A HOLISTIC APPROACH TO SUPPORTING ACADEMIC LIBRARIES IN RESOURCE ALLOCATION PROCESSES

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Abstract

E-content revolution, technological advances, and ever-shrinking budgets oblige libraries to efficiently allocate their limited resources among collection and services. Unfortunately, this resource allocation is a complex process due to the diversity of data sources and formats required to analyze prior to decision-making, as well as the lack of efficient methods of integration. The contribution of this article is twofold. We first propose an evaluation framework to holistically assess academic libraries. To do so, a four-pronged theoretical framework is used in which the library system and collection are analyzed from the perspective of users and internal stakeholders. The second contribution of this article is to present a data warehouse architecture that integrates, processes, and stores the holistic-based collected data. By proposing this holistic approach, authors aim to provide an integrated solution that assists library managers to make economic decisions based on an "as realistic as possible" perspective of the library situation.

A HOLISTIC APPROACH TO SUPPORTING ACADEMIC LIBRARIES IN RESOURCE ALLOCATION PROCESSES[1]

1 Introduction

Amid limited funding resources, libraries strive to efficiently deal with technological advances and e-content revolution (Bertot 2011). In fact, academic libraries face hard *budget constraints* due to the global economic crisis (Sudarsan 2006; McKendrick 2011). This dilemma stems from library services usually being "free of charge", but not free of costs and strongly dependent on public funding (Stouthuysen et al. 2010). As a result, despite cuts, mergers, and budget freezes, libraries must create, maintain and improve their services (Guarria and Wang 2011; Cottrell 2012; Cox 2010). Furthermore, the latest *technological advances and e-content revolution* such as the growing presence of e-books, and proliferation of tablets and mobile devices have influenced the manner how information is disseminated and consumed (Allen Press, Inc 2012; Brook and Salter 2012). As a consequence, academic libraries are rapidly reallocating budgets from printed to digital resources. In fact, Nicholas et al. (2010), for example, report that although e-books still account for a small proportion of total spending, approximately 5%, this figure is rising

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very fast. Online content facilitates managing information, is often cost effective, and more easily accessible than printed resources; however, it also contributes to increasing the complexity of the resource allocation process (Chan 2008; Guarria 2009; Poll 2001). For instance, one of the problems with subscription-based digital library collection is the variability of yearly prices that has evolved in the last years (Allen Press, Inc 2012). Furthermore, in order to provide these e-services, academic libraries have to deal with several challenges such as the lack of uniformity in license terms, lease conditions, access restrictions, and librarians' expectations (Walters 2013).

These dynamic components such as e-content revolution, technological advances, and ever-shrinking budgets, constantly force libraries to be more innovative in providing, justifying and evaluating the effectiveness of their services (ACRL Research Planning and Review Committee 2010; Blixrud 2003). Ernst and Segall (1995) state that institutions in these difficult circumstances are called to develop a strategic and well-coordinated budget plan by means of a "holistic approach". The objective of the holistic approach is to help organizations to define a set of measures that reflect their objectives and assess their performance appropriately (Matthews 2011). This holistic approach requires interconnecting all necessary components in a way that responds to both, shrinking resources, and dynamic library services. Unfortunately, interconnecting and analyzing all the heterogeneous data sets are complex

processes due to the large number of data sources and volume of data to be considered. Therefore, the aim of the paper is twofold, firstly, to present a holistic structure and the required set of tools for collecting data from an economic point of view. The holistic structure uses a theoretical framework based on a two-dimensional evaluation matrix (Table 1) in which the library system and its collection are analyzed from an internal and external perspective. Secondly, to propose the design of an integrated decision support system that integrates, processes, and stores the collected data.

		Topic	
		Library System	**Collection**
Perspective	**Internal (Library)**	[1] What does the library system consist of?	[4] How is the library system manipulated?
	External (Users)	[2] How effective is the library system?	[3] How useful is the library system?

Table 1: Conceptual matrix for holistic measurement (Nicholson 2004)

2 Theoretical background

A budget is a financial plan that normally reflects the organization´s priorities; through this, managers boost important activities by allocating enough resources and rationing resources to less important areas of an organization (Linn 2007). Many approaches of budgeting systems have been proposed in the literature, such as incremental line-item, formula-based, mathematical decision model based, zero-based, and many “home-made” resource allocation methods (Linn 2007; Smith 2008). Each

budgeting system functions differently and is often used in combination with other methods. For instance, one method can be used externally when applying for funds and another method used when distributing those funds internally.

In the case of academic libraries, collection budgets used to be allocated taking into account several factors such as the number of students, circulation of materials, interlibrary loans, number of researchers, and average cost of materials per discipline (Kao, Chang, and Lin 2003). Unfortunately, these indicators to quantify the collection requirements or the usage statistics are not enough anymore. Libraries nowadays must be able to show on the one hand their investments and resources availability to produce better results in research and education; and on the other hand their effectiveness to deliver library services (Laitinen and Saarti 2012). To do so, library managers must have enough data to ensure the integration of different areas involved in the library system in order to evaluate and decide how to allocate and prioritize resources to each service or material that a library requires. In this respect, a holistic evaluation to obtain a thorough knowledge of the library system becomes an interesting alternative to be used as a manner to organize the data collected for a resource allocation process.

Holism is a concept which emphasizes the importance of the whole and the interdependence of its parts (Editors of the American Heritage Dictionaries 2011). It means that systems work as a whole and that they

cannot be fully understood by analyzing their components separately. If this concept is translated to libraries, holism could be seen as an analysis that emphasizes the importance of the entire library and the interdependence of its processes, collection and services. Many resource allocation approaches based on holistic evaluations have been proposed; however, most of them mainly focus on economic allocation for physical or digital collections separately. For instance, Lancaster (1977; 1988) establishes evaluation procedures only for traditional library services, and Zhang (2010) and Fuhr et al. (2007) propose a holistic evaluation model for digital library services. On the contrary, Nicholson (2004) proposes a theoretical analysis framework to support libraries in gaining a more thorough and holistic understanding of their users and services for both digital and physical services. As can be seen in Table 1, the author proposes an evaluation matrix with four quadrants, in which columns represent the topic: library system and collection, and rows represent the perspective of library staff and users. Due to the ease of understanding, completeness, and applicability to both physical and digital resources, this theoretical framework is adopted as a basis to propose a holistic structure for data collection and, in turn uses these data sets as an input for an integrated decision support system.

The following paragraphs briefly describe the main features of each quadrant proposed by Nicholson:

1. If the library system is analyzed from an internal perspective, the question to be answered is: **What does the library system consist of?** This is a traditional type of analysis that can include bibliographic collection aspects, organizational flows, computer interfaces, processes, staff, and resources.
2. The second quadrant evaluates the user's perception about service quality. Aboutness, effectiveness and usability of the library services are the main aspects studied. The question to be answered is: **How effective is the library system?**
3. The third quadrant is centered on: **How useful is the library system?** This quadrant allows quantifying the impact of the library collection on its users, providing library managers with better basis for decision making when acquiring new bibliographic materials. By evaluating the current bibliographic collection, libraries may discover possible gaps and plan future collection development (Agee 2005).
4. The fourth quadrant aims to answer the question: **How is the library system manipulated?** This quadrant analyzes the use patterns followed to manipulate the library system. For instance, in digital library services, unlike circulation patterns in traditional services, is possible to track everything users do within the library system; allowing libraries to know what users retrieve, but also what they look for and could not receive.

Thus, by incorporating this simple but at the same time powerful theoretical framework to organize the data collection required to our model, this study ensures that evaluating the collection and services in academic libraries is based on a holistic model. The remainder of this article is divided into three sections; Section 3 describes the data collection procedure to holistically analyze academic libraries from an economic perspective. Section 4 proposes the design method and structure of a decision support system based on based on data warehouse and data mining technology. Finally, conclusions are drawn in the last section.

3 Data collection through a holistic perspective

In this section, Nicholson's conceptual matrix is used as a basic reference to propose a structured data collection that ensures a holistic analysis of an academic library from an economic point of view. Based on this structure, a set of tools is provided to collect data for the specific requirements of each quadrant. An example of implementing the proposed holistic approach and tools is presented by Siguenza-Guzman et al. (2013b). The authors highlight the key benefits, challenges and lessons learned from the implementation of this holistic approach in an academic library in Belgium.

3.1 First quadrant: internal perspective of the library system

In this quadrant, the traditional library evaluation (i.e. measurements based on library staff, processes, or systems, but not users) is the main

aspect studied. Internal perspective of the library system especially covers the topics related to processes and services carried out within the library system. From an economic perspective, it refers to the need of analyzing the costs incurred and the resources consumed by library processes. Cost analysis techniques have been present in libraries for many years, of which the traditional costing system has been one of the most widely used. Ellis-Newman et al. (1996), for instance, describe several studies on library costs that were undertaken in the United States. These studies were carried out with cost allocation models compatible with traditional costing methods. In this type of systems, the total cost consists of *direct costs* such as the cost of consumed resources and direct labor hour, and a percentage of overhead as *indirect costs*. Indirect costs are specific costs such as maintenance, marketing, depreciation, training, and electricity. Traditional costing systems are adequate when indirect expenses are low and service variety is limited (Ellis-Newman and Robinson 1998). However, in environments with a broad range of services such as libraries; indirect costs have become increasingly more important than direct costs (Siguenza-Guzman et al. 2013a).

Seeking to remedy these limitations, libraries started employing more advanced cost calculation techniques, such as Activity-Based Costing (ABC). ABC is an alternative costing system promoted by Cooper and Kaplan (1988). Compared to traditional costing methods, ABC performs a more accurate and efficient treatment of indirect costs (Ellis-

Newman and Robinson 1998). In fact, ABC first accumulates overhead costs for each activity, and then assigns the costs of the activities to the services causing that activity. An activity, for libraries, is defined as an event or task undertaken for a specific purpose such as cataloging, loan processing, shelving, and acquisition orders (Ellis-Newman 2003). An extensive stream of literature describes ABC as a system that provides interesting advantages to decision making in libraries (Ching et al. 2008; Ellis-Newman 2003; Ellis-Newman and Robinson 1998; Gerdsen 2002; Goddard and Ooi 1998; Heaney 2004; Novak, Paulos, and Clair 2011; Skilbeck and Connell 2001). However, ABC has great limitations, for instance, a high degree of subjectivity involved in estimating employees' proportion of time spent on each activity; the excessive time, resources and money for data collection; and the difficulties to model multi-driver activities (Siguenza-Guzman et al. 2013a).

TDABC is an ABC approach developed by Kaplan and Anderson in order to overcome the ABC limitations (Kaplan and Anderson 2003). TDABC uses only two parameters to assign resource costs directly to the cost objects: 1) the unit cost of supplying resource capacity; and 2) an estimated time required to perform an activity (Yilmaz 2008). For each activity, costing equations are calculated based on the time required to perform an activity (Yilmaz 2008). This time can be readily observed, validated and then computed by time equations which are the sum of individual activity times (Kaplan and Anderson 2007). By using these

equations, all possible combinations of activities can be represented, for example, when different types of services do not necessarily require the same amount of time to be performed. Siguenza-Guzman et al. (2013a) highlight five TDABC advantages: 1) simplicity to build an accurate model; 2) possibility of using multiple drivers to design cost models for complex operations; 3) good estimation of resource consumption and capacity utilization; 4) versatility and modularity to update and maintain the model; and 5) the possibility of using the model in a predictive manner.

Up to now, four important studies concerning TDABC in academic libraries have been applied to very specific processes such as inter-library loan (Pernot, Roodhooft, and Van den Abbeele 2007), acquisition (Stouthuysen et al. 2010), circulation (Siguenza-Guzman et al. 2014), and cataloguing processes (Siguenza-Guzman 2013). In these case studies, TDABC is described as a model that offers a relatively quick and less expensive way to design useful costing models. In addition, Siguenza-Guzman et al. (2013b) document the experience of implementing TDABC in twelve library processes. The paper highlights three specific advantages such as the possibility to disaggregate values per activity, to compare different scenarios, and to justify decisions and actions. Two specific challenges are also reported: the significant time required in the data collection, and the staff discomfort of being observed. However, potential solutions to overcome these challenges are also recommended. For

instance, the use of a dedicated software tool to perform TDABC analyses, as well as the need of an appropriate communication strategy among library managers and staff to clearly explain the purpose of measurement. In all case studies, the authors conclude that TDABC is so far the best system to evaluate costs, processes and services in academic libraries. TDABC provides accurate information of the library activities and which may help managers to get a better understanding of how the library uses its time, costs and resources. Nevertheless, this information is not sufficient for making management decisions in the library. For instance, consider the following scenario:

- A library manager is asked to reduce the staff number due to the high costs spent on salaries. He consults the costing system, and after a "what-if" analysis, he finds that reference service occupies a surplus of librarians, and that by shortening this amount, he fulfills the requirement.

Initially, this seems a good alternative; however, it provides only a partial solution. The library manager should still consider other aspects such as 1) users' perception of the service quality falls below the tolerated levels; 2) the decision impacts on the entire library system.

3.2 Second quadrant: external perspective of the library system

Once the library system has been measured from an internal point of view, the evaluation is balanced by introducing the users' perspective. By doing

this, the framework allows library managers to see beyond the system, staff, or processes and to understand what really users need and desire from the services performed by a library. Nicholson (2004) proposes to evaluate the aboutness, pertinence and usability of a library system including both physical and digital resources. *Aboutness* refers to analyzing the relevance of library resources/services to their users. It is based on the users' personal judgment of the conceptual relatedness between users' need and services offered (Kowalski 2011). *Pertinence* takes into account the user and the situation in which the service is to be used. It assumes that users can only make valid judgments about the suitability of services to solve their information needs (Kowalski 2011). Finally, *usability* refers to evaluating the library system reliability to be used without having problems.

Libraries have a long history of collecting users' statistics to monitor service quality (Horn and Owen 2009). In literature, different approaches have emerged (Nitecki and Hernon 2000), for instance, one approach is centered on the use of SEVQUAL (for SERVice QUALity) measurements; a popular tool from the 80's developed for assessing service quality in the private sector. The model uses the service quality gap theory proposed by Zeithaml et al. (1990) to summarize a set of five gaps showing the discrepancy between perceptions and expectations of customers and managers. Nitecki and Hernon (2000) note that by applying this instrument, libraries gain knowledge about the customer

conceptualization of what a service should deliver and how well the service complies with idealized expectations. Another approach is based on the work of Hernon and Altman (1996; 2010), who build their analysis on an extensive set of expectations around the gaps theory to look at the service nature of libraries. They suggest a pool of more than 100 candidate service attributes from which staff can select a subset potentially having the greatest relevance to their library (Nitecki and Hernon 2000). An additional approach, described by Matthews (2013), combines data about the library use and its services with other data available on the academic campus. For instance, the author suggests that for university students, library use and its services should correlate with either direct or indirect measures of student achievement. Examples of direct measures include the capstone experience, use of a portfolio, or a standardized exam. Indirect measures could include students' grade point average, success in graduate school exams and graduate student publications.

Wright and White (2007) report the top five assessment methods used in the past by libraries to measure service quality. These include the following assessment methods: statistics gathering, suggestion boxes, Web usability testing, user interface usability, and satisfaction surveys. Within these methods, the authors mention that locally designed user satisfaction surveys were widely used; however, it has lately been replaced by surveys developed elsewhere. A detailed description of some

of these user survey methods is provided by Creaser (2006). The author focuses his analysis in the SCONUL user survey template and the LibQUAL+® surveys. In this article, SCONUL is described as a standard template with a considerable degree of flexibility. SCONUL is offered by the Society of College, National and University Libraries (SCONUL) which can be adapted to suit local circumstances. LibQUAL+®, likewise, is described as a valuable tool for benchmarking, because of its uniformity and limited scope for customization.

LibQUAL+®[2] survey is a set of services based on Web surveys offered by the Association of Research Libraries (ARL). This Web surveys is based on SERVQUAL measurements that allows requesting, tracking, understanding and acting upon users perceptions of the service quality offered by libraries (Association of Research Libraries 2012). LibQUAL+® has been applied by more than a thousand libraries around the world, and thanks to its great success, LibQUAL+® which initiated in 2000, as an experimental project, is now considered a standard assessment tool for measuring the quality of services from users' perception (Cook 2002). It helps libraries to assess their strengths and weaknesses, and also benchmark themselves with other peers in order to improve their library services (Saunders 2007; Franklin, Kyrillidou, and Plum 2009). The LibQUAL+® survey consists of 22 items or questions which are grouped into three quality dimensions: services provided, physical space, and information resources (Saunders 2007). The measurement for each

[2] http://www.libqual.org

perspective is a scale from 1 to 9. For each question, users give three ratings or levels of service: the minimum expected service quality, the observed or perceived service level, and the desired service level or maximum expectations. Siguenza-Guzman et al. (2013b) document the experience of utilizing the LibQUAL+® survey to assess library service quality. The article describes the survey results and the action points taken. The authors state that although LibQUAL+® provides information on the set of services that require additional attention; some considerations need to be taken into account, for example, a data preparation period required to define language and population, granularity to provide benchmarking within branch libraries, and the need of strategies to stimulate participation rates.

By integrating the users' satisfaction criteria to the proposed analysis, library managers now have a broader view of the library system, as they have information about their services and the users' opinion on such services. Assessment methods such as statistics gathering, suggestion boxes, Web usability testing, user interface usability, and satisfaction surveys (e.g. LibQUAL+®, locally designed, etc.) are valuable tools to be integrated in our evaluation matrix. The library manager may use LibQUAL+® for instance to analyze if the quality of service provided by the reference librarians still lies under the tolerance zone once the changes have been made. Alternatively, libraries can also devise their own instrument which can be particularly useful for investigating detailed

issues (Creaser 2006). Nevertheless, the decision of selecting one or more tools to be used in this quadrant depends on the current availability of them in the library and the decision of library managers to include other measures to the model.

3.3 Third quadrant: external perspective of the library collection

The goal of this quadrant is to evaluate the usefulness of the library collection. Knowing this information allows libraries to gain a more holistic understanding of users' needs, and to acquire material that complement current holdings, either improving weak areas or enriching strong collections (Agee 2005). To do so, two types of measurement are available: 1) through *direct contact* with the users in order to ask or document which bibliographic materials were valuable for them; 2) *indirect contact* through the use of bibliometric analysis (Nicholson 2004).

Bibliometrics can be defined as the use of mathematical and statistical methods to analyze the usage of library information resources. The main focus of bibliometric analyses is on bibliometric distributions of events, such as: the productivity of scientific journals, distributions of words in a text, productivity of scientific authors, circulation of journals within a library or a documentation center (Lafouge and Lainé-Cruzel 1997). Traditional bibliometrics studies use information about the creation of bibliographic documents such as authors and documents cited, and the metadata associated with them, for example, a general topic area or the

specific material in which it appeared. For these studies, the frequency-based analysis is mainly used; nevertheless, many newer bibliometric studies are using visualization techniques and data mining to explore patterns in the creation of these analyses (Nicholson 2006a).

Within these methods, *citation analysis* is the most well-known and used, and is also the one that best couples our requirements to analyze the use of library information resources. Citation analysis is defined by several authors as: 1) the "wide-ranging area" of bibliometrics that considers the citations to and from documents (Diodato 1994), 2) a method often used to generate core lists of journals deemed critical to the research needs of an institution (Wallace and Van Fleet 2001), 3) a technique to count, tabulate and rank the number of times sources are cited in a document (bibliographies, footnotes, and/or indexing tools) (Edwards 1999), 4) a method to identify journals which are often cited, some of which are not from the collection (Feyereisen and Spoiden 2009). Summarizing the definitions and adjusting them in the context of this research, citation analysis is defined as a technique to count, tabulate and rank the number of times sources are cited to and from documents in order to analyze the use of a collection. Citation analysis is normally based on samples collected from student's PhD dissertations and master theses. Zipp (1996) states that citations from these sources can be reliably used because they are much more easily and comprehensively gathered, and because they reflect the interests of local research groups. Nevertheless,

Enger (2009, 109) recommends the use of citation analysis with some caution. For instance, common lists should be created by comparing their own results to external institutions because students tend to seek only on locally owned sources and in many cases may lack the expertise needed to identify the most appropriate sources (Feyereisen and Spoiden 2009). Likewise, useful information may not be cited, or may be cited by professors, post docs or researchers in other documents such as syllabuses, reports or books (Feyereisen and Spoiden 2009) or by those who do not publish such as undergraduate and graduate students (Duy and Vaughan 2006). One solution to avoid these omissions is proposed by Bland (1980) who suggests the use of citation analysis of the textbooks used in the curriculum.

Vendor-supplied statistics is an additional bibliometric method to evaluate the usefulness of a library collection. The vendor-supplied statistics also called electronic journal usage data is usually collected via publisher websites. These lists are normally supplied by vendors as part of their subscription contract. A case study performed by Duy and Vaughan (2006, 515) advocates the use of this technique to replace the “traditional, expensive and time-consuming manual compilation” of reference lists.

On the other hand, in published journal papers, authors include several references to papers, books, links, etc. These citations are used to describe the source of some concepts or ideas included in the document. At the same time, they help the reader to find relevant information

regarding the topics that were introduced in the original paper (He and Cheung Hui 2002). To measure the value of a journal by the number of citations that a document has had, *citation databases* have been created. According to Buchanan (2006), a citation database serves two purposes: 1) to index the literature using cited articles as index terms; 2) to measure the number of times a publication has been cited in the literature. A citation database is a warehouse database to analyze the impact of peer-reviewed literature. The most famous citation databases are Web of Science and Scopus. The decision of selecting a database depends on the research focus. For instance: Scopus is the citation database that covers more relevant journals of Medical Informatics than Web of Science (Spreckelsen, Deserno, and Spitzer 2011).

The study considers that by combining citation analysis, citation database and vendor-supplied statistics, library administrators will gain an extensive knowledge about the value of their collection. This proposal is also supported by several authors that agree with the use of different methods to have a more robust indication of collection use and users' needs (Beile, Boote, and Killingsworth 2004; Duy and Vaughan 2006; Enger 2009). The early experiences in developing a project combining these methodologies is documented by Siguenza-Guzman et al. (2013b). The project analyzes more than 1,200 PhD theses submitted over a six-year period (2005-2010). In addition, four databases are created to evaluate citations patterns, publishing patterns, journals downloaded, and

journals' impact factor. Up to now, the authors describe several challenges faced. For instance, 1) the amount of time required to collect the information and incorporate them into databases, 2) need of a defined standard for naming; e.g. journal's abbreviations, and 3) the necessity of dedicated software to collect the large amount of information and to evaluate the results.

3.4 Fourth quadrant: internal perspective of the library collection

The final quadrant measures users' behavioral aspects within a library system, namely the users' interaction with the system. This interaction is utilized to study users' preferences, and to use this information to personalize services (Agostii, Crivellari, and Di Nunzio 2009).

Transaction log analysis (TLA) is one of the most important and well-known techniques that has been utilized for this purpose. TLA is defined by Peters (1993) as "a form of system monitoring and as a way of observing, usually unobtrusively, human behavior". GonÇalves et al. (2002) describe log analysis as a primary source of knowledge about how digital library users actually exploit digital library systems and how systems behave while trying to support users' information seeking activities. In the context of Web search, the storage and analysis of log files are mainly used to: 1) gain knowledge on users and improve services offered through a Web portal, without the need to bother users with the explicit collection of information (Agostii, Crivellari, and Di Nunzio 2009); 2) assist users with query suggestions (Kruschwitz et al. 2011); 3)

study online journal's use and their users' information seeking behavior (Jamali, Nicholas, and Huntington 2005). Measures of usage analysis can include: number and titles of journals used, number of article downloads, usage over time, a special analysis of subject, date and method of access (Nicholas et al. 2006).

Many studies have been conducted to corroborate the use of logs analysis to analyze the users' behavior in a digital environment. For instance, Deep Log Analysis (DLA) is a technique employed by Nicholas and colleagues to demonstrate the utility and application of transaction log analysis. The authors conduct series of studies such as the comparison between two consumer health sites: NHS Direct Online and SurgeryDoor (Nicholas, Huntington, and Williams 2002), a comparison of five sources of health information (Nicholas, Huntington, and Homewood 2003), and the impact of Consortia "Big Deals" [3] on users' behavior (Nicholas, Huntington, and Watkinson 2003; Nicholas, Huntington, and Watkinson 2005). Nicholas and colleagues state that Web usage logs offer a direct and immediate record of what people have done on a Web site. Some of the outcomes of DLA include: 1) site penetration, as the number of items viewed during a particular visit; 2) time online or page view time; 3) type of users, identified by IP address; 4) academic departments usage; 5) differentiation among on-campus and off-campus users; 6) user satisfaction as an attempt to track returnees by IP (Nicholas et al. 2006). Another example on user behavior analysis is presented by Davis and

[3] For detailed information on this subject see Peters (2001).

Solla (2003). The authors report a three-month analysis of usage data for 29 American Chemical Society electronic journals downloaded from Cornell University. They demonstrate that while the majority of users limited themselves to a small number of journals and article downloads, a small minority of heavy users had a large effect on total journal downloads. They conclude that a user population can be estimated by knowing the total use of a journal because of the strong relationship between the amount of downloaded articles and the number of users. Nevertheless, the authors use IP addresses as a representation of users, which is not necessarily true and might lead to biased results.

Moreover, log analysis can be supported and validated by other types of users studies such as eye-tracking systems to understand users' behavior in different situations. Eye-tracking systems are a set of devices for measuring eye positions and eye movement (Mehrubeoglu et al. 2011). Saito et al. (2009) analyze search behaviors and eye-movement data to conclude that different tasks and levels of experiences affect the behavior of students searching for information on the Web. In general, users' studies and logs are used in a separate way, since they are adopted with different aims in mind (Agostii, Crivellari, and Di Nunzio 2009). For instance, Capra et al. (2009) describe the use of log data from the OPAC to develop a set of grounded tasks. At the same time, through the use of a remote eye tracker in a controlled laboratory setting; they collect eye-tracking data to examine users' behaviors developing exploratory search

tasks. The authors report that data collection using the eye-tracker was a difficult process, as well as using the log data to develop the search tasks.

Woong Yun (2009) differentiates two types of methods to collect log files: clients and servers. Server-side is a low-cost non-intrusive method for collecting data from a large number of individuals with minimal staff involvement. This method uses Web log files to identify user accesses to files in a certain Web server. On the other hand, client-side logs are methods which require some contact with study participants because of the need to install a monitoring program on the users' computers. Client-side methods are very invasive, require a high staff involvement and have high costs due to users' recruitment. Muresan (2009) states that data captured by server-side and client-side logging are complementary and typically used to answer different research questions.

To enhance the results of log analysis and test findings, some other data gathering methods can be conducted, such as: questionnaires, surveys, interviews or observation studies (Jamali, Nicholas, and Huntington 2005; Kostkova and Madle 2009; Black 2009; Agostii, Crivellari, and Di Nunzio 2009). Combining quantitative data, for example, log analysis with these qualitative data allows to cross-check the analysis and fills in knowledge gaps. In addition, this combination provides a much more in-depth picture of how a digital library may be impacting its users' community and their work, and also explains the information seeking behavior of the users discovered in the logs. One

specific example, presented by Agostii et al. (2009), concludes that by combining implicit methods such as users' interaction logs, and explicit methods such as users' questionnaires, the results are more scientifically informative than those obtained when the two types of studies are conducted alone. Thus, by incorporating log analysis to our holistic matrix, library managers gain an important input on users' behavior and the possibility to identify potential failures in the library system at the time of delivering services to the users.

3.5 The proposed holistic evaluation matrix

By combining the methodologies discussed above and the conceptual matrix defined by Nicholson, this paper proposes a holistic view of the processes, resources and activities present in libraries from an economic perspective (Table 2). We strongly support the idea that information must be collected from many separate sources, such as: library information systems, library statistics, observation, surveys, users' inquiries, etc. in order to have enough input and also different points of view to be used in an adequate decision-making process.

		Topic	
		Library System	**Collection**
Perspective	**Internal (Library)**	**Cost analysis** Processes, Time, Resources	**Log analysis** Implicit and explicit data

	External (Users)	**Quality** Statistics gathering, Suggestion boxes, Usability testing, Satisfaction surveys	**Bibliometrics** Citations patterns, Publishing patterns, Journals downloaded, and Journals' impact factor

Table 2: Methodologies proposed to economical evaluate a library through a holistic perspective

The approach for implementing this matrix is to start by identifying the services or activities involved in libraries and calculate the costs incurred by the different resources (staff, equipment, facilities, collection, etc.). In order to do so, qualitative mechanisms for assessing library effectiveness should be included, for example, observation, interviews, surveys, expert opinions, process analysis, organizational structure analysis, standards, peer comparison, etc. Quantitative techniques are also required to evaluate the efficiency, usefulness and manipulation of the system. Citation analysis, log analysis, statistics gathering and stopwatch techniques are some useful methods that can be included for the analysis.

To collect these data, typical data sources could be the following: 1) integrated library systems which contain information about process performance in the library, circulation data, acquisition, etc.; 2) the library Portal used as a front-end to the different types of electronic resources; 3) the OPAC as a system to support digital reference services; 4) interlibrary loan system from consortiums (Nicholson 2006a); 5) LibQUAL+® survey system; and 6) information systems for demographic information.

However, some considerations need to be taken into account when collecting data from these heterogeneous data sources (Poll 2001). For instance 1) lack of well-defined standards for some specific analysis such as journal's abbreviations, access to electronic collection, and e-lending; 2) need of a common understanding of what sources and data must be considered; 3) need of integrating multiple data sources from the library, university, consortiums and suppliers; 4) differences of requirements between traditional and digital collection, for example digital libraries require licenses for a certain time period, links to remote resources, or prepaid pay-per-view; 5) large volume of data generated by all different sources, for instances web logs. To develop a structure for a holistic analysis, data generated by multiple data sources must be integrated. Unfortunately such integration presents a big challenge to be addressed since these different sources normally use dissimilar formats and access methods (Ying Wah, Hooi Peng, and Sue Hok 2007). To overcome these shortcomings, Nicholson (2003) proposes the aid of a data warehouse to integrate, filter and process all the information extracted from many different systems based on the holistic matrix.

4 Data warehouse architecture for library holistic evaluation

A data warehouse is defined as "a repository of integrated information from distributed, autonomous, and possibly heterogeneous, sources" (cited by (Bleyberg et al. 1999)). Based on the measures proposed in this study, and the typical structure of a data warehouse (Inmon 2005), the resulting

system architecture of a library's data warehouse, as shown in Figure 1, is composed of three layers: 1) data source, 2) data extraction, cleansing and storage, and 3) data presentation area.

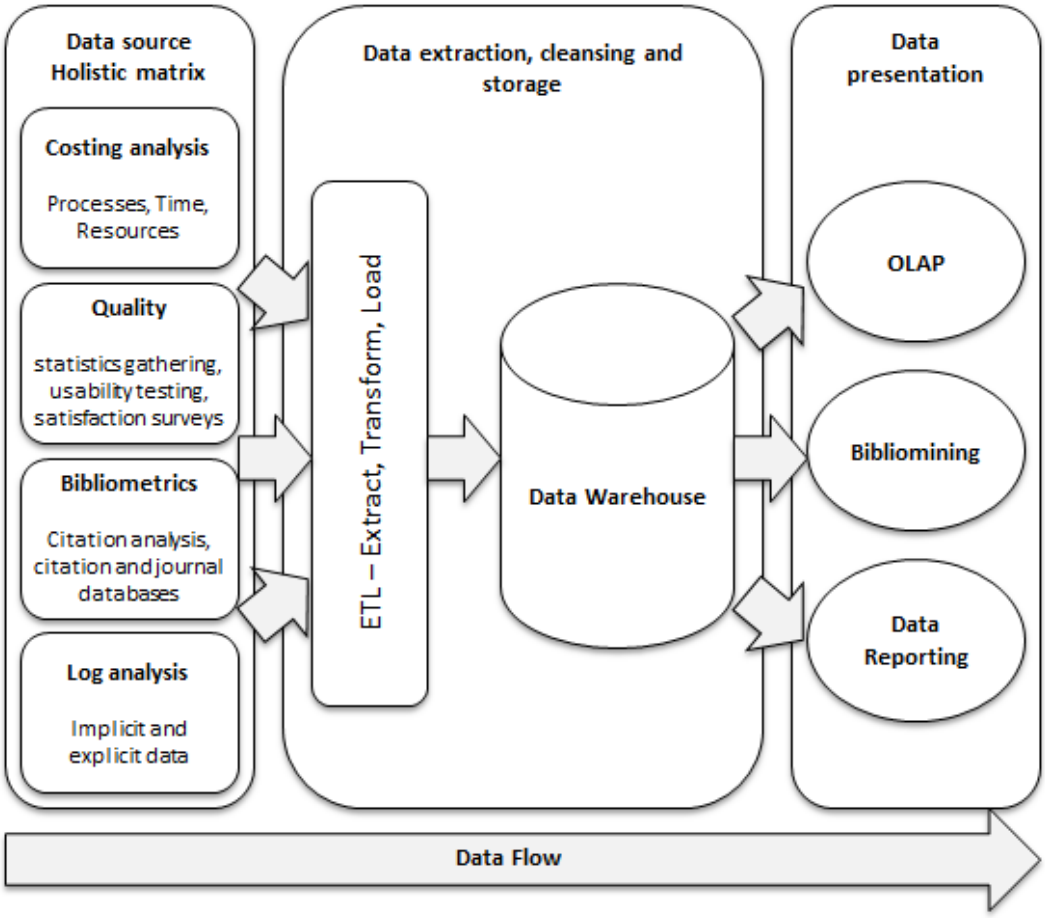

Figure 1: Data warehouse architecture for library holistic evaluation

4.1 Data source layer

This layer is composed by the information extracted from different data sources. In our structure, data sources selected are based on the holistic matrix which includes: 1) the analysis of processes, resources and costs of the library services, 2) the point of view of the users on the quality of

services, 3) the usefulness of the library collection, and 4) the users' behavior in the library system.

4.2 Data extraction, cleansing and storage layer

The resulting data are processed by the data extraction, cleansing and storage layer through ETL (Extract, Transform, Load) processes. This allows having a clean, homogeneous and anonymous version of the library data. ETL is a group of processes whereby the information collected from the operative systems is converted into a uniform format required by the data warehouse (Laitinen and Saarti 2012). ETL also includes tools for loading the data into the data warehouse as well as for periodically refreshing it. At this point, this is a big challenge and time-consuming task because this process needs to combine all the different data sources and converts them into a uniform format, excluding possible inconsistencies, redundancies, and incompatibilities (Nicholson 2003). At the same time, the ETL processes are the key part to protect patron privacy during a data warehousing (Laitinen and Saarti 2012).

Once the data have been processed, the following step is to build the data warehouse. Because this process is the most tedious and time-consuming part, Nicholson (2003) suggests to start with a narrowly specific query and work through the entire process, and then, iteratively continue developing the data warehouse. This is done in order to minimize the initial time required and also to improve the collection and cleansing algorithms as early as possible.

4.3 Data presentation layer

Eventually, the stored data are analyzed through reporting techniques located in the data presentation layer such as: data reporting, OLAP (On-Line Analytical Processing) and Bibliomining tools. The tools utilized in this area depend on the needs of the library manager to make decisions. For instance, *data reporting tools* are traditional reports that allow library managers to ask basic information about the data (Hwang, Keezer, and O'Neill 2003). *OLAP tools* are methods to produce reports without the need of knowing a database query language (Nicholson 2006b). Hudomalj and Vidmar (2003) describe them as a multidimensional system that allows to browse the data by dimensions and measures. The authors show how OLAP tools can be used to prepare regular and unplanned reports, ensure quality, check data integrity, monitor the development of science, and evaluate or benchmark disciplines, fields or research groups.

Bibliomining is defined by Nicholson and Stanton (2003) as the combination of data mining, bibliometrics, advanced statistical, and reporting tools used to track patterns of behavior-based artifacts from library systems. Bibliomining is an important tool to discover unknown and useful information in historical data in order to support budget allocation decisions (Kao, Chang, and Lin 2003). Once the information has been collected into a data warehouse, bibliomining explores the content with data mining tools and then analyzes, validates and generates the results (Hwang, Keezer, and O'Neill 2003). The resulting information

gives the possibility to perform scenario analysis of the system, where different situations that need to be taken into account during a decision making process are evaluated (Nicholson 2006b). For instance, different type of users, services, resources, budgets, etc. At the same time, the matching of bibliomining with demographic information allows to discover patterns of use in order to, for example, offer and personalize services to meet the needs of specific group of users (Nicholson and Stanton 2003). In addition, Nicholson (2006b) suggests the use of bibliomining to standardize structures and reports in order to share data warehouses among groups of libraries, allowing a library to benchmark its information with data collected by other libraries.

Since bibliomining is a powerful tool that combines different techniques for analysis and reporting, and may also be used for different purposes, in our study its use is promoted as an important part to implement a strong decision support system that allows, for instance, to justify difficult decisions about budget or to clarify funding requests that library managers must make.

The final result of this architecture is: 1) an ETL that collects, links and cleans the information gathered through different data sources generated by the library system and its users, 2) a data warehouse database that stores the collected information, 3) a group of presentation tools that reports more accurate library information on how the resources and services are being accessed by users.

5 Conclusion

Libraries are accustomed to being constantly evaluated; consequently they have a long history on data collection statistics (Laitinen and Saarti 2012). Unfortunately, these statistics are only partially used for decision-making processes due to the wide variety of formats and the lack of efficient methods for grouping information. In this paper, a complete framework and set of tools to holistically analyze libraries for financial decisions has been proposed. The approach for implementing the structure is to start extracting and collecting the information generated based on the two-dimension holistic matrix. The theoretical matrix is used to analyze the library collection and services from internal and external perspectives. Furthermore, several methods and appropriate measurement tools were evaluated and proposed for an integrated decision-making process. Library managers can select one or more instruments in every quadrant based on the current availability or decide to include other measurements and detailed issues to the model. An example of organizing and collecting the information based on this holistic approach is presented by Siguenza-Guzman et al (2013b). The authors document the preliminary experiences of the implementation, concluding that the holistic model is a simple and powerful structure for grouping library information. Although, the authors support the practical validity of the proposed approach and describe the model as a simple and powerful structure, they also describe important considerations that need to be borne in mind, for example, the time

required to implement the complete approach, as well as the need of dedicated systems to automate the different quadrants.

In addition, this study proposes the architecture of a data warehouse to store the collected data. This resource will allow the use of information not only in traditional measures or for generating reports, but also to enhance decision making. For instance, information on the following four scenarios is accessible: 1) redistributing and prioritizing the allocation of resources assigned to a specific service; 2) gaining knowledge about users coming into the library but also users that are served by digital services; 3) being aware of gaps and strengths of their services and collection; and 4) building collections based on their holdings, users priorities, and technological tendencies. Ultimately, this study attempts to include the integration of this structure with an optimization tool to determine an optimal resource allocation decision in some specific scenarios, such as budget decreases, journal subscriptions and cancellations, and the creation of new services.

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