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Least Common Multiple and Multiplicative AHP Methodical Approaches to Accounting Software Selection

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Abstract: The paper outlines a three-phase methodology for assessing and choosing packaged accounting software, emphasizing the preference for off-the-shelf solutions. The process involves creating a shortlist using a non-compensatory choice model, followed by a detailed analysis using least common multiple (LCM) method and multiplicative analytic hierarchy process (MAHP) method in the multiple criteria decision making (MCDM) theories, and ultimately confirming the selection through a "test drive". The methodology is exemplified in the development of a fixed asset system for a medium-sized hospital, covering technical requirements, functional accounting specifications, documentation, and training needs.

Key words: multiple criteria decision making, fixed asset system, elimination by aspect choice model, least common multiple

JEL codes: C65

1. Introduction

The selection of software is crucial for businesses, as inadequate examination can lead to implementation difficulties or failures. Despite numerous proposed approaches, some critical factors, such as screening processes and custom alternatives, have often been overlooked. This paper presents a structured methodology aimed at addressing these gaps and ensuring effective software selection for mid-market firms.

Various choice models have been proposed for software evaluation, each with its strengths and limitations. Criticisms against weighting schemes can be mitigated through screening processes and shortlisting. This methodology emphasizes the importance of identifying the best-fit software through rigorous evaluation and trade-off analysis.

The methodology targets firms with revenues ranging from $5 million to $500 million annually (especially small to medium-sized businesses and enterprises), representing a significant market segment for accounting software. By addressing the specific needs of mid-market firms, the methodology aims to streamline the selection process and control implementation costs.

The methodology begins with the selection of a shortlist of fixed asset (FA) accounting software packages using the elimination-by-aspects (EBA) choice model (Tversky, 1972). This non-compensatory model ensures that each package meets minimum performance levels for screening attributes. In the second stage, a least common

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multiple (LCM) method (Shin et al., 2012) in multiple criteria decision making (MCDM) tools allows for comparisons between performance ratings of different attributes, leading to the selection of the best-fit package. Finally, the chosen package is tested through practical applications to confirm its effectiveness.

2. General Hospital Case

General Hospital, a subsidiary of Hospital Intergroup (HI), faces challenges in tracking assets among its affiliated facilities. Assets, including medical equipment, move swiftly between General Hospital, General Rehabilitation Facility, MRI Center, and General Hospital Hotel, leading to difficulties in monitoring their location. The outdated fixed asset system currently in use is reaching its limits and poses a risk of data loss. Various stakeholders, including the Vice President of Operations, Director of Tax, and Comptroller, express different needs for a new Fixed Asset (FA) system.

The FA system should efficiently track fixed assets, providing accurate reporting on their current value, accumulated depreciation, retirements, and transfers. General Hospital utilizes an Authorization for Expenditure (AFE) system for capital expenditures, which requires monitoring spending within approved limits. The FA system plays a crucial role after bill approval, recording data, ensuring compliance with AFE limits, and tracking cumulative spending on each AFE.

To select an optimal FA system, General Hospital's search team establishes screening criteria in four categories: technical, functional, documentation, and vendor information. Technical requirements include compatibility with the LINUX network operating system and capacity to handle the company's PC environment. Functional criteria emphasize record capacity and support for AFE procedures. Documentation requirements involve an on-line tutorial, and vendor information prioritizes a minimum of five years of experience offering dedicated FA solutions to the public.

In summary, General Hospital seeks a modern FA system to address asset tracking challenges, meet the diverse needs of stakeholders, and ensure compliance with AFE procedures. The chosen system should align with technical specifications, offer robust functionality, provide adequate documentation, and come from an experienced vendor in the FA programming market.

3. Screening Criteria and Development of an Evaluation Matrix

The initial screening process in the software evaluation involved a meticulous review of 84 fixed asset programs against specific criteria. After applying factors like independence from general ledger systems, compatibility with GH's PC environment, and substantial product evidence, the list was narrowed down to 30 vendors. Further elimination based on technical and functional constraints left three finalists for intensive review: Vendor A, Vender B, and Vender C.

To assess the strengths and weaknesses of the finalists, the GH search team devised expanded criteria in technical, functional, documentation and training, and vendor information categories (Table 1). Within functional criteria, the team considered the specific needs of accounting and finance, tax, and operations departments. Each criterion was assigned a weight to reflect its perceived importance, and the finalists were evaluated accordingly.

Table 1 Evaluation Matrix

Technical Criteria	Weight
CPU	3
RAM	3
Secondary Storage	3
LINUX Network Compatible	3
Functional Criteria	
Flexible Reporting	2
Easy Maintenance	1
Comprehensive Tax Depreciation	3
Compute Govt 10K/10Q Schedules	3
Import/Export to Spreadsheets	1
Bar Code Compatibility	1
Complete Project Accounting	3
Lease/Buy Considerations	3
Multiple Users	3
Upgradeability	1
Documentation and Training	
Thorough Coverage of All Items	3
Readability	2
On-Site Training Ability	3
Vendor Information	
Length of Offering	3
Vendor Reputation	2
Add-on Enhancements	2
Number of Copies in Market	1

Technical requirements, including compatibility with GH's PC environment, were considered relatively non-restrictive. Functional criteria were categorized into user groups, emphasizing the importance of accounting and finance, tax, and operations departments. Key functional criteria included flexible reporting, easy maintenance, comprehensive tax depreciation methods, government schedule computation, import/export capabilities, bar code compatibility, complete project accounting, lease/buy considerations, multiple users, and upgradeability.

Documentation requirements emphasized thorough coverage, readability, on-site training, and vendor support. Vendor information criteria focused on the length of offering (at least 5 years in the market), reputation, enhancements, and the number of copies sold.

In the following section, the GH search team carefully evaluated the three finalists based on an extensive set of criteria to select the optimal fixed asset system that aligns with the organization's technical environment,

functional needs, documentation standards, and vendor reputation. The chosen system will play a crucial role in asset tracking, financial reporting, tax projections, and overall operational efficiency.

4. Selection Process With LCM Method

In a decision matrix with three alternatives (Vendor A: A_1, Vendor B: A_2, and Vendor C: A_3) and four criteria (organization's technical environment: C_1, functional needs: C_2, documentation standards: C_3, and vendor reputation: C_4), ratings are assigned using a 10-point scale in the ratings mode. The numbers in Table 1 are averages of each vendor in criteria with weights derived from evaluation matrices to ensure the avoidance of inconsistent measurements in the decision-making process (Table 2).

Table 2 Decision Problem Data Set

Alternatives	Decision criteria (weights)			
	C_1 (.3)	C_2 (.21)	C_3 (.26)	C_4 (.23)
A_1	8	8.7	8	8.5
A_2	9.5	9.1	9.3	9.8
A_3	9.5	6.5	6	6.8

In the decision problem matrix A_{ij}, where *i* represents alternatives and *j* represents criteria, to obtain local priorities of alternatives, these measurements are divided by the sum of measurements across all other criteria. The proposed approach, referred to as the LCM method (Shin et al., 2012), transforms all measurement values to commensurate values by multiplying with the LCM of all column sums of criteria in the decision matrix. Before computing composite weights for all alternatives, the matrix A_{ij} is multiplied by L, the LCM of column sums of criteria, where

$$L = \sum_{j=1} \sum_{i=1} a_{ij} \tag{1}$$

Now the weight vector of criteria (C_j) is given by $C_j = [\ c_1 \quad c_2 \quad c_3 \quad \text{----------} \quad c_j\ ]^T$. Then, multiplying the criteria weight vector C_j by the revised value matrix A_{ij} yields

$$X_i = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ .... \\ x_i \end{bmatrix} = \begin{bmatrix} \frac{a_{11}\ c_1 L}{\sum_{i=1} a_{i1}} + \frac{a_{12}\ c_2 L}{\sum_{i=1} a_{i2}} + \frac{a_{13}\ c_3 L}{\sum_{i=1} a_{i3}} + ... + \frac{a_{1j}\ c_j L}{\sum_{i=1} a_{ij}} \\ \frac{a_{21}\ c_1 L}{\sum_{i=1} a_{i1}} + \frac{a_{22}\ c_2 L}{\sum_{i=1} a_{i2}} + \frac{a_{23}\ c_3 L}{\sum_{i=1} a_{i3}} + ... + \frac{a_{2j}\ c_j L}{\sum_{i=1} a_{ij}} \\ \frac{a_{31}\ c_1 L}{\sum_{i=1} a_{i1}} + \frac{a_{32}\ c_2 L}{\sum_{i=1} a_{i2}} + \frac{a_{33}\ c_3 L}{\sum_{i=1} a_{i3}} + ... + \frac{a_{3j}\ c_j L}{\sum_{i=1} a_{ij}} \\ ..... \\ \frac{a_{i1}\ c_1 L}{\sum_{i=1} a_{i1}} + \frac{a_{i2}\ c_2 L}{\sum_{i=1} a_{i2}} + \frac{a_{i3}\ c_3 L}{\sum_{i=1} a_{i3}} + ... + \frac{a_{ij}\ c_j L}{\sum_{i=1} a_{ij}} \end{bmatrix} \tag{2}$$

The normalized composite weights of alternatives are determined through the following equation:

$$X_i' = \left[\frac{x_1}{\sum_{i=1} x_i} \quad \frac{x_2}{\sum_{i=1} x_i} \quad \frac{x_3}{\sum_{i=1} x_i} \cdots\cdots \frac{x_i}{\sum_{i=1} x_i} \right]^T \tag{3}$$

By utilizing the least common multiple of all column sums, the composite weight vectors are rescaled to represent an overall decision matrix unit encompassing all alternatives and criteria. Table 3 indicates that the ranking of the three alternatives is $A_2 > A_1 > A_3$. A_2 is the most preferable vendor, and A_3 is the least preferable.

Multiplicative Analytic Hierarchy Process (MAHP) (Triantaphyllou, 2001) contends that combining the partial rankings of smaller problems yields the most reliable results, by applying the weighted product model (WPM). That is, when two alternatives at a time are compared in smaller submatrices, this case adheres to transitivity rules (e.g., if $A_2 > A_1$ and $A_1 > A_3$, then $A_2 > A_3$) and maintains the rankings of three alternatives. This ensures the validity of results from the LCM multiple criteria decision-making method.

Table 3 Priority Rankings from LCM Method and Multiplicative Method

Method	Alternative	Criteria				Composite priority	Derived ranking
		C_1	C_2	C_3	C_4		
LCM	A_1	36800	44466.67	42643.78	42059.76	0.331	$A_2 > A_1 > A_3$
	A_2	43700	46511.11	49573.39	48492.43	0.378	
	A_3	43700	33222.22	31982.83	33647.81	0.291	
MAHP	A_1	36800	44466.67	42643.78	42059.76	0.467	$A_2 > A_1$
	A_2	43700	46511.11	49573.39	48492.43	0.533	
	A_1	36800	44466.67	42643.78	42059.76	0.532	$A_1 > A_3$
	A_3	43700	33222.22	31982.83	33647.81	0.468	
	A_2	43700	46511.11	49573.39	48492.43	0.565	$A_2 > A_3$
	A_3	43700	33222.22	31982.83	33647.81	0.435	

5. Results and Conclusion

The ranking procedure may not be a critical element in a software and evaluation and selection process that begins with a screening of software alternatives. Supported by the EBA choice model as applied in this case study of accounting software, the detailed evaluation of a short list of packaged software reduces the risk of implementation failure by helping to ensure the selection of a software alternative that best meets requirements. By expediting a purchase decision for a FA system, EBA also accelerates the benefits (less expensive and faster implementation) to be derived from package-based system development.

General Hospital determined the most suitable software package by computing the composite priorities from the evaluation matrix (refer to Table 2). Using LCM method, Vendor A emerged as the preferable alternative with 37.8% priority points, followed by Vendor B at 33.1%. The hospital set a minimum requirement of 30% for a package to be considered viable, and Vendor C failed to meet this standard. MAHP method adheres to transitivity rules and maintains the rankings of three alternatives.

In addition, the last stage of software confirmation, essentially a test drive before purchase, further ensures the selection of the best packaged alternative and provides a final option to consider a custom-built system if that proves to be the best choice. The most critical phases of this study are the development of a shortlist and the design and trial of specific applications with the selected package. No unified and comprehensive software evaluation and selection methodology as presented herein has been heretofore suggested. It is the authors' belief that this approach is quite easy-to-use and pragmatic in efficiently choosing an accounting package.

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