Controlling the Data Quality of e-Business:
A Total Solution of Web-based Survey Knowledge Management Systems

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Abstract: Management and other behavioral researches heavily relies on survey while the evaluation of the data quality of the survey varies, this research attempts to: (a) Construct a web-based decision support mechanism: Survey Knowledge Management Systems (SKMS) to support the development of e-business. (b) Initiate a total solution for the survey environment through knowledge management (KM) including methodological accuracy, socio-cultural fit, and usability for internet-intranet users.

The SKMS consists of 4 systems: a Sampling Management System, a Measuring/Questionnaires Design Support System, a Group Interviewing Management System, and a Data Analysis/Decision Support System.

The development of SKMS and the collection of parameters of the knowledge were based on a 20-year series of empirical survey researches.

Keywords: *Survey, Knowledge Management, Information Systems, Data Quality, Decision Support, Management Sciences*

1.Specific Objectives

This research covers the analysis, design and use of web-based 'Survey Knowledge Management Systems (SKMS)' that take into account survey data quality control and decision support through knowledge management (KM) of methodological, cross-cultural, and user oriented knowledge.

'Can the survey be considered scientific research?' is a frequently asked question as business researchers rely heavily on survey data to plan marketing strategies, reform organization policies, compare management styles and to make a lot of decisions concerning human behavior. The demand shows the importance of survey logic; the criticism indicates the proven records of poor data quality that have been drawn by unreliable data gathering tools.

As a very good example during the history of e-commerce research, the comparison of the two results from the CommerceNet/Nielsen (2005)'s Internet Demographic Survey and the Find/SVP (1996)/Cyber Dialogue (2005)'s American Internet User Survey was very heuristic. Both of the two conductors were respectable, they continuously investigated the North America Area in the same time frame from 1995 to 1999, and they adopted a large-scaled probability sampling procedure, similar skills in sampling, measurement and interviewing, etc.

One of the most important findings was their estimate of the size of internet users. A summarized number is as follows:

	1995	1999
CommerceNet/Nielsen	16%	41%
Find/SVP/ Cyber Dialogue	6.40%	30%

It revealed a difference from more than fifty percent to almost four hundred percent and asserted that something was wrong. You are not able to ensure which number was true since they

were severely unreliable to each other. You might make very bad decision that was based on either of the reports.

This significant story alleges that there is an emerging need to employ recent KM theories and information systems techniques to direct survey processes, to evaluate the real meaning of collected data, to reveal the error range and to support sophisticated decisions. It is the turning point to accomplish an epistemically scientific survey research setting to support the planning of behavioral research.

Therefore, the specific objectives of this paper are:

--Investigating the explicit and implicit methodological issues that influence the data quality through survey. Explaining why the past and current data gathering systems were not able to respond these issues.

--Constructing a web-based decision support mechanism: Proposing, analyzing and designing a new 'Survey Knowledge Management Systems (SKMS)' to build up decision support tools and ensure the data gathering process in response to the continuously growing demand of various survey researches. SKMS will improve the former Computer-Assisted Telephone Interviewing (CATI) and Computer-Assisted Survey Information Collection (CASIC).

--Managing a knowledge ground: Initiating, integrating and organizing a total solution for the survey environment through KM of methodological accuracy, socio-cultural fit, and usability for internet-intranet users.

The author also contributes some creative functions into SKMS as follows:

--Sampling Precision Management: to define 4 rates to draw a clearer picture for sampling precision that could be measured automatically by the SKMS.

--Changing Parameters Base Management: to maintain an integrated database and model base that is deduced from distributed survey data.

--Cross-cultural Templates Base Management: to collect homogeneous data by different survey templates and measuring scales in different cultures.

--User Dialogues Management: to develop interactive user interfaces and survey-designing wizards for users who do not have the expertise in research methodology.

The development of SKMS and the collection of parameters of the knowledge were based on a 20-year series of empirical survey researches.

2.Emerging Issues

Survey research, by its interviewing methods, usually have been categorized into personal, mail, telephone and recently internet interviews. Empirical evidence, both in Taiwan and the United States, indicate that rapid social change has led to personal interview is becoming more difficult, with a lower response rate, lower data quality, being more time consuming, involving greater expense, and more errors. (Blankenship, 1977); (Frey, 1983); (Taylor, 2000), (Wu, 1984), (Wu, 2000b), (Wu, 2002) Mail interview is used to glance over rough references or promotions instead of supporting prediction and decision-making because it always suffers from seriously a low response rate and unstable quality (Dillman, 1978). The current internet interview will be under investigation very carefully in the medium ranged future, though it has some specific advantages such as convenience and cost efficiency. It is not a valid tool for public surveys yet, since it is still impossible to include a complete sampling frame, even a virtue frame (Couper et al, 2004), (Couper, 2000), (Shonlau et al. 2002).

On the other hand, telephone interview combined with information and communication technology has brought brand new idea and developed the CATI two decades ago. (Groves et al., 1984); (Shanks, 1983); (Shangraw, 1986)

CATI was a word processor based system of questionnaires editing tools with an on line interviewing function. The next developed CASIC enhanced the new functions of Prepared Data Entry (PDE), Touch-Tone Data Entry (TDE) and Voice Recognition Entry (VRE) to CATI (Weeks, 1992). However, some critical problems beyond the capability of CATI and CASIC were found during the longitudinal practice. Furthermore, the user interface seemed not friendly enough to the commercial survey project leaders and even to the academic researchers who have little knowledge of research methodology.

As Warren Mitofsky, the director of the survey center of CBS, criticized that ‘a pig-headed who had ten phones and a typewriter would think himself could conduct a survey’. It is easier to have a machine that can produce trash numbers while investigating scientific data is another thing. It requires comprehensive, interdisciplinary, sometimes fermenting perspectives for analyzing and designing the data collection tools. We need the tools to be accurate, suitable, and easy.

To develop new survey tools, to construct a better survey setting, especially on the internet platform, and to manage all the survey knowledge into an intuitive research environment are the concerns of the author and the new requirements of the SKMS as well.

3.Development Foundations

3.1.KM and DS via the Internet

There are two approaches to explain the practice of KM. Peters (2000), Hoffman (1999), Saunders (2000) put KM as a design of process and environment to answer specific questions. Spiegler (2000) and Microsoft advocated KM as the new field look on information systems, decision support systems, even data management and the use of the internet while others considered it a combination of recycled concepts

Reviewing the current literature, the author summarized the construction of KM consisting of four processes: The first is to create a setting for sharing knowledge. Access to knowledge breeds more knowledge, and the best KM techniques ensure that every detail's involved and without geographic boundaries. The second is to eliminate communication filters by allowing people to skip technical levels—which leads to more ideas on how to do things better. The third is to prioritize the tasks. A prioritization process can align brainpower and effort behind what's truly strategic. Project leaders get together to rank all vital activities first to last, no ties allowed. The process lets people share knowledge about what is being accomplished, and break down the departmental barriers that bottle up ideas and creativity. The last is to keep efficiency. Effective KM helps people to save time and expense.

The realization of KM is to provide a total solution of decision support (DS) environment via the internet. The point of departure is the observation that yesterday's data are today's information, which will become tomorrow's knowledge, and knowledge, in turn, recycles down the value chain back into information and into data. KM articulates the basic terms of this perpetual process. The proposed model defines operations and transformations of data-to-information, information-to-knowledge, and their reverse order. Such transformations correspond to a time dimension of past-present-future and resemble the process of abstraction.

The specific questions here we are going to answer is the knowledge of survey methodology.

3.2.Methodological Accuracy

We could not access quality data if we are lacking an accurate and careful process to discover scientific knowledge. (Kuhn, 1977) There are three types of problems for accessing methodological accuracy:

1. There is a current solution, but few researchers employ it.
2. There is a current solution; however, it may be wrong.
3. There is not a solution for an implicit or emerging problem yet.

The author's effort has rendered improvements for the above situation. Some examples are the following. The definition of unknown population and the design of the sample size were usually determined by the researcher's personal arbitrary experience in present survey practice because its' theoretical and mathematical calculation was too complicated to cope with. If we could build up a design model in the SKMS, it would produce more reasonable decision for the sampling frame, allocation size, estimation of sampling precision and, furthermore, cost evaluation. On drawing samples, there were various methods including directory method, random digits dialing (RDD), plus 1 method, etc. (Hauck et al., 1974) (Klecka et al., 1978) Through the database management system, the SKMS would integrate all methods from diverse theories.

3.3.Socio-cultural Fit

There is no single method that fits to measure human behavior in every corner of the world. Social and cultural factors always remind system designers' attention concerning organizational behavior, (Liao et al., 1997) so the SKMS is the same.

As the first researcher conducting professional CATI survey in Taiwan, the author found firmly existing cultural differences from reports in other countries.

For example, the direct self-report has been the most common method for public opinion survey in USA. But Wu (1997e) found that this method might cause two problems in Taiwan. The first is a low response rate or nonresponse (Dunkelberg et al., 1973) (Francis et al., 1975). The second is the interviewee's inconsistency in attitude and behavior. Bassili (1991) also discovered the differences of response latency and certainty on voting intentions with a CATI Survey in Canada.

Another example, it is essential that the probability of who is to answer the phone in a family should be random. Wu (1997e) indicated that there are lots of large families in Taiwan, and the households do not share an equal chance to answer the phone. Any survey interviewing the first person on the line will contact much more the housewife or young adult rather than male and senior members. Thus, the 'selection of household method' (Kish, 1949) (Paisley et al., 1965) (Wu, 1995b) seemed to be quite necessary in Taiwan.

3.4.Friendly Usability

There are two kinds of surveys and users. One is a public or commercial survey conducted by media or business users. The statistics that they use are only frequencies or percentages. Its productivity for decision-making was relatively poor. We expect to add more decision support functions for this. The other is an academic survey by research institute users. They use various statistic techniques including multivariate analysis. Its meaning of numbers, sometimes, was too complicated to understand quickly. It was expected to have an easy on line dialogue for interpreting the meaning of data. It could be done by a wizard, template library and intranet setting.

When Kuhn (1977) revised his discussion of paradigms, he emphasized that scientific knowledge actually belongs, and only belongs, to the members of a small community. If we want outsiders to share the knowledge, we need SKMS to form an invisible environment.

The above problems, current solutions and possible improvements by the author could be summarized as follows:

Problems	Current Solutions	Author's Improvements
Methodological accuracy		
List of Sample Frame	Random digits dialling (RDD)	Virtual frame RDD DBMS
Sample Size	Binomial estimate	All types of data DSS
Replacement	Replaceable samples*	1. Trace back 2. Update of none-working samples
Household Selection	Pre-prepared tables	1. Online random selection 2. All households selection
Measurement	1. Self-report 2. Likert's scales*	Psychometrics scales DSS
Forecast Modelling	Rare	Modelling DSS
Data Weighting	By democratic variables*	-
Parameters and Changing Parameters	None	Parameters base
Impacts of New Technology	Rare	Mobile survey procedure
Data quality control	Rare	Data evaluation DSS
Cost-effectiveness evaluation	None	Evaluation DSS
Scientific knowledge procedure	Unclear	Knowledge management systems
Socio-cultural fit		
Honesty of interviewee	Rare	Filtering skill
Undeciders' opinions	None	Psychometrics measurement
Predicting interviewees' behavior	Direct methods	Inference by parameter base
Bias of who always answers the phone	None	Household selection sampling
Friendly Usability		
Easy to design	Rare	Wizards
Easy to implement	Template	Template library
Interpreting the meaning of data	Rare	Easy decision suggestions
Group and distributed operation	Client-Server	Intranet and web-based design

*Solutions are doubtful, defective, incomplete or may be wrong.

SKMS have a web-based integrated intranet as the survey center and it can also work with remote groups via the internet.

4.System Characteristics

The SKMS consist of 4 systems:

--Sampling Management System: to design sampling methods, sample sizes, to select eligible respondents, especially, with unknown or incomplete sample frame.

--Measuring and Questionnaires Design Support System: to organize the structure flexibly, to manage the psychometric scale database, to guide an auto purifying measurement procedure.

--Group Interviewing Management System: to support, and monitor online or offline or mobile interviewing groups.

--Data Analysis and Decision Support System: to examine sampling precision and data quality, to provide weighting skills and intensive statistical interpretation with user-friendly processes.

The main flow chart of the SKMS modules is as Figure 1.

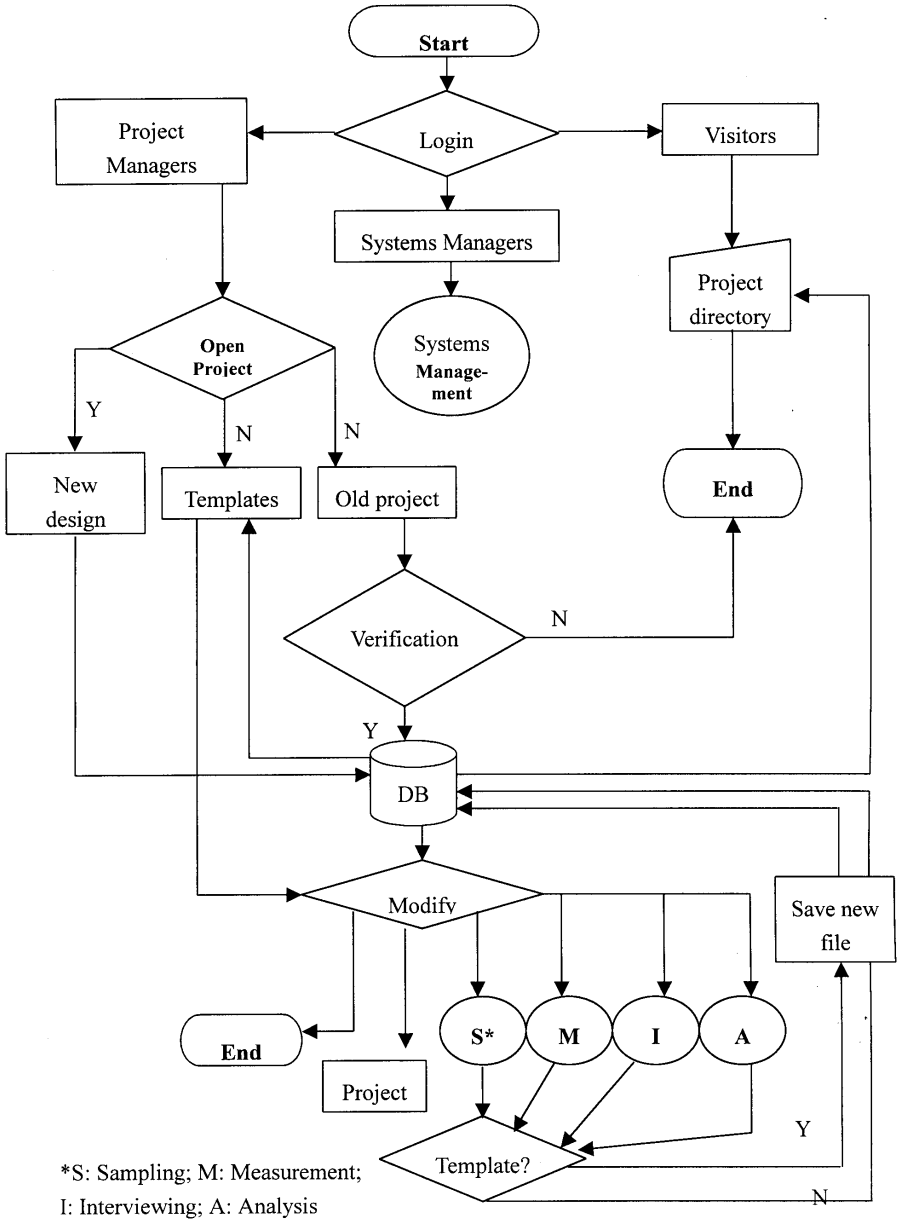

Figure 1. Main flow chart of SKMS

A brief comparison between CATI, CASIC and SKMS could be summarized as follows:

	CATI	CASIC	SKMS
System Environment			
Word Processing	**Y**	**Y**	**Y**
Database Management	**N**	**N**	**Y**
Modeling Management	**N**	**N**	**Y**
Parameters Base Management	**N**	**N**	**Y**
Graphic User Interface	**N**	**Y**	**Y**
Project and Design Wizard	**N**	**N**	**Y**
Templates	**N**	**N**	**Y**
Work Group			
Local Area Network	**Y**	**Y**	**Y**
Client Server Architecture	**N**	**N**	**Y**
System Functions			
Sampling			
Sample Database Management	**N**	**N**	**Y**
Sample Size Decision Support	**N**	**N**	**Y**
Random or Systematic Sampling	**Y**	**Y**	**Y**
Random Digits Dialing	**N**	**N**	**Y**
Household Random Selection	**N**	**N**	**Y**
Update Invalid Samples	**N**	**N**	**Y**
Measuring and Questionnaires Designing			
Item Design	**Y**	**Y**	**Y**
On Line Help	**D**	**D**	**Y**
Multiple Data Types	**D**	**D**	**Y**
Contingency Questions	**Y**	**Y**	**Y**
Appointment Design	**N**	**N**	**Y**
Open-ended Questions	**D**	**D**	**Y**
Missing Value or Attitude Categorization	**N**	**N**	**Y**
Auto Numbering	**D**	**D**	**Y**
Templates	**D**	**D**	**Y**
Group Interviewing			
Interviewers Management	**D**	**D**	**Y**
Login and Performance Control	**D**	**D**	**Y**
Auto Sample Assignment and Dialing	**D**	**D**	**Y**
On Line Interviewing	**Y**	**Y**	**Y**
On Line Auditing	**Y**	**Y**	**Y**
Data analysis and Decision Support			
Sample Precision and Cost Analysis	**N**	**N**	**Y**
Data Processing	**N**	**N**	**Y**
Reliability and Purifying Measurement	**N**	**N**	**Y**
Data Analysis	**Y**	**Y**	**Y**

5.Discussion and Conclusions

5.1.Decision support through the SKMS

‘Can the survey be considered scientific research?’ The answer should be proven by its reproducibility. A profound lab of hardware and equipment is the most important in physics

research while humans are always directly responsible for data collecting in social and behavioral studies. The latter can hardly be reproduced, if different researchers do not share the same research knowledge.

SKMS will manage and hide all complicated issues behind a user-friendly interface. It will control research procedure and minimize errors and initiate a promising future for survey reproducibility.

5.2.Evaluation of data quality

SKMS will also automatically produce a new reference framework for sampling precision rates to evaluate the data quality of a survey.

Valid rate = samples with working phone numbers/ designed samples that are drawn from a sample database (+ samples of replacement)

Access rate = connected samples (someone picks up the phone)/ valid samples

Response rate = samples which answer the core item/ valid samples

Eligibility rate = samples which pass the filtering/ valid samples

The access rate was very useful to project the sampling precision while the valid rate could also reflect the cost-efficiency of research design.

5.3.Applications of the SKMS

The social need of a more sufficient and sophisticated survey method was profoundly felt in Western countries (Farago et al. 1993) (Killias, 1990) and in Taiwan. Wu (1994), using SKMS, collected data from a series of elections in Taiwan. It was helpful to initiate an innovative theory of voting behavior and to predict voters' decisions. Another application of SKMS was on an internet user survey that could assist to plan internet activities such as e-commerce, new media, life long learning and the marketing data for e-business (Wu, 2004g).

These findings implied a promising future for SKMS to replace CATI and CASIC. SKMS can be used by commercial organizations, survey organizations, and governments for various other applications, such as: public policy, e-business planning, marketing analysis, media effects, learning cultivation and other survey research.

5.4.Future issues

GIS could provide visual decision support and ecological analysis. GIS database management could also produce a geographic sampling of regional comparisons.

The mobile survey method could be initiated upon the wireless communication technology; it could improve SKMS as a mobile station. The problems of traditional personal survey such as data processing, monitoring system would be eliminated. The mobile SKMS could integrate the advantages both of the personal and the CATI survey.

The multimedia reporting system could prepare materials both of hard copies and multimedia, including web-based presentations that combine with graphics, animation, and audio. It could also produce broadcasting titles.

User-computer interaction was neither hardware nor software, but it would be a very important part in a survey to implement training, project management, and interviewer-interviewee interaction. The dominant role of information systems is the human rather than the machine. SKMS will assist more than audit the users.

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