retail Sales (3)	Telecommunications, Consumer (4)
Employment, Temporary (2)	Toys, Retail (2)
Extermination, Pest (2)	Video & Game Rental (2)

However, there is much academic license to legitimately employ convenience sampling within the context of this study. Kerlinger (1986) advises convenience sampling can be used "with reasonable knowledge and care" and so long as "circumspection in analysis and interpretation of data" is used. Deming (1960) states that the reader "relies upon the expert's judgment" when encountering "judgment samples … in which an expert … makes a selection of 'representative' or 'typical' … business establishments." Babbie (1973) states that judgmental sampling "to be done effectively … requires … expertise ... well versed … in the area under consideration so that selection … is based on an educated guess as to its representativeness."

In this study, the authors exercise that allowed reasonable judgment and expertise to argue that there exists a reasonable degree of homogeneity and representativeness across individual units of a large service company with many units comprising its national presence. Such individual units are typically governed by centralized models, procedures, training and management practices. Hence, if one manager has not been trained or exposed to a specific quality concept by his company, there is fair reason to suspect that other managers at other units have likewise been untrained or unexposed. Accordingly, the authors believe that the sample is much more representative of the population than non-representative in nature, and so sufficient for the intent of this study, i.e., to find some exploratory support for the hypotheses that have been argued. (This argument simultaneously addresses any argument regarding the sufficiency of n.) Regardless, the authors must acknowledge that geographic proximity is a formal limitation upon any conclusions and generalizations drawn from this study.

One shortcoming of the research design was that since, in a number of industries only two or three companies existed or were proximate, less reliable measures of dispersion for those industries resulted. A second shortcoming of the design is that the survey instrument was not designed to distinguish the source of the respondent's knowledge of the concepts, i.e., whether the knowledge was internally or externally derived, formally or informally diffused into the organization. It was only after the design and distribution of the instrument that the authors recognized that they might wish to control or analyze this factor. Hence, the conclusions and generalizations are also limited by these design factors.

Of the 126 survey instruments distributed, 114 usable responses were received, which translates into a 91% overall survey response rate. The high response rate is primarily attributed to the use of face-to-face method in survey distribution and collection. While there is no general safe limit to nonresponse (Deming, 1960), such a high response rate greatly reduces the risk of any nonresponse bias. Further, of the twelve nonresponses, the surveyors reported that eight nonresponses were cited as due to company policies against the release of competitive information. Consideration of this additional information, in combination with the high response rate, leads the authors to conclude the likelihood of nonresponse bias is extremely low.

DATA ANALYSIS AND CONCLUSIONS FOR H1: DEGREE OF KNOWLEDGE

Table 3 presents the descriptive statistics for each of the 24 concepts measured. These descriptive statistics indicate the overall degree of knowledge of these concepts within the service sector is very low. None of the 24 quality concepts measured resulted in a mean greater than five, the median value within the nine-point Likert scale employed. Fully one-third of the concept means fell within the lowest quartile of the scale. The grand mean of 3.04 and grand median of 2 are even stronger evidence of the overall low degree of knowledge.

Table 3: Descriptive Statistics for Concepts Measured

Concept Measured	Mean	SD	Min	Max	Median
Benchmarking	4.76	2.75	1	9	5
14 Points for Management	3.36	2.27	1	9	3
Hidden Factory	2.44	2.02	1	8	1
Ishikawa/Fishbone Diagrams	2.5	2.09	1	9	1
ISO 9000	2.73	2.39	1	9	1
Juran's 80:20 Rule	3.05	2.35	1	9	2
Kaizen/Continuous Improvement	3.61	2.58	1	9	3
Kanban/Pull Methods	2.75	2.14	1	9	1
Kano's "Delightful Quality" Model	2.48	2.19	1	9	1
Moments of Truth	3.47	2.74	1	9	3
Pareto Charts	2.31	1.94	1	9	1
PDSA Cycle	2.67	2.13	1	8	1
Poka-Yoke & Mistake-Proofing	2.41	2.12	1	9	1
Quality Circles	3.88	2.64	1	9	4
Quality Dikes	2.82	2.23	1	9	1
Root Cause Analysis	3.94	2.68	1	9	4
Service Bookends	3.05	2.34	1	9	2
Service Recovery	3.54	2.55	1	9	3
Shingo Methods	1.94	1.77	1	9	1
Six Sigma	2.23	1.8	1	7	1
Statistical Process Control Charts	3.35	2.6	1	8	3
Taguchi Methods	1.85	1.55	1	9	1
The Four Costs of Quality	3.68	2.51	1	7	3
Zero Defects	4.14	2.73	1	9	5
All Concepts	3.04	2.42	1	9	2

While similar descriptive statistics from a sample of the manufacturing sector would be required in order to perform a formal comparison between the two sectors, the extremely low numbers tabled greatly increase the likelihood of significant difference between the two sectors. Based on the values tabled, so very near the lowest values possible, the authors conclude that the analysis provides reasonable informal evidence to support H1, that the degree of production & operations discipline concepts diffused into the practice of service operations is relatively low.

DATA ANALYSIS AND CONCLUSIONS FOR H2: DIFFERENCES IN CONCEPT DIFFUSION

Table 4 presents the 95% confidence intervals for the 24 concepts measured, tabled in decreasing order of the lower bound. The tabling of ranked confidence intervals, rather than a complete tabling of all possible t-tests and resulting p-values, greatly simplified the illustration of these comparisons within the confines of this paper. The confidence intervals adequately facilitate determinations regarding whether concepts significantly differ in degree of diffusion. For example, the lower bound for the benchmarking concept is greater than the higher bound of concepts 5 through 24. Hence we may conclude that the benchmarking concept has a significantly higher diffusion into the service sector than those twenty concepts. Examining the table from the bottom in similar fashion also yields significant differences. For example, the upper bound for the Taguchi Methods concept is lower than the lower bound for concepts 1 through 16. The authors note that the issues of lack of pooled variance and paired comparison place some minor limitations upon the claim of significance. The results of these comparisons are displayed in Table 5.

Table 5 facilitates an informal categorization of the concepts into five strata: concepts 1 through 4, concepts 5 through 12, concepts 13 through 16, concepts 17 through 22 and concepts 23 and 24. The authors offer some speculation regarding of the nature of these tiers. The first-tier concepts are relatively easy to verbalize and transfer "by word of mouth." Many of the second-tier and third-tier concepts have been highly visible in press, trade magazines and popular books. The nomenclature regarding a number of the fourth-tier concepts may well be unfamiliar—results might have been different had different nomenclature been used. The fifth-tier concepts are generally more technical and complex, not easily transferred without formal study. The authors believe this argument suggests that most of the service knowledge that was measured was not transmitted through formal organizational channels.

Again, while calculation and illustration of all possible t-tests and resulting p-values would have added a slightly more formal significance, would have added the additional information that p-values offer, and would have perhaps added a somewhat more precise stratification of the concepts, the confidence interval approach tabled above is more compact and yet still yields more than adequate statistical evidence to support H2, that differences in diffusion exist between the various production & operations discipline concepts transferred into the practice of service operations.

Table 4
95% Confidence Intervals for Concepts Measured

Concept Measured	Mean	Lower Bound	Upper Bound
1) Benchmarking	4.25	4.76	5.28
2) Zero Defects	3.63	4.14	4.65
3) Root Cause Analysis	3.44	3.94	4.44
4) Quality Circles	3.39	3.88	4.37
5) The Four Costs of Quality	3.21	3.68	4.14
6) Kaizen/Continuous Improvement	3.13	3.61	4.09
7) Service Recovery	3.06	3.54	4.01
8) Moments of Truth	2.97	3.47	3.98
9) 14 Points for Management	2.94	3.36	3.78
10) Juran's 80:20 Rule	2.92	3.05	3.49
11) Statistical Process Control Charts	2.87	3.35	3.83
12) Service Bookends	2.62	3.05	3.49
13) Quality Dikes	2.4	2.82	3.23
14) Kanban/Pull Methods	2.35	2.75	3.14
15) ISO 9000	2.28	2.73	3.17
16) PDSA Cycle	2.27	2.67	3.06
17) Ishikawa/Fishbone Diagrams	2.11	2.5	2.89
18) Kano's "Delightful Quality" Model	2.08	2.48	2.89
19) Hidden Factory	2.06	2.44	2.81
20) Poka-Yoke & Mistake-Proofing	2.02	2.41	2.81
21) Pareto Charts	1.95	2.31	2.67
22) Six Sigma	1.89	2.23	2.56
23) Shingo Methods	1.61	1.94	2.27
24) Taguchi Methods	1.56	1.85	2.14

Table 5: Confidence Intervals Comparisons

Concept Measured	Significantly Different By Upper Bound from Concepts	Significantly Different By Lower Bound from Concepts	Not Significantly Different from Concepts
1) Benchmarking		5-24	2-4
2) Zero Defects		10, 12-24	1, 3-9, 11
3) Root Cause Analysis		13-24	1-2, 4-12
4) Quality Circles		13-24	1-3, 5-12
5) The Four Costs of Quality	1	14-24	2-4, 6-13
6) Kaizen/Continuous Improvement	1	14, 16-24	2-5, 7-13, 15
7) Service Recovery	1	16-24	2-6, 8-15
8) Moments of Truth	1	17-24	2-7, 9-16
9) 14 Points for Management	1	17-24	2-8, 10-16
10) Juran's 80:20 Rule	1-2	19-24	3-9, 11-18
11) Statis. Process Control Charts	1	19-24	2-10, 12-18
12) Service Bookends	1-2	22-24	3-11, 13-21
13) Quality Dikes	1-4	23-24	5-12, 14-22
14) Kanban/Pull Methods	1-5	23-24	6-13, 15-22
15) ISO 9000	1-5	23-24	6-14, 16-22
16) PDSA Cycle	1-7	23-24	8-15, 17-22
17) Ishikawa/Fishbone Diagrams	1-10		11-24
18) Kano's "Delightful Quality" Model	1-10		11-24
19) Hidden Factory	1-11		12-24
20) Poka-Yoke & Mistake-Proofing	1-11		12-24
21) Pareto Charts	1-11		12-24
22) Six Sigma	1-12		13-24
23) Shingo Methods	1-16		17-24
24) Taguchi Methods	1-16		17-24

DATA ANALYSIS AND CONCLUSIONS FOR H3: INDUSTRY EFFECT

As displayed within Table 2, only two or three useable responses per industry were collected from a number of industries. While two responses within a specific industry would technically allow for the calculation of a standard deviation, the authors believe that such deviations would not be adequately representative of the population. Accordingly, pair-wise industry comparisons were not conducted. However, an overall analysis of variance was conducted to determine whether any industry effect was present. The results of that ANOVA are displayed in Table 6.

Table 6
Analysis of Variance, Industry Effect

Source of Variation	SS	df	MS	F	p-value
Industry	74.011	30	2.467	0.913	0.599
Error	224.276	83	2.702		
Total	298.287	113			

The ANOVA finds no significant industry effect and the resulting p-value indicates any industry effect present is, indeed, quite weak. This result displayed in Table 6 allows for the reasonable conclusion that the diffusion of production & operations quality concepts into the service sector is poor regardless of the specific service industry. Accordingly, the authors conclude that support is found for H3, that there is no industry effect upon the degree of production & operations discipline concepts diffused into the practice of service operations. The conclusion serves to strengthen the notion that services, as a single entity, suffer from deficient diffusion of production and operations management knowledge.

CONCLUSION

While this study is exploratory and, to some minor degree, informal in nature, the authors believe it represents a significant contribution to discipline knowledge, in that it provides sufficient evidence that, after nearly a quarter-century of "a service economy," the production and operations discipline perspective has not sufficiently metamorphosized in a manner that would facilitate the diffusion of its body of knowledge into the service industries.

The authors have noted other calls in the production & operations management literature for researchers to redirect their research efforts when the discipline is in need of alignment. For example, in the early 1990s, a number of calls to conduct more empirical production & operations research appeared in major journals (Flynn, Sakakibara, Schroeder, Bates, & Flynn, 1990; Meredith, Raturi, Amoako-Gyampah, & Kaplan, 1989; Swamidass, 1991). The authors have found no equivalent call in the literature stating that a more significant shift in the production & operations management discipline toward service is warranted. It is hoped that this paper, as well as its exploratory evidence, illustrates the need for such a shift and that it will serve as such a call.

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THE EBAY FACTOR: THE ONLINE AUCTION SOLUTION TO THE RIDDLE OF REVERSE LOGISTICS

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ABSTRACT

Cottrill (2003) observed that "reverse logistics is no longer an afterthought, as companies discover gold in the mountains of returned products at the back end of the supply chain" (p. 20). This article examines this proposition, looking at the increased focus on the handling of returned and excess goods and merchandise through reverse logistics operations. The article outlines the dimensions of the returns problem and gives an overview of the concept of reverse logistics, examining the ways that management of the "reverse supply chain" differs markedly from a firm's forward facing operations. The article explores how and why online auctions through eBay are becoming an integral part of leading retail and consumer goods' companies reverse logistics strategies. It offers guidance as to what key questions executives face in developing a proactive strategy for handling returns and excess goods and whether to do so in-house or via third-party providers.
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INTRODUCTION

No company wants to see its products returned. No retailer wants to see customers lined-up at its service desk with armfuls of merchandise. No store wants to see goods languishing on the shelves far past their saleable date, such as computers with processing speeds that are too slow or licensed apparel for movies that are long forgotten. Likewise, no OEM (Original Equipment Manufacturer) wants to see its products arriving at its loading docks, rather than being shipped out. In short, returns are an area that no one wants to deal with, but which *all* partners in the retail supply chain inevitably have to.

With today's competitive business environment, every consumer-facing company must concentrate on maximizing the efficiencies and effectiveness of its *forward* supply chain (Lee, 2002). However, we have reached the point today where electronic methods for both acquisition and sales support have, in effect, become simply *defacto* standards for all firms. Now, no less an authority than Dr. Michael Hammer (2001), the founder of the reengineering movement, has observed that because e-procurement and CRM (Customer Relationship Management) techniques have become competitive necessities today, "competitive advantage must be sought in parts of the value chain that thus far have been either overlooked or under-addressed" (p. 4).

Now, attention is being focused on the "flip side of the supply chain" (Mason 2002, p. 42). Writing in the *Harvard Business Review*, Guide & Van Wassenhove (2002) labeled the handling of returned goods and merchandise as the "reverse supply chain," which they describe as "the series of activities required to retrieve a used product from a customer and either dispose of it or reuse it" (p. 25). This area is now referred to as *reverse logistics*, defined by The IQ Business Group (2003) to be: "The process of managing the movement of specific goods away from their typical final destination in order to maximize its value or for proper disposal" (p. 1).

In this article, we will look at the problem of returned merchandise and how an effective reverse logistics strategy, including online auctions of a significant portion of these items, can produce dramatic results for companies. We will examine the scope of returns today, examining the size and scope of the problem. Then, we will look at the practice of reverse logistics and how it can help companies cut the costs of returns, even producing positive revenue for leading edge companies through online auction sales. Finally, we will conclude with advice on how to pursue an online auction strategy as part of an overall reverse logistics operation.

RETURNS - "THE UGLIEST PART OF THE RETAIL ENVIRONMENT"

We may not think much about the fishing pole, oil filter, or cereal that we return to our local Wal-Mart. However, in the aggregate, customer returns represent 4% of retailers' total revenues - or an astonishing total of approximately $100 billion per year (Trebilcock, 2001)!

Current statistics show that the overall return rate for products sold in the United States is approximately 6%. The rate of returns for different categories of products can be staggeringly high – up to 50% of all products shipped for some goods. For instance, for the consumer electronics area, the return rate is 8.5%. (Lee, 2002). There are some ninety million individual items returned items annually (Cox, 2001). The cost to manufacturers just in handling, processing and transporting returns has been estimated to be up to $150 per item, which amounts to over $40 billion annually across the American economy (Mannella, 2003). This corresponds to an estimate from the Reverse Logistics Executive Council, which approximated that in the U.S. alone, the costs associated with reverse logistics are approximately $35 billion annually (Kim, 2003).

When looking at statistics such as these, it is clear that product returns should be an area of concern for all consumer goods companies. The high level of returns in areas such as retailing, computers, mass merchandising and publishing makes managing them effectively a "competitive necessity" (Pathania & Andrews, 2003, p. 9).

In the consumer area, returns have been categorized by Jeff Roster, a senior analyst with Gartner, as "the ugliest part of the retail environment...(being) all expense with no upside" (op. cited in Sant, 2000). Until recently, most companies have looked upon the area of product returns as a "black hole" (Anonymous, "Reverse Logistics Services: New Prospects for Carriers," 2003). In fact, the landfill was often the most attractive option for firms dealing with such volume of reverse flow. For instance, before implementing a companywide reverse logistics solution, large retailers, such as Sears and Radio Shack, routinely saw the landfill as the best route for returned goods to take (Mason, 2002). For instance, Estee Lauder used to dump $60 million worth of cosmetics annually that had been returned to them (Caldwell, 1999).

REVERSE LOGISTICS

Reverse logistics has been categorized as "the 'neglected child' in the extended family of the supply chain" (LIS, 2003, p.1). The concept was first defined in the academic literature by Murphy & Poist (1989) as "the movement of goods from a consumer towards a producer in a channel of distribution" (p. 179). de Brito, Dekker, and Flapper (2003) categorized reverse logistics as a newly recognized and increasingly academic field of study, examining "the processes associated with the reverse stream from users/owners to re-users" (p. 1). Yet, while there is increasing interest amongst firms in reverse logistics, most articles dealing with reverse logistics are still published in practitioner-focused magazines and newsletters, rather than in academic journals (Dowlatshahi, 2000).

The flow of goods encountered in reverse logistics operations has been dubbed every company's "worst nightmare" (Lee, 2002, p. 1). This is far from hyperbole. Clay Valstad, Director of Reverse Flow and Specialty Distribution for Sears, categorized the principal difference between forward and reverse logistics as being that: "on the forward side, you deal with order. On the reverse side, you deal with chaos, trying to create order" (quoted in Harps, 2003, n.p.). Think of it, on the procurement side, an organization is dealing with an organized flow of items, coming into its possession in an organized manner (in truckloads, pallets, and cases) and clearly labeled and packaged. On the opposite end, reverse logistics deals with a random flow of goods and materials of all types. To compound the problem, these items, which have been accurately referred to as "castaway stuff", comes in various states of operability and usability and with varying degrees of marketability and value (Wilder, 1999). This led Veerkamolmal & Gupta (2002) to observe that the operational characteristics of reverse logistics were fundamentally different than the forward logistics involved in manufacturing and distribution.

As Kim (2003) points out, managing the reverse supply chain is a very different and much more complex matter than trying to make an organization's forward supply chain more efficient and cost-effective. According to Zeiger (2003), the barriers to effective reverse logistics include: company policies, competitive issues, financial resources, the relative importance placed on reverse logistics, the lack of systems, legal issues, management inattention, and personnel resources. This is compounded by the fact that because the complexity of reverse logistics means that there really is not, at present, an effective "off-the-shelf" software solution available to handle the reverse flow.

IS REVERSE LOGISTICS A COST OF DOING BUSINESS?

Are these costs associated with returns just a cost of doing business? Today, many astute companies are answering "no." They are working to cut their net costs in handling returns and even finding ways to derive positive revenue from these operations.

Managing returns is not a core competency of *any* traditional organization. Thus, companies today that do not actively manage their reverse logistics to dispose of excess inventory and surplus assets efficiently incur sizeable costs. These are brought on by inefficiently allocating internal resources to manage the administrative burdens of this non-core function. These costs, both of the obvious and hidden variety, include: opportunity costs, poor space utilization, depreciation expenses, tracking and inventory expenses, maintenance costs, insurance costs, lower ROA (return on assets), and higher taxes (Mannella, 2003). Poor management of returns can thus be a significant drag on a company's financial performance, or worse, actually push a business towards bankruptcy. Companies must ultimately decide whether to handle returns internally or to outsource much, if not all, of the process to a growing sub-industry of third-party service providers (3PSPs) emerging in the reverse logistics area.

If a company looks to sell the portion of its returned goods inventory that is saleable, the traditional method has been through the use of liquidators or auction houses. Traditional liquidators represent a quick path to cash, but they *rarely* are a method through which firms can achieve the best possible price on their returns. A company may deal with two or three liquidators who bid within a narrow range, sometimes averaging only 3 to 5 cents on the dollar. In addition, most liquidation houses won't take small lots, resulting in additional warehousing and handling costs to the firm. On the other hand, traditional auction houses focus on one-time sales of surplus, rather than providing an *ongoing* solution to companies' surplus needs. Traditional auctioneers emphasize physical events that bring together a limited number of buyers in one place to bid at a specific time. Thus, the limited market produces limited recoveries on firms' returns. Additionally, the associated logistics costs, sales commissions and long lead-times can significantly affect total return on assets.

Companies certainly benefit from the sale of such surplus items. In fact, according to ATKearney (2002), 70-90% of every dollar generated through asset recovery goes straight to the bottom-line. Thus, even at low rates of recovery, companies gain from simply disposing of the unwanted "stuff" and gaining revenue from formerly lost goods.

The market for surplus goods has been accurately described as being a difficult market, characterized by inefficient processes and illiquidity (Draenos, 2000, p. 126-127). The chief reason that the market is illiquid and inefficient is poor information, making it hard for buyers and sellers to connect (Hickey, 1999). Traditionally, the surplus market has also been localized in scope, with trading being geographically confined (Norman, 2003).

In market after market, the Web is forcing transparency throughout the economy, making information sharing an economic imperative today (Hof, 2003). According to Hannon (2001), "the core benefit of online exchanges is that they disseminate real-time information globally…opening up previously isolated markets" (p. 24). The market for surplus is thus another area of the economy where the use of e-tools can create whole new ways of doing business. One such e-tool is the use of online auctions.

THE ONLINE AUCTION SOLUTION

Surplus auctions were defined by Hickey (1999) as a mechanism that "liquidates surplus at the best possible prices by allowing a range of potential buyers to bid for products at below market prices" (p. 29). According to Connection to eBay (2003), online auctions for surplus can be defined as "a dynamic pricing structure where buyers compete for the product(s); therefore, pushing the price to fair market value and maximizing cost recovery versus other disposition options" (p. 3).

According to *Investor's Business Daily*, total online sales will double over the next four years reaching over $100 billion annually by 2007 (Barlas, 2003). Forrester Research estimates that online auction sales are expected to reach $54.3 billion annually by 2007, with eBay projected to have an 85-90% share of this marketspace (Johnson, 2002).

The key for any online auction site is for it to reach "critical mass," in that you need a sufficient number of bidders and enough merchandise to interest them for to get competitive pricing (Teschler, 2000). Writing in *Decision Sciences*, Bapna, Goes, Gupta, and Karuga (2002) stated that online auctions, in the absence of spatial, temporal, and geographic constraints, provide an "alternative supply channel for the distribution of goods and services" (p. 558). Online auction sites such as eBay benefit from what economists term "network effects." In essence, this means that: "The more buyers who go to eBay (or other auction sites), the more sellers they attract, who in turn draw even more buyers as the site becomes a larger source of supply with more competitive prices" (Schonfeld, 2002, p. 54).

Leading original equipment manufacturers (OEMs) and retailers are increasingly looking to online auctions - and primarily, though not exclusively to eBay - as a way to dispose of excess inventory and returned goods (Hannon, 2001). These include household names, such as: Disney, Donna Karan, Ford, Hewlett-Packard, J.C. Penney, IBM, Kodak, Nike, Nokia, Ritz Camera, Sears, and Samsonite (Kemp, 2001; Berkowitz, 2003; Junnarkar, 2003).

Why eBay? According to Kane (2003), eBay is fast-shedding its reputation as an "online flea market" and attracting the large, corporate sellers. Now, particularly in the area of technology products, these goods are finding a ready, global pool of both individual and corporate buyers. eBay – or more precisely the individuals and companies selling on the site – "create markets where none existed before" (Schonfeld, 2002, p. 56). Based on dollar volume, business buyers now comprise 10% of all purchases on eBay (Connection to eBay, 2003).

The numbers on eBay are mind-boggling. According to the e-commerce analyst, eMarketer, on an average day in late 2003, eBay racks-up: 20 million listings, 120 million searches, 7.4 million bids, $64 million in goods sold, and 100,000 new users (Berkowitz, 2003). eBay is the most visited website online, with visitors lingering 3.5 times longer than on any other site. The "sales velocity" of items on eBay is startling, when one considers that, on average, three consumer electronics products are sold each second in the online marketplace (Connection to eBay, 2003). eBay's sales of over $20 billion in 2003 mean that the value of the trading volume on the firm's site exceeds the Gross Domestic Product of 130 of the nations of the world (Hof, 2003).

Kane (2002) pointed out that the lasting technologies of e-commerce are ones that help facilitate transactions. She cited eBay's introduction of the "Buy-It-Now" feature as one such example. Since introducing the feature in 2000, eBay has brought in buyers who might otherwise have been unwilling to participate in the auction process, with its inherent uncertainty and time demands. With approximately 20% of all transactions being consummated through the "Buy-It-Now" option, eBay has seen its average auction length shrink dramatically.

Companies are finding that eBay represents an ideal outlet for what Rogers and Tibben-Lembke (2002) labeled the "'B' channel," for goods that have been through a reverse flow. While the "B" channel is intended to operate separately and distinctly from a companies primary sales channel (their "'A' channel"), the "B" channel can also handle first quality and never used items as well. By operating as a "B" channel, companies can derive positive revenue, without harming their "A" channel. According to Barbara Gore, eBay's Senior Director of Marketing and Industry Relations, companies are often surprised to learn that their products are already being sold on the eBay marketplace, listed by individuals and bulk resellers who are hawking the firms goods online (op. cited in Berkowitz, 2003). For instance, according to Connection to eBay (2003), in 2002, approximately $2.2 billion in consumer electronics products were sold on eBay by manufacturers and retailers. Yet, in the same year, individuals sold approximately the same volume of used consumer electronics on eBay.

eBay can also be used not as a sales outlet, but as a dynamic source of market information. Today, many companies routinely use eBay for the pricing intelligence that can be gained by monitoring sales of like items on eBay. In this way, companies can glean a no-cost gauge on what they should be charging for their surplus or excess inventory items to see them move, whether in an online or offline sales environment (Berkowitz, 2003).

What kind of results on surplus sales are companies finding on eBay? Research has shown that companies that employ auctions increase their recovery prices on assets by, on average, 25% (Queree, 2000). According to Bill Angrick, CEO of Washington, DC-based Liquidity Services, Inc., online surplus auctions produce returns 50-200% higher than in-person, physical auctions (cited in Norman, 2003, n.p.).

CONCLUSION

Andre Brysha, Chief Marketing Officer of Ritz Interactive, observed that there will always be a need for remarketing refurbished and excess inventory, so long as American retailers continue to have liberal return policies (op. cited in Battey, 2001). As we have seen, reverse logistics is on the rise as an important part of a complete supply chain management strategy, and online auctions are increasingly being used as a tactic for turning returned goods and merchandise from a "black hole" into positive revenue. Far from being the "small beer" that Cottrill (2002) characterized them as, it is clear that online auction venues, led by the predominant eBay marketplace, are perhaps the most significant channel for returned and surplus merchandise for marketers of all stripes today.

Thus, firms will have to examine how directly they want to engage with their "B" sales channel through eBay. The overarching goal, of course, should be to maximize returns on the assets being auctioned, while minimizing costs of all forms (direct and indirect) associated with these items (Tulip, 1998).

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