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AN INFORMATION QUALITY FACTOR DEVELOPMENT AND ANALYSIS

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ABSTRACT

One of the most important issues in information technology (IT) and Information Systems (IS) is the quality of information that organizations are using in their daily transactions, decision-making, and development of strategic advantage. Unfortunately, it is an area that has been lightly studied in terms specific to information technology. Our research questions explore information quality and its influence on modern organizations. Our study first develops an overall measure of information quality as determined by how information integrity, information maturity, and information consistency are viewed by CFOs (Chief Financial Officers) from 481 US and other countries. Through exploratory factor analysis, this one information quality (IQ) factor is used as a measure of an organization's overall quality perception. Our study then explored and found that IQ varied by size of the company with larger companies having higher IQ. Industry type had no effect. Broad based secondary survey data from large sample of financial executives were used to explore these questions via a variety of statistical methods. Overall and specific effects are reviewed and summarized.

Keywords: quality, information technology investments, information integrity, information maturity, information consistency, information quality

INTRODUCTION

The need for organizations to have information they can rely on is essential. Modern businesses rely on information technology processing to provide them with current, accurate, and consistent quality of data, information, and knowledge in a wide variety of areas. From base transactions to complex decision models, all organizations depend on their information technology departments to provide them with quality of information. As a result, information quality is an area of research interest both from a practical as well as theoretical viewpoint. Our study will survey the extant research on various facets of information quality prior to development of an information quality factor.

Literature review of information quality

Information quality is a concept that has received some study but mostly in the context of total quality management. One researcher, Kuo [12] examined the overall effect of information quality on project management. He found that information quality provided specific, significant, positive effects on overall project management. This supports a basic underlying proposition that information quality (IQ) is a measurable, desirable, and significant advantage for organizations at least in this one particular area.

There are a number of researchers who have been credited with developing overall models of information system quality. Delone and McLean [4] are credited with developing an overall information systems success model including both system quality and information quality. Their model suggested correlation with user satisfaction and successful use of the system. Pitt, Watson, and Kavan, [22] in 1995, added service quality to the Delone and McLean model. Subsequently, other studies have used this modified model for information system quality [1] [17] [19] [20]. Specifically with regard to information quality, Shih and Lin [25] used the following attributes to develop an overall information quality factor for outsourcing: Information accuracy, understandability, timeliness, effectiveness, usefulness, communication with service provider, education service, good attitude of service provider, and technique ability of service provider. McGill [16] examined how end user development affected system quality. Saeed, Hwang, and Yi [24] suggested information quality as one of the key factors in an integrated view of consumer online behavior.

The Delone-McLean model [5] used the following attributes for development of their information quality factor Information quality: Completeness, Ease of understanding, Personalization, Relevance, and Security. In addition, for

systems quality and service quality the following attributes were used Systems quality: Adaptability, Availability, Reliability, Response time, Usability. Service quality: Assurance, Empathy, Responsiveness [5]. Our study uses a variation on this quality attribute set using broader questions. Our survey includes not only accuracy, consistency and reliability, but also including relevance, usability and response time and availability in a specific question rating, "ability to readily provide relevant analyses, decision making, and management reporting information" [9].

Longbottom and Murphy [14] studied this broader aspect of information quality by examining quality with regard to knowledge management. It is important that we consider not just accurate and timely data, but the ability of the provided data to be useful for decision-making purposes. Terziovski [28] notes the importance of continuous improvement in information quality. Perhaps the most comprehensive study of information quality comes from Eppler [6]. His work started in 2000 with Witting, where they identified seven approaches to IQ common through a comprehensive review of information quality studies. Eppler, M. and Wittig [7] include the following:

1. Fit for use
2. Meet expectations
3. Meet specifications
4. High value
5. Content, Form, and Time
6. No difference between required and obtained information
7. Meet all needs of all stakeholders

Eppler [6] refined this work in a comprehensive text on Managing Information Quality. In it he identified 70 typical information criteria, but then combined those down to 16 criteria: Comprehensiveness, Accuracy, Clarity, Applicability, Conciseness, Consistency, Correctness, Currency, Convenience, Timeliness, Traceability, Interactivity, Accessibility, Security, Maintainability, and Speed. The author suggests the first four fall into a relevance category, the second four are soundness, the next are process, and the final four are infrastructure.

All prior research has explored a variety of definitions and measures of information quality. There is little work on the development of a useful overall measure of information quality. This is the most important research gap we are attempting to address. Our first goal is develop a workable information quality factor. In addition, little work has been done on measuring IQ variance across companies. Our study will explore relationship of information quality on industry type and size. This study is based on this past theoretical work, and attempts to simplify the theory in order to make the research usable, practical, and accessible, as well as to begin to understand the current state of Information Quality in industry today.

INFORMATION INTEGRITY

The concept of information quality has also been expressed in other terms. One of these monikers is information integrity (II). Khurana and Mandke [11] found that information integrity can be a key component of a business process modeling approach and can be a major competitive advantage for organizations. Their study goes on "identifying the criticality of information integrity for business competitive advantage and listing the emerging information integrity requirements." According to Rajaraman and Mandke [23], quoted in Khurana and Mandke [11], "Information integrity is dependability and trustworthiness of information and is a key factor determining strategic business advantage. Its determinants are accuracy, consistency, and reliability of information.". Larkin [13] also stresses the importance of increasing information integrity, noting specific examples of how II has increased organizational performance. Ma, Johnston, and Pearson [15] found information integrity as one of the four factors that serve as information security objectives. Miller and Voas [18] see Information integrity and IT professionals' integrity as intertwined. Professional integrity is required to maintain information integrity. Nergui, Acharya, Rajendra, and Yu [21] note the importance of information integrity in critical applications. Their application is medicine.

INFORMATION CONSISTENCY

Another concept that is mentioned with regard to information quality is information consistency. Consistency, as noted, is one of the components of information integrity according to [11]. "Consistency (C) is defined as the degree to which multiple instances of a value satisfy a set of constraints. The multiple instances may exist across space (such as databases or systems) or over time. Consistency is then, with respect to a set of constraints, and data/information is said to be consistent with respect to a set of constraints if it satisfies all constraints of the data/information model." Khurana, R., & Mandke, V. V. [11] include consistency, integrity, and reliability in their study of information quality. Basili, Donzelli, and Asgari [2] emphasize the concepts of information dependability and consistency in their study. They propose a Unified Model of Dependability. Their model focuses on availability, accuracy, and performance, and deals with consistent system responses to external events.

INFORMATION MATURITY

A final area that has been associated with information quality is information maturity. Most instances of information maturity mention the maturity model hierarchy first developed by Carnegie Mellon Software Engineering Institute, the Capability Maturity Model. "CMMI (Capability Maturity Model Integration) is a process improvement approach that provides organizations with the essential elements of effective processes, which will improve their performance. CMMI-based process improvement includes identifying your organization's process strengths and weaknesses and making process changes to turn weaknesses into strengths" [26]. The maturity levels are five progressive steps of increasing process improvement. Vayghan, Garfinkle, Walenta, Healy, and Valentin [29] note the transformation of information maturity in five successive levels similar to CMMI:

1. Data to run the business – Focus on data and reporting
2. Information to Manage the Business – Basic Information Interaction
3. Information as a Strategic Asset – Information in Business Context
4. Information to Enable Innovation – Information-Enabled Business Innovation
5. Information as a Competitive Differentiator – Adaptive Business Performance

These represent 5 levels of increasing functional maturity.

COMPANY SIZE AS AN IMPORTANT ISSUE

In understanding a firm's information technology decisions, there is an important demographic that needs to be considered, company size. Company size has been used as an important variable in a number of IS studies. The use of size as a variable affecting organization performance and issues is well established in the literature. González-Benito and González-Benito [10] performed their study and found company size to be a determinant factor in stakeholder environmental pressure. Biesebroeck [3] looked at the company size effect on manufacturing firms from in sub-Saharan African countries He found that large firms achieve higher productivity levels and are more likely to survive. The labor market relocates workers toward the most productive firms, and this reinforces the importance of large firms for aggregate productivity growth. Formal credit institutions award most financing to large firms, and access to credit is positively correlated with productivity, even conditional on firm size. According to Biesebroeck [3], size affected the success of the manufacturing firms he studied. Larger firms performed better. Our study will review the effects of the relationship between company size and information quality.

RESEARCH QUESTIONS

Based on the literature review, there are several research questions that will be explored in this study. The first deals with the concept of information quality. It is proposed that the various concepts of information integrity, maturity, and consistency, though reported to be unique qualities, all will result in a single factor that we will call information quality.

Research question 1
Information integrity, information maturity, and information consistency will develop into a single Information Quality (IQ) factor.

It is then suggested that this concept of information quality is the same across all sizes of organizations. In other words, neither larger nor smaller companies will experience higher or lower levels of information quality. It is also proposed that due to scalable and affordable technologies, information quality can be achieved by all organizations. An exploration of applicability across industries is also explored.

Research question 2
Information Quality (IQ) will not vary based on organizational demographics of size and industry.

SURVEY SOURCE AND METHODOLOGY

In order to explore quality in information technology, specific corporate data were required. We found a rich data set that was available from Financial Executives International. Financial Executives International is "the preeminent association for CFOs and other senior finance executives." It has … CFOs, VPs of Finance, Treasurers, Controllers, Tax Executives, Academics, Audit Committee members [in] companies large and small, public and private, cross-industry. [8] The FEI, each year, commissions a large scale study of "technology issues for Financial Executives". The survey instructions follow.

As a part of this study, specific information was obtained from top financial executives on information technology actions as well as attitudes towards information integrity, consistency, and maturity. These questions and responses were sufficiently detailed and pertinent to our research questions to serve as the bases for testing this study's research questions. The main advantage is the large data set and the independent collection from a private membership trade group. All data has been collected and furnished by the Financial Executives International and remains their property. Use for academic and research purposes was obtained by the author. The author wishes to sincerely thank the organization for their cooperation.

The overall questionnaire included 44 questions in the noted categories, but sub-questions and ranked responses raised the overall individual data points to more than 220. From this overall report, a small subsection was used to analyze the relevant research questions. Selected responses from the Demographics section were included as well.
The specific questions used to test the research questions as well as more detail on the survey are listed in the Appendix 1.

RESULTS

In order to explore the research questions, a variety of statistical methods were used including factor analysis, scale reliability, and multiple regressions.

Table 1 Descriptive Statistics of Quality Variables

		Maturity	Consistency	Integrity
N	Valid	482	482	482
	Missing	1	1	1
Mean		2.50	1.78	1.64
Std. Deviation		1.266	1.021	1.436

Before exploring the first research question, an overall review of the average rating for each of the relevant variables was analyzed. As shown in table 1, there were 482 usable responses. The averages were all favorable overall. A Likert scale was used for each with a 1-5 scale where 1 was most favorable, 3=neutral and 5=least favorable.

Maturity was rated exactly between Superior and Average, Consistency was rated between highly and quite consistent (more towards quite consistent), and Integrity was rated between highly satisfied and somewhat satisfied (a bit more towards somewhat satisfied).

Research question 1
Information integrity, information maturity, and information consistency will develop into a single Information Quality (IQ) factor.

The literature review supported the three quality variables that were in the survey: maturity, consistency, and integrity. After examining each of the quality characteristics that were explored in the survey, the approach was to see if the three variables would coalesce in one overall factor.
An exploratory factor analysis was undertaken to explore this question. The three questions in the survey that were used to determine this factor were:

2a. How would you grade the relative maturity of your management information environment in terms of its ability to readily provide relevant analyses, decision making and management reporting information?
2b. Please indicate how consistent is the management and financial reporting delivered by the finance team with other operational reporting performed by line of business managers.
9a. What is your overall level of satisfaction with your organization's "information integrity", defined as accuracy, consistency and reliability of information?

The results of this analysis are presented in table 2. The three questions converged on one factor with an eigenvalue over 1.0. The component matrix shows all the components are over .5 (table 3). Scale reliability was then reviewed and the Cronbach's alpha calculation resulted in .828 (table 4), well above the .7 recommended minimum. As a result, the three questions posed all support a single factor which we shall call information quality (IQ). The results of research question one is that information maturity, integrity, consistency, accuracy, and reliability, all represent one measurable factor.

Table 2 Total Variance Explained for Quality Factor

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.295	76.499	76.499	2.295	76.499	76.499
2	.496	16.524	93.022			
3	.209	6.978	100.000			

Extraction Method: Principal Component Analysis.

Table 3 Component Matrix[a] for Quality Factor

	Component
	1
Maturity	.912
Consistency	.906
Integrity	.802

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Table 4 Reliability Statistics

Cronbach's Alpha	N of Items
.828	3

Research question 2
Information Quality (IQ) will not vary based on organizational demographics of size and industry

Size

For company size, a regression analysis was performed with the Quality factor as the dependent variable and company size as the independent variable. Table 5 examines the regression coefficient for company size and the Quality factor independent variable. At a $p < .001$ significance, larger companies have higher recognized Information Quality. The reason for this is unclear but a possible explanation is that information quality has an economies of scale aspect to it that larger companies are able to exploit, due to their larger revenues and income.

Table 5 Size Coefficients[a] Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.241	.084		2.870	.004
	Size	-.105	.031	-.153	-3.403	.001

a. Dependent Variable: QualFac

Industry

For industry type, an analysis of variance was performed with the Quality factor as the dependent variable and industry as the fixed factor. The complete list of industries surveyed is in the Appendix. The result of this analysis is shown in table 6. The variance between groups was not significant at $p < .05$ (actual p was .169). This suggests that there is no significant difference in IQ based on type of industry. All industries have a similar IQ rating and variance. Larger companies may have higher perceived information quality (IQ). But our results show no difference between *industries* for perceived information quality.

Table 6 Industry ANOVA QualFac

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37.087	30	1.236	1.256	.169
Within Groups	443.913	451	.984		
Total	481.000	481			

LIMITATIONS

As with any study there were limitations. The study was based on secondary data from a major international financial organization. Though many researchers have used such an approach, this may not be representative of other locations or groups. In addition, the sample, though significant, may not be representative of the population as a whole. More extensive sampling with other groups and in other regions of the US as well as internationally should be undertaken to verify results. The study also only measures one particular time period, 2010. This is about two years after a major financial crisis and one year after the major recession. There may be some effect of a recovery in

IT spending included in the results. Though the survey was carefully prepared, there may have been some confusion with regard to the questions. Since the survey was emailed, there was no opportunity for clarification of questions. This, of course, is standard with email surveys, but may have influenced some results. This shortcoming may be clarified through more detailed instructions or an interview approach. Of course, this would most likely be cost prohibitive. The authors perhaps erred on the side of simplicity so as not to burden the reader with unnecessary detail that would have reduced response. This may have had some limited ambiguity issues.

This work, similar to other studies noted, includes major financial executives. There may be different results if CIOs (Chief Information Officers) or presidents were surveyed. The use of financial executives as a proxy for organizational actions has been accepted in the past, and it is suggested that the findings can be extrapolated and relevant to overall corporate views. One caution may be related to the US centric nature of the participants. Nearly 85% of the respondents were US based. Caution should be taken when extrapolating these results to a broader international population. The results should still be useful for practical real world situations with primarily US companies. A study with a broader international group of financial IT professionals should be undertaken to validate results to a more general population.

DISCUSSION AND IMPLICATIONS FOR RESEARCHERS AND PRACTITIONERS

Our study reviews two general research questions: Research question 1

Information integrity, information maturity, and information consistency will develop into a single Information Quality (IQ) factor.

The first research question explored was: Information integrity, information maturity, and information consistency will develop into a single Information Quality (IQ) factor. The results of the factor analysis and scale reliability show that, indeed, a single factor can measure information maturity, integrity, and consistency. Our study has important implications because we have provided further support for a modified Delone and McLean model for information quality but also expanded this factor by adding in a variable (maturity) that reflects a broader decision making approach. Maturity as defined in the survey includes "ability to readily provide relevant analyses, decision making and management reporting information". This information quality aspect has not been included in the Delone and McLean model prior to this time, and needs to be incorporated as information technology has evolved over the past decades. No longer are IT departments providing data and transaction processing. Rather they are incorporating advanced tools and applications to assist in running the entire organization from data collection to strategic decision processes. The inclusion of this variable is thus an important addition to an overall information quality analysis. The results exploring this first question yielded consensus, that generally information quality is viewed favorably by a broad cross section of major corporations. This is an important finding in itself as practitioners can take confidence that IT does still provide good information needed to run major corporations. Researchers can take this as a start that IQ is generally good. Further research is necessary to determine why IQ is not better still and what can be done to improve in this area. The primary result of exploring Research Question 1 was the development of a single IQ factor. Indeed, this factor was found and did include the decision making maturity factor. Practitioners can use this factor in analyzing IQ in their organizations. Researchers can use this factor in further analysis of IQ in organizations.

Research question 2: Information Quality (IQ) will not vary based on organizational demographics of size and industry

In order to verify this factor, this research analyzed whether organization size and specific industry influenced whether IQ would be viewed differently. It was proposed that due the ubiquity of scalable IT hardware, software, and cloud solutions, IQ would not vary based on either industry or size of the organization. The results, however, show that though there is no variance based on industry, company size did have a significant impact. Larger corporations experienced higher IQ than smaller companies. This presents a fertile area for further research. The reasons behind these findings are unclear, but as noted there may be still economies of scale at work here. Another option might be that larger companies do higher levels of outsourcing, which may lead to improved quality. Finally,

larger companies may just have more resources available to explore and implement newer technologies. For practitioners, the results of research question 2 are important since they first suggest that all industries can achieve good information quality. Software and systems are available or able to be developed that can support all organizations. Practitioners can be confident that their industry is not subject to some IQ bias. But practitioners, particularly of smaller organizations, need to understand that their size may preclude more positive results compared to their perhaps larger competitors. Extra work should be undertaken to explore all avenues in this area so that they can achieve the highest level of IQ possible. They seem to be starting from a weaker position than their larger rivals. Outsourcing may provide some of these advantages.

CONCLUSIONS AND FURTHER RESEARCH

This work has extended the research with regard to the information quality. Many researchers have studied the concepts of information quality. Our work extends this past work by adding a dimension of information maturity to development of an overall information quality factor. We believe our work has established a more comprehensive and accurate information technology quality factor that can be used in future information research. This variable adds an evolved understanding of the role that information technology plays in today's organizations, including decision-making and relevant analysis. We therefore suggest this factor to be more indicative of the way information technology works today and provides a more accurate representation of information quality. Also, this study is perhaps the most extensive in that it surveys 428 major organizations and their views towards information quality. The survey was also conducted by an in-profession trade organization. This may suggest higher levels of disclosure and acceptability. At the very least it presents a broad cross section of major organizational views on information technology quality. The study also finds that IQ does not vary by type of industry but does vary by size, with IQ being higher in larger organizations. Future work needs to be undertaken to validate these results among other organizations and particularly among other business professional groups. This study only examined results from financial and senior executives and should be duplicated with other operational personnel as well as IT personnel. Different levels of the organization can be surveyed as well. The authors welcome consultation on the development of further study in this fertile area.

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Apppendix 1: FEI Study Prologue and Industries Used in Analysis

FEI's Committee on Finance & Information Technology (CFIT) and Financial Executives Research Foundation (FERF), in partnership with Gartner, are conducting the twelfth annual survey of Technology Issues for Financial Executives. This research examines and reports on information technology from the perspective of the financial executive. As part of this year's effort, we have set an ambitious goal: responses from 1,000 FEI members. This level of participation will enable us to expand the report to include more analyses by industry and company size, allowing you to better compare and benchmark your company. We strongly encourage you to participate. You can learn a lot about current trends just by reading the questions. This year's questionnaire incorporates feedback and suggestions from last year's respondents. To make it easier to participate, we have reduced the number of questions by 25%. Before starting the survey, you will need to know your company's total planned expenditures in the next year related to its analytical and decision support capabilities. If you have any questions, please call Bill Sinnett, FERF Director of Research, at 973.765.1004 or bsinnett@financialexecutives.org. Thank you for participating. We appreciate your time and input. Bob SchultzChai rman, CFIT

The 2010 Gartner FEI Technology Study elicited responses from 482 people to more than 50 questions that covered senior finance managers' views of technology. This survey was open from late October 2009 through January 2010. Respondents represented a wide array of companies and reflected the FEI membership (predominantly North American companies). Eighty-three percent of responses reflected a corporate perspective, while 11% represented divisions, and 6% were responses from groups or sectors in which multiple business units were included in the response. Senior financial executives accounted for 74% of respondents. Fifty-nine percent of firms were privately held, 35% were publicly traded organizations and 6% had other forms of ownership, such as joint ventures. Many industries were involved in the survey, with high technology (14%), professional services (10%), and discrete manufacturing (7%) being the largest groups. Twenty-six percent of the organizations had more than $1 billion in revenue. For a detailed analysis of the methodology, see "ATV: 2010 Gartner FEI Technology Study Research Collection." [9]

4. In what primary industry does your organization operate?
(Select only one industry).

Aerospace and Defense	Leisure and Hospitality
Chemicals	Industrial Manufacturing - Discrete
Consumer Goods Mfg. - Durable	Industrial Manufacturing - Process
Consumer Goods Mfg. - Non-Durable	Media and Entertainment
Distribution	Mining and Metals
Engineering and Construction	Oil and Gas
Financial Services - Banking	Other Nonprofit (non-Governmental)
Financial Services - Insurance	Professional Services
Financial Services - Other	Publishing and Printing
Government	Real Estate
Healthcare - Payor	Retail
Healthcare - Provider	Telecommunications
Healthcare - Pharmaceuticals	Transportation Services
Higher Education	Utilities
High-tech	Wholesale
	Other (Please specify.) _____