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Evaluating the Success of Lodging Yield Management Systems

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Abstract
Although there are more than 7,000 properties using lodging yield management systems (LYMSs), both practitioners and researchers alike have found it difficult to measure their success. Considerable research was performed in the 1980s to develop success measures for information systems in general. In this work the author develops success measures specifically for LYMSs.

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Although there are more than 1,000 properties using lodging yield management systems (LYMSs), both practitioners and researchers alike have found it difficult to measure their success. Considerable research was performed in the 1980s to develop success measures for information systems in general. In this work the author develops success measures specifically for LYMSs.

Lodging yield management is the measurement and manipulation of internal and external economic variables to allocate specific lodging capacities to specific market segments at prices that maximize the firm's total revenue. Lodging yield management systems (LYMSs) are computerized programs that formalize the lodging yield management process. Since the inception of LYMSs[1] in the mid-'80s, more and more properties have begun to use them. A 1994 survey indicated that there were approximately 1,000 properties actively using LYMSs, but their acceptance has been slow. Part of this slow acceptance may be related to the difficulty of measuring their success.

Like any corporate asset, it is important that managers are able to measure their success. For example, purchase decisions may be based upon the success of an existing LYMS. Success measures may also be used by vendors to persuade managers to purchase one system over another. Chain organizations, as well, need to convince unit managers that their in-house LYMSs work. Once a system has been installed, success measures may be used to help determine if the system is functioning properly. Success measures may also be used to identify the system's strengths and weaknesses.

Both practitioners and researchers alike have found it difficult to accurately measure the success of information systems.[2] Many system benefits are subjective or intangible, and objective measures are often confounded by competitive and economic forces. Nevertheless, measuring LYMS success is necessary to justify the system's usage and expense.

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A fair amount of research has been performed, particularly during the 1980s, to develop reliable and valid instruments to evaluate the success of information systems in general, but none has focused specifically on LYMSs.[3] This article explains the development of a valid and reliable instrument that can be used by both researchers and practitioners to measure LYMS success.

Measures of Success Are Multi-faceted

Measures of system success can be either objective or subjective, and they must measure both organizational and technical validity. As Christensen[4] explained, a system that functions well mechanically (i.e., has technical validity) may not be successful unless it is perceived to be useful and usable (i.e., has organizational validity). Success measures must therefore consider the system's technical qualities, interface, impact on the user and the organization, and the user's and the organization's impact on the system.

Examples of objective measures include increases in profit (or revenue) directly related to system usage, system utilization, and increased productivity. Examples of subjective measures include level of user-satisfaction, measures of the perceived value of the system, and increases in information quality (e.g., accuracy, reliability, timeliness). Some variables can be measured in either a subjective or objective fashion. Examples include user decisional performance, cost-benefit analysis, and utility.

Some researchers in the general literature feel the use of several different surrogate variables enhances the accuracy of system evaluation while others are comfortable employing a sole variable. Delone[5] measured system usage by tracking the amount of computer generated reports. Ein-Dor and Segev[6] measured system usage by tracking time on the system. Montazemi[7] chose to measure user-satisfaction. King and Rodriguez[8] used the contribution to decision performance as a measure of system success. Raymond[9] measured both user-satisfaction and system utilization. And, Park[10] selected user-satisfaction, system utilization, and the perceived contribution of the information system to the firm's success for his measures.

Different measures often produce different results since the characteristics of each measure differ.[11] This makes it difficult to compare and contrast studies that have selected different success measures. It also makes it important to develop a valid and reliable instrument that can be used to standardize these measurements.

Sprague and Carlson[12] have provided a summary comparison of information system evaluation methods. They are presented in Table 1 and include event logging, attitude surveys, cognitive testing, rating, weighing, system measurement, system analysis, cost-benefit analysis,

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Table 1
A Summary Comparison of System Evaluation Methods

Model	Objective	Measures	Treatments / Experimental Units	Analysis Criteria & Techniques
Event Logging	To log system events relating to impact on services	Events relating to services	Before and after implementation / Services	Qualitative comparison of logged events
Attitude Survey	To determine system impact on users attitudes on service	Questions on services	Before and after implementation / Users	Chi-square comparison of response frequencies
Cognitive Testing	To determine system impact on decision processes	Role repertoire tests	Before and after implementation / Users	Comparison of test scores
Rating & Weighing	To determine system impact through service ratings	Ratings	Before and after implementation / Service Parameters	Compare sums of overall times and weight scores
System Measurement	To test null hypothesis of no difference between services	Time, quantities, and others	Before and after implementation / Services	Wilcoxon signed rank comparisons
System Analysis	To determine impact on methods of service delivery	Service aspects	Before and after implementation / Services	Qualitative comparison of standard descriptions
Cost-Benefit Analysis	To determine impact on cost and benefits of service	Dollar value of system services	Before and after implementation / Cost/Benefit items	Compare cost-benefit ratios
Value Analysis	To determine whether or not to continue	Dollar value of services and system	Prototype System. / Cost/Benefit items	Are benefits within threshold?

Adapted from Sprague and Carlson[13]

and value analysis. These techniques are compared on the basis of their objectives, measures, treatments, experimental units, analysis, and criteria techniques.

As a result of these alternative measures, there is considerable debate over which success measures are best. Much of the discussion centers on whether it is most appropriate to use objective or subjective measures.

Objective Measures Are Attractive

Objective measures are attractive because they involve less human bias and their quantitative interpretation is more direct than subjective measures. Objective productivity measures have been used to evaluate the impact of information systems on decisions, decision making, and the technical merit of the system.[14] The objective approaches listed in Table 1 include rating and weighing, system measurements, cost-benefit analysis, and value analysis. Rating and weighing and system measurement may also be applied using subjective analysis techniques.

Experience has shown that objective measures like system utilization, utility, and decisional performance are not useful in field settings because they are difficult to implement.[15] There are some situations, like controlled experimental settings, where objective measures are appropriate, but, in general, they have been the subject of criticism for a variety of reasons.

Objective processes often exclude intangible, qualitative, and strategic benefits.[16] It is difficult to identify costs and benefits of information systems since they contain many non-quantifiable characteristics preventing a straight-forward quantitative approach. It is also difficult to specify an acceptable measure of performance, and there are many factors that affect performance which are not related to the information system.[17] There are also delayed effects of usage and economic fluctuations. Thus, measures of change in profit (or revenue) are not useful when measuring LYMS success.

Another important concern is the problem of voluntary verses involuntary usage. Objective usage measures may be useful when system usage is voluntary but many information systems are designed to force users to use them even if they prefer not to.[18] Management ultimatums, political pressure, or self-protection (justifying a poor decision) may induce employees to use a system.[19] Thus, utilization measures are not possible with LYMSs because their usage is normally mandated.

Subjective Measures Are Popular

Since objective measures often fail to account for intangible benefits, and are difficult to implement and validate, and because there is

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considerable evidence in the literature that subjective factors are related to system success, most information system researchers use subjective measures to operationalize the measure of system success.[20] The subjective approaches listed Table 1 include event logging, attitude surveys, cognitive testing, rating and weighing, system measurement, and system analysis techniques.

In an analysis of a dozen or so studies, Christensen[21] concluded that quality as perceived by users was a more powerful measure than the system's technical characteristics. User attitudes and perceptions were found to be fundamental to system usage and output.

In Lee's[22] review of the subject, he found the most common measure of information system success to be user-satisfaction. Lee asserted that it was important to use a broad-based measure such as user-satisfaction when the decision makers have broad-based responsibility, like LYMS users.

> When the effectiveness of an information system is measured from the organizational outcome level, user satisfaction has been shown to be an appropriate measure...It has been regarded as an appropriate methodology since it can overcome the limitations other methods have by measuring how users view their information systems rather than the technical quality of the system.[23]

Christensen[24] found user-satisfaction to have several advantages over objective measures. In particular, it measures the extent to which the system matches user-expectations. The variable is also strongly associated with user attitudes, beliefs, and perceived social pressures. Hamilton and Chervany[25] also concluded that user-satisfaction integrated many different criteria and provided the most useful assessment of system effectiveness. A user focus is also justified because the long-term survival of an organization is dependent upon the satisfaction of its client's needs and the quality of any product or service must ultimately be determined from the client's perspective.[26]

A fair amount of research has been devoted to the development of valid and reliable measures of the user-satisfaction variable. Bailey and Pearson[27] developed a 39-factor measure that was tested for reliability and validity by Ives, Olson, and Baroudi.[28] Raymond[29] proposed a measure of user-satisfaction designed for small organizations. His user-satisfaction instrument was used in Lee's[30] empirical study of critical success factors for the effective management of information systems in small businesses. Of the two instruments, Bailey and Pearson's instrument appeared to be more complete and has been tested more frequently for validity and reliability.

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Potential LYMS Success Measures Are Identified

To properly measure LYMS success, the system's technical qualities, interface, impact on the user and the organization, and the user's and the organization's impact on the system should be considered. A literature search identified Bailey and Pearson's 1983 instrument to be the most complete, valid, and reliable user-satisfaction instrument to date. The authors made it clear that their instrument must be adapted to each particular type of information system and user setting. They suggested couching the factor descriptions in the user community's specific vocabulary, omitting factors not relevant to the interest of the specific situation, and redefining the factors in situation specific terms. When the instrument was examined with respect to LYMSs, the following variables were found to be useful:

- **Convenience of access:** The ease or difficulty with which the user may act to utilize the capacity of the computer system.
- **Accuracy:** The correctness of the output information.
- **Timeliness:** The availability of the output information at a time suitable for its use.
- **Reliability:** The consistency and dependability of the output information.
- **Completeness:** The comprehensives of the information content.
- **Format of output:** The material design of the layout and display of the output contents.
- **Relevancy:** The degree of congruence between what the user wants or requires and what is provided by the information products and services.
- **Security of data:** The safeguarding of data from misappropriation or unauthorized alteration or loss.
- **Documentation:** The recorded description of an information system. This includes formal instructions for the utilization of the system.
- **Perceived utility:** The user's judgment about the relative balance between the cost and the considered usefulness of the computer-based information products or services that are provided. The costs include any costs related to providing the resource, including money, time, manpower, and opportunity. The usefulness includes any benefits that the user believes to be derived from the support.
- **Flexibility of system:** The capacity of the information system to change to change or to adjust in response to new conditions, demands, or circumstances.
- **Integration of system:** The ability of the system to communicate/transmit data between systems servicing different functional areas.
- **Expectations:** The set of attributes or features of the computer-based information products or services that a user considers reason-

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able and due from the computer-based information support rendered within his organization.

- **Job effects:** The changes in job freedom and job performance that are ascertained by the user as resulting from the modifications induced by the computer-based information systems and services.

An extensive review of both the LYMS and general information system literature was made. Users and developers of LYMSs were also contacted and asked for their thoughts on the subject. The set of additional potential variables relating to system success derived from the literature review and discussions with users and developers, with "change in revenue" and "change in profit" added because some users felt that objective measures should be included, and it provided an opportunity to test their reliability and validity, follows:

- change in revenue
- change in profit
- better sales decisions
- reduces my workloads
- reduces others' workloads
- focused goal achievement
- improved image of computer technology
- commitment gained from employees
- improves the property
- strengthened communication between marketing and operations departments
- strengthened communication between reservations and sales departments
- friendliness
- adaptability

Validation and Reliability Evaluation Is Carried Out

In order to select and test the actual LYMS success measures a questionnaire was developed by operationalizing the potential LYMS success measures using a seven-point Likert scale ranging from "highly disagree" to the middle with "neither disagree or agree" to "highly agree." Respondents were asked to indicate general agreement or disagreement to each statement by checking the box that most accurately represents their feelings. If they were not able to answer, they were asked to leave the row blank.

Statements were as follows:

- The revenue management system improves communications between reservations and sales.

Figure 1
Questions About the Revenue Management System

On the table below, please indicate the degree to which your current revenue management system can be characterized by each variable by checking the appropriate box on each row.
For example, the first row reads
"Extremely Unreliable" on the far left and
"Extremely Reliable" on the far right.

In my best estimation, I would say that our current revenue management system is/has: (Please check one box on each row. If you can't answer leave the row blank.)

Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Unreliable	Unreliable	Unreliable	Unreliable nor Reliable	Reliable	Reliable	Reliable
Incomplete	Incomplete	Incomplete	Incomplete nor Complete	Complete	Complete	Complete
Inaccurate	Inaccurate	Inaccurate	Inaccurate nor Accurate	Accurate	Accurate	Accurate
Irrelevant	Irrelevant	Irrelevant	Irrelevant nor Relevant	Relevant	Relevant	Relevant
Untimely	Untimely	Untimely	Untimely nor Timely	Timely	Timely	Timely
Unadaptable	Unadaptable	Unadaptable	Unadaptable nor Adaptable	Adaptable	Adaptable	Adaptable
Unfriendly	Unfriendly	Unfriendly	Unfriendly nor Friendly	Friendly	Friendly	Friendly
Unuseful	Unuseful	Unuseful	Unuseful nor Useful	Useful	Useful	Useful
Inflexible	Inflexible	Inflexible	Inflexible nor Flexible	Flexible	Flexible	Flexible
Vulnerable to Unauthorized Access	Vulnerable to Unauthorized Access	Vulnerable to Unauthorized Access	Vulnerable to nor Secure From Unauthorized Access	Vulnerable to Unauthorized Access	Vulnerable to Unauthorized Access	Vulnerable to Unauthorized Access
Poorly Designed Manuals	Poorly Designed Manuals	Poorly Designed Manuals	Poorly nor Well Designed Manuals	Poorly Designed Manuals	Poorly Designed Manuals	Poorly Designed Manuals
Poor Reports and Other Output	Poor Reports and Other Output	Poor Reports and Other Output	Poor nor Good Reports and Other Output	Poor Reports and Other Output	Poor Reports and Other Output	Poor Reports and Other Output

Note: "Convenience of access" and "integration of systems" were originally included in this figure and later dropped due to low Cronbach alphas.
"Change in profit" and "change in revenue" measures were originally listed as separate questions and later dropped due to low response rates.

- The revenue management system improves communications between operations (rooms and front office) and marketing.
- The revenue management system improves my property's sales related decision-making.
- The revenue management system reduces my workload.
- The revenue management reduces my employees' workload.
- The revenue management system helps my property focus on its goals and strategies
- The revenue management system has improved my image of computer technology.

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- Employees who work with the revenue management system are usually committed to it.
- My property is better off by using the revenue management system.
- The revenue management system has met my overall expectations.
- The revenue management system has positively impacted my job.

Questionnaires were mailed to system 870 LYMS users at 209 properties; 320 users responded from 180 properties for a 37 percent response rate. A Chi-square test of independence was used to determine that responses were independent. To determine which variables were most useful and appropriate, correlation, reliability, and factor analyses were employed.

Once the questionnaires were returned, the variables were examined to verify that they had a sufficient percentage of responses to be useful. The "change in profit" and "change in revenue" variables were dropped because of low response rates. Approximately two-thirds of the respondents failed to provide an estimate for change in revenue and even fewer provided an estimate for change in profit. When the "change in revenue" variable was tested with the 25 other system success measures (in the sample that responded) Cronbach's alpha was reduced by more than .20.

After the "change in profit" and "change in revenue" variables were dropped from the pool of potential success variables, the intercorrelations of remaining system success measures were examined. Statistically, nothing unusual was discovered. Only two correlations out of more than 300 were as high as $r = .7$, while the great majority of variables correlated in the $r = .3$ to $r = .5$ range.

Cronbach's alpha was used to evaluate the reliability of the success variables. According to Carmines and Zeller,[31] Cronbach's alpha is superior to the test-retest, alternative form, and split-halves methods of reliability evaluation. As a general rule, Carmines and Zeller[32] suggested that Cronbach's alpha's should not be below .80 for widely used scales and that scores in the .90s were preferable. Tests of internal reliability using Cronbach's alpha indicated that the "convenience of access" and "integration of systems" variables from the Bailey and Pearson instrument should be removed. After this was done, Cronbach's alpha was measured at .9211.

Factor analysis was then used to assess the construct validity of the selected success variables by evaluating whether the system success measures actually measured a single phenomenon as they were supposed to. Carmines and Zeller[33] suggested that factor analysis using the principal components model can test the hypothesis that variables are measuring a single phenomenon and thus support the

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Table 2
Factor Analysis of Success Variables

Variable	Factor	Eigen Value	Pct of Var	Cum Pct
Reliable	1	9.25	40.3	40.3
Complete	2	1.71	7.4	47.7
Accurate	3	1.52	6.6	54.3
Relevant	4	1.40	6.1	60.4
Timely	5	1.01	4.4	64.8
Adaptable	6	0.90	4.0	68.8
Friendly	7	0.86	3.7	72.5
Useful	8	0.71	3.2	75.7
Flexible	9	0.69	3.0	78.7
Secure	10	0.64	2.8	81.5
Manuals	11	0.55	2.4	83.9
Reports	12	0.50	2.2	86.1
Ressale	13	0.48	2.1	88.2
Oprmktg	14	0.42	1.8	90.0
Salesdec	15	0.38	1.7	91.7
Myload	16	0.37	1.7	93.4
Empload	17	0.31	1.3	94.7
Goal	18	0.25	1.1	95.8
Image	19	0.23	1.0	96.8
Commit	20	0.21	1.0	97.8
Better	21	0.18	0.8	98.6
Overall	22	0.17	0.7	99.3
Impact	23	0.15	0.7	100.0

construct validity of the instrument. They stated that the unrotated factor matrix supports this hypothesis if 1) the first extracted component explains a large proportion of the variance (> .40), 2) subsequent components explain fairly equal proportions of the remaining variance except for a gradual decrease and, 3) all or most of the items have substantial loadings on the first component (> .30).

Another technique recommended by Carmines and Zeller[34] to test construct validity was to factor analyze a second time using only the variables with the highest loading on each factor extracted during the first factor analysis in the rotated matrix. If the factors remained intact there would be evidence that one or more phenomenon were being measured. If the factors collapsed into one factor there would be evidence that the measures were parallel and had construct validity.

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Table 3
Factor Loadings on Factor 1
and Adjusted Factor Score Coefficients

Variable	Loadings on Factor 1	Adjusted Factor Score Coefficients
Better	.83526	.058243
Overall	.80637	.056425
Impact	.77631	.055159
Useful	.77500	.054218
Goal	.76582	.051967
Reliable	.74335	.050901
Salesdec	.71691	.049164
Complete	.71552	.047120
Accurate	.70170	.046054
Relevant	.69191	.045615
Timely	.68644	.045534
Adaptabl	.66612	.045001
Flexible	.64095	.044750
Commit	.61436	.042687
Reports	.60265	.042424
Ressale	.57586	.040342
Image	.52480	.039997
Myload	.44113	.038054
Friendly	.41147	.034285
Empload	.39158	.031150
Manuals	.38825	.029451
Oprmktg	.38636	.027896
Secure	.30289	.023569

A third test is the Scree test. This test is commonly used by analysts to help determine the appropriate number of factors to extract. The recommendation is to retain all components in the sharp descent before the line where they start to level off.[35]

As shown in Table 2, the first test supported the hypothesis that success variables were measuring one phenomenon. The first unrotated factor matrix explained 40.3 percent of the variance. Subsequent components explained approximately equal proportions of the remaining variance except for a gradual decrease. Finally, as shown in Table 3, all variables had loadings on the first component greater than .30.

The second test proposed by Carmines and Zeller[36] also supported the construct validity of the survey instrument. When the variables

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with highest loadings from the rotated matrix of the first factor analysis were factor analyzed by themselves, the five factors merged into one. This result offered rather striking evidence that the 23 variables were measuring one phenomenon, thus supporting the construct validity of the success variables.

The third test, known as the Scree test, also supported the construct validity of the success variables. The Scree plots had sharp Eigen-value drops on the first factor, dropping from 9.26 to 1.52.

As suggested by Carmines and Zeller[37] there was prima facie evidence of the instrument's content validity because the success variables were conceived from an extensive literature review and interview process where the full domain of the content relevant to system success was specified and an instrument was designed that adequately reflected the domain of the content that was to be measured. In addition, many of the variables selected had been tested by researchers or recommended by practitioners and there was strong support for the conclusion that the variables possessed high content validity. These combined analyses supported the hypotheses that the variables selected to measure LYMS success were reliable and valid.

LYMS Success Measures Can Be Applied

The LYMS success variables that produced the highest reliability score and were found to have construct and content validity (in order of their respective loadings) are as follows:

- property is better off with system
- system meets overall expectations
- system positively impacts job
- system usefulness
- focuses property on goals and strategies
- system reliability
- improved sales decisions
- system completeness
- system accuracy
- system relevancy
- system timelines
- system adaptability
- system flexibility
- employees become committed to system
- system reports
- improved communication between reservations and sales
- improves image of computer technology
- reduces my workload
- system friendliness

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- reduces employee's workload
- system manuals
- improved communication between operations and marketing
- system security.

Managers who want to evaluate the success of their own LYMSs can do so using several approaches. Respondents should be instructed that the purpose of the questionnaire is to help improve their LYMS. Once the surveys have been collected, an analysis can be performed.

The first approach is a simple summation technique. To do this, scores must be ascribed to each cell on the Likert scale. A value of one would be attributed to the least favorable cell and a value of seven would be attributed to the most favorable cell. These values would then be summed for each respondent. As a point of reference, the average value for the systems surveyed in this study was 122. The standard deviation was 19. The value at the 25th percentile was 113, 126 at the 50th percentile, and 136 at the 75th percentile. The minimum value was 36 and the maximum value was 153.

An alternative approach would be to divide the sum of each respondent's answers by 23 to determine the average score for each question. As a point of reference, the average value for the systems surveyed in this study was 5.32. The standard deviation was .822. The value at the 25th percentile was 4.91, 5.48 at the 50th percentile, and 5.91 at the 75th percentile. The minimum value was 1.57 and the maximum value was 6.65.

The second, and more accurate approach, is to multiply each respondent's answer by its respective "adjusted factor score coefficient" found in Table 3 and then sum the products. The "adjusted factor score coefficients" are the adjusted score weights computed by the factoring program for the data used to test the variables for this research. They have been adjusted so that their sum equals 1.00. As a point of reference, the average value for the systems surveyed in this study was 5.38. The standard deviation was .846. The value at the 25th percentile was 4.90, 5.54 at the 50th percentile, and 5.97 at the 75th percentile. The minimum value was 1.56 and the maximum value was 6.67.

The most accurate approach is to develop a new set of factor scores for the new data. Most statistical packages can do this as a feature of their factor analysis program. Hair, Anderson, and Tatham,[38] suggested that if a scale is well-constructed, valid, and reliable, factor scores are a better alternative than surrogate variables since factor scores have the advantage of representing a composite of all variables.

This article explains the development of a valid and reliable questionnaire which can be used to measure LYMS success. Managers may

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use this questionnaire to evaluate their own LYMSs. Several different approaches may be used, from simple to sophisticated. Managers may use the scores of the systems surveyed in this research to compare the performance of their systems. By examining average responses of the individual variables, the questionnaire may be used to determine which areas need to be improved and which areas are functioning well. Follow-up surveys may be used to evaluate the success of training programs, system updates, and new installations.

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