DSS and EIS applications in Information Technology

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Introduction

The increased competition, along with the rapid development of new information technologies, has forced more and more businesses to rely on information systems (IS). It is often believed that using information technology properly to support decision making can be a powerful weapon for competitive advantages. As a result, decision support systems (DSS) and executive information systems (EIS) have gained much attention from IS researchers and practitioners. Hundreds of applications have been reported (Eom and Lee, 1990) and many articles have been published in recent years.

The concept of DSS appeared before EIS. In early years, DSS were defined as computer-based information systems aimed at supporting decision makers in a particular domain. A typical DSS must meet three criteria:

(1) support but not replace decision makers;

(2) tackle semi-structured decision problems; and

(3) focus on decision effectiveness, not efficiency (Keen and Scott Morton, 1978; Sprague and Carlson, 1982; Turban, 1995).

Alter (1977) classified a large variety of systems having the above features into two categories: data-oriented and model-oriented. A data-oriented DSS provides data selection, aggregation, and simple analysis, whereas a model-oriented DSS provides simulation or other complicated mathematical decision models to support decision makers. EIS were later introduced as a special type of data-oriented system. They provide integrated internal and external information, and present the information to senior managers in a timely manner through a very flexible and user-friendly graphic interface (Rockart and DeLong, 1988).

A large amount of DSS and EIS research has been conducted in the past. They focus on a few key issues, including:

- motivation for using the system (e.g. Millet and Mawhinney, 2002; Watson et al., 2008, 2010);
- design frameworks (e.g. Byun and Suh, 2009; Watson et al., 2010);

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- determination of executive information requirements (e.g. Frolick and Robichaux, 1995; Rockart, 1979; Volonino and Watson, 1990; Watson and Frolick, 1993; Wetherbe, 1991);
- major difficulties and critical success factors in implementation (e.g. Rainer and Watson, 1995a, 1995b; Watson *et al.*, 1995);
- impact on executive decision making (e.g. Belcher and Watson, 1993; Elam and Leidner, 1995; Leidner and Elam, 1993; Vandenbosch and Higgins, 1995, 1996).

Successful applications of DSS/EIS are considered useful for increasing a firm's competitiveness.

In order to know whether DSS/EIS can, in fact, generate competitive advantages, investigation of their actual uses is necessary. For example, Hogue and Watson (1985) examined decision makers' use of DSS outputs. Watson *et al.* (1991, 1995) surveyed actual uses of EIS in the USA. These studies, however, are primarily based on American firms. Little knowledge of how Asian firms use these systems is available.

The purpose of this research is to study DSS and EIS applications in Taiwanese companies. Taiwan, Singapore, Hong Kong, and Korea are four newly developed economic powers in Asia (called four little dragons). Their firms are globally competitive. A better understanding of how new information technologies are perceived and used in Taiwan can give us a better sense of Taiwanese firms' management styles and their attitudes towards high-end computer applications. In this paper, we present results from two mail surveys that examined the extent to which DSS and EIS were used, major application domains and system functions, user characteristics of these systems, reasons for not using DSS/EIS, and major problems in using DSS/EIS.

The remainder of the paper is organized as follows. The next section describes the research methodology; the third summarizes major findings from the surveys and the fourth discusses the results, their implications, and future research issues.

Research methodology

The primary method used in the study is surveys. Two mail surveys were conducted. The first one focused on the status of DSS and EIS use, whereas the second focused on the use of quantitative decision models in particular.

In the first survey, questionnaires were mailed to the information systems managers in the top 500 firms ranked by the *Common Wealth Magazine* (a popular commercial magazine in Taiwan). The questions covered DSS/EIS usage, the firm's general background, domains for system application, managerial ranks of major users, the perceived importance of the systems, major functions of DSS/EIS, reasons for not using systems, and major difficulties in system development. The framework behind the questionnaire design was that DSS/EIS usage (measured by the frequency of system use) would be affected by the background of the firm, user characteristics (such as

managerial ranks and perceived importance of systems), system functions, and application domains.

Eighty responses were received (a responding rate of 13 per cent). Their demographic information is summarized in Table I. Approximately 60 per cent of the responding firms had an annual sales of more than 5 billion NT dollars (1 US$ = 28 NT$). Forty per cent of the firms had an annual IS budget of over 10 million NT dollars. Sixty-seven per cent of the respondents employed fewer than 20 IS persons and 20 per cent of them had their IS departments installed for more than 15 years. A typical respondent had an annual sales of 7 billion NT dollars and a ten-year-old IS department that consists of fewer than ten IS professionals and is run under an annual budget of 15 million NT dollars.

After analysing the data collected from the first survey, the second questionnaire was mailed to the same 500 companies to explore their use of decision models in much depth. Forty-four responses were received. A follow-up phone call generated an additional 16 responses to make a total of 60 responses. Among them, four were incomplete or inconsistent. Therefore, 56 useful responses (the responding rate = 0.112) were collected. The demographic information of the responding firms is quite similar to the information shown in Table I and is skipped here.

The second survey asked the IS managers to provide information about: whether they use quantitative models in DSS/EIS; if they did, in what domains were the models applied; what modelling tools did they use for DSS modelling; and what were the reasons or difficulties that caused failure in using models.

Annual sales (billion)							
Range	<5	5-9	10-14	15-19	20-24	>25	N/A
Number of firms	33	16	2	4	4	8	13
Per cent	41.25	20	2.5	5	5	10	16.25
IS department budget (million)							
Range	<9	10-19	20-29	30-39	40-49	>50	N/A
Number of firms	18	10	6	1	1	15	29
Per cent	22.5	12.5	7.5	1.25	1.25	18.75	36.25
Number of IS employees							
Range	<10	20-39	40-59	60-79	80-99	>100	N/A
Number of firms	40	14	10	5	2	6	3
Per cent	50	17.5	12.5	6.25	2.5	7.5	3.75
History of IS department							
Year	<5	6-10	11-15	16-20	21-25	>25	N/A
Number of firms	19	21	18	5	7	2	6
Per cent	23.75	28.75	22.5	6.25	8.75	5.0	7.5

Note: The monetary unit is NT dollars; 1 US$ = 28 NT$

Table I.
Profile of the sample firms

Research findings

First survey

Results from the first survey are discussed in terms of the extent of DSS/EIS use, major users, major functions of DSS, major problems in using DSS/EIS, and reasons for not using systems.

Extent of DSS/EIS use. The extent of system use may be measured by the claimed use or the actual use. The claimed use is what the respondents claimed in the survey whether they used DSS/EIS, whereas the actual use is whether they used systems having DSS/EIS functions such as what-if analysis, drill-down and on-line analytic process (OLAP) capabilities. The actual use was measured by the researchers based on the data in valid questionnaires. It is thus possible that a respondent claimed not using DSS/EIS is classified as an actual user if OLAP or what-if analysis is reported available in the firm's systems, and vice versa. The difference is primarily due to the heterogeneity in recognizing DSS/EIS among IS practitioners.

Among the 80 firms, 20 per cent of them responded that they had DSS or EIS in use, 36.25 per cent had systems under development, and 43.75 per cent did not use DSS or EIS (as shown in Table II). Five per cent of them claimed using DSS, 12.5 per cent using EIS, and 2.5 per cent using both. An interesting fact is that the use of EIS was higher than that of DSS in Taiwanese firms, though EIS was introduced later. This may be due to their emphasis on executive support, or easy access to EIS tools (such as Lightship and other user-friendly development tools).

Table II.
Extent of claimed use

DSS/EIS use	No. of firms	Percentage
Use DSS only	4	5.00
Use EIS only	10	12.50
Use DSS and EIS	2	2.50
Under development	29	36.25
Non-use	35	43.75

In general, firms claiming using DSS/EIS are larger and have a longer history in IS applications. The average annual sales of the using-firms is 71 billion, compared with 7 billion for non-using firms. Their average history of having an IS department is 14.2 years, compared with 10.2 and 9.7 years for firms having DSS/EIS under development and non-users, respectively.

A further data analysis indicates that the claimed use may be misleading. Sometimes, the respondents might use a system having DSS or EIS functions (e.g. simulation or what-if analysis), but were not sure whether it could be claimed so. This effect is particularly significant when the survey is performed in non-English-speaking countries, where the term DSS may be alien to local practitioners. After re-classifying those responding with using OLAP, what-if

analysis and other DSS/EIS functions as actual users, 57 firms (71.25 per cent) were found using or developing DSS/EIS systems, a big jump from the claimed system use. Only 23 firms had not used the systems (see Table III).

Concerning the importance of the system to business competitiveness, a large portion of the users reported that DSS/EIS did play some roles in their companies. For those reporting not using DSS or EIS, most of them still considered the systems important. In the questionnaire, 87 per cent of the responding firms assessed the systems to be very important or important (45 per cent very important and 42 per cent important). Ten per cent chose so-so and 3 per cent chose unimportant. This implies that some of the non-users will, sooner or later, become users of these systems.

Who uses the system. Existing literature has shown several times that DSS and EIS users are primarily middle- and upper-level managers (Hogue and Watson, 1985). In our survey, middle-level managers are primary users, but lower-level managers are also popular in DSS or EIS use in Taiwan (see Table IV). A reason for this may be the extension of EIS to everybody information systems, which allows more lower-level managers to access EIS. For example, China Steel claims that their EIS has 5,000 users among 10,000 employees. Although the use of DSS/EIS among high-level executives is less than half, we believe that it will grow rapidly in the future.

Concerning the frequency of system use, over a half of the respondents reported using their systems every day (see Table V). Twenty-two per cent used

DSS/EIS use	No. of firms	Percentage
Use DSS/EIS	57	71.25
Do not use	23	28.75

Table III. Extent of actual use

User level	No. of firms	Percentage
Top executives	25	43.85
Middle manager	45	78.94
First-line manager	43	75.44
Others	14	24.56

Note: Owing to multiple answers, the percentages do not sum to 100

Table IV. DSS/EIS users

Frequency of use	No. of firms	Percentage
Every day	32	56.14
Often	13	22.81
Occasional	14	24.56
Seldom	3	5.26

Table V. Frequency of DSS/EIS use

the system very often. Less than 30 per cent of the respondents used their systems occasionally or rarely. This shows that the companies with DSS/EIS rely heavily on their systems to support decision making.

System functions. As shown in Table VI, the most popular functions of DSS and EIS are data aggregation (78.94 per cent) and what-if analysis (40.35 per cent). Data aggregation is to integrate data from various sources to provide critical information requested by decision makers. The information sources may be internal and external databases. What-if analysis provides decision makers with the capability to answer contingency questions, such as what would happen if certain conditions change? The third is optimization models that include operations research and other quantitative decision models. The fourth is goal-seeking that allows users to set up a goal for the system to find alternatives for achieving the goal. Simulation models construct a mathematical environment so that the decision makers can manipulate parameters to find satisfactory solutions. The extent of its use is only about 7 per cent. Because the last three functions normally require complex mathematical operations, it is not unexpected that they are less popular.

Major function	No. of firms	Percentage
Data aggregation	45	78.94
What-if analysis	23	40.35
Optimization	11	19.29
Goal-seeking	10	17.54
Simulation	4	7.02

Note: Owing to multiple answers, the percentages do not sum to 100

Table VI.
Functions of DSS/EIS

A few domains were found popular for systems application. They are production management, human resource management, quality control, financial management, marketing, procurement, accounting, economic analysis, environmental protection, energy management, factory safety, insurance, project management, and investment. This shows that applications in Taiwanese firms are quite broad.

Problems in adopting DSS/EIS. Although DSS/EIS applications are successful in Taiwanese companies, many problems exist. The following list shows the major obstacle in DSS/EIS uses:

(1) difficult to determine user requirements;

(2) user resistance to the use of computers;

(3) lack of user commitment;

(4) lack of support from other departments;

(5) lack of system builders;

(6) lack of top management support;
(7) lack of proper development tools;
(8) difficult to build appropriate models;
(9) lack of well-known successful cases;
(10) difficult to integrate existing systems.

The most frequently mentioned was the difficulty in determining information requirements. User resistance to using computers, lack of user commitment, and lack of support from other departments are other factors ranked highly by the IS managers. These are, to some extent, consistent with existing literature, except that the data problem, ranked very high in Watson *et al.* (1995), is not important in our study.

Reasons for DSS/EIS non-use. For those 60 firms claiming not to use DSS/EIS, they were asked why they did not use the systems. Table VII summarizes their responses. It turns out that the immaturity of MIS was the most frequently cited reason. This is understandable because some IS departments in the sample are pretty young (less than ten years old). They have to focus on primitive applications rather than high-end systems. Other reasons include cannot find proper development tools (30.33 per cent), do not understand DSS/EIS (21.25 per cent), lack of system builders (16.25 per cent), hard to find proper application domains (5 per cent), and lack of top management support (2.5 per cent). The top three reasons, in fact, reflect that the IS managers do not have adequate knowledge of DSS/EIS to develop and use the system properly. Education is important for eliminating the problems.

Reason	Frequency	Percentage
MIS not mature	28	35.00
No proper development tools	24	30.33
Do not understand DSS/EIS	17	21.25
Lack of system builders	13	16.25
Hard to find proper domains	4	5.00
Lack of top management support	2	2.50

Note: Owing to multiple answers, the percentages do not sum to 100

Table VII.
Reasons for not using DSS/EIS

Second survey

The second survey focused on the application of quantitative models in DSS. The results are as follows:

Extent of model use. Among the 56 respondents, 19 of them (34 per cent) reported using decision models, whereas the other 37 (66 per cent) did not use them. Similar to our first survey, the firms that use models are larger in size and have a longer IS application history. The average annual sales of the using firms

was 105 billion NT dollars (compared with 10.9 billion for non-users), larger than the 71 billion for the DSS/EIS users in the first survey. This may be because only large firms have the resource to develop complicated quantitative models, whereas smaller firms rely more on data aggregation, what-if analysis, and simple decision models in their DSS.

For model users, we further asked them how often did they use the model. Most users use models often or occasionally. Table VIII shows the results.

Perceived usefulness. The perceived usefulness of decision models is measured in three dimensions: whether the models meet the business needs, whether model outputs are useful, and whether the models generate benefits. Five-point Likert scales were used in the questionnaire. Table IX summarizes the results.

The mean scores of the perceived usefulness are 3.59, 3.76 and 3.41 for meeting needs, output usefulness, and generating benefits, respectively. These values indicate that decision models were perceived to be moderately useful in Taiwanese firms.

Application domains. A total of 149 model-based DSS applications were reported in the survey. These systems fall into several major application areas: finance, production, transport, marketing, and strategic management. Other applications include crisis management, quality control, human resources, and research and development. Table X shows the frequency of reported model applications in each area.

These results show that decisions in financial management and production operations are the major focus of DSS applications in Taiwanese companies. This is consistent with the demographic information of our sample. That is, large manufacturing firms are the major user of decision models.

Table VIII.
Frequency of model use

Frequency of use	No. of firms	Percentage
Every day	2	10.53
Often	5	26.32
Occasional	6	31.58
Seldom	3	15.79
No information	3	15.79

Table IX.
Perceived usefulness of models

Benefits	Very high Freq.	%	High Freq.	%	Medium Freq.	%	Low Freq.	%	Very low Freq.	%	Unknown Freq.	%
Meeting needs	3	15.79	5	26.32	8	42.11	1	5.26	0	0	2	10.53
Output usefulness	2	10.50	10	52.63	4	21.05	1	5.26	0	0	3	15.79
Generating benefits	1	5.26	8	42.11	5	26.32	3	15.79	0	0	2	10.53

Modelling techniques. A number of techniques may be used to develop models, such as linear programming, regression, simulation, queuing, or other operations research and statistical methods. The survey indicates that more than 30 modelling techniques have been used for decision support in Taiwanese firms. Among them, linear programming, PERT/CPM, and linear regression are the top three on the list. Table XI lists the top ten techniques and their application frequency.

Application domain	Frequency	Percentage
Finance	61	43.26
Production	34	22.81
Strategic management	24	16.10
Marketing/transport	20	13.42
Others	10	6.71

Table X. Applications of models

Software tools. In order to understand the software tools Taiwanese firms used for implementing decision models, a list of 18 software packages (such as Microsoft Excel, SAS, GAMS, LINDO, STELLA, etc.) were included in the questionnaire. The results, as shown in Table XII, show that only a few tools are used. Microsoft Excel turns out to be the most popular one.

Reasons for not using models. For those not using decision models, they were asked to identify their reasons from a list of 24 candidates. The results, as shown in Table XIII, indicate that lack of knowledge in model development and hard to identify proper models for their problems were the major ones. Over 60 per cent of the 37 non-users had chosen them. Other reasons include: do not understand model usage; no immediate needs; lack of model builders, etc.

For the 19 firms that use decision models, they were asked to identify the critical success factors for using decision models. The top one is the experience and ability of model builders. Other factors include support from chief

Modelling technique	Frequency	Percentage
Linear programming	14	9.40
PERT/CPM	13	8.72
Regression	12	8.05
Integer programming	9	6.04
Inventory analysis	9	6.04
Variance analysis	8	5.40
Capital budgeting models	8	5.40
Financial analysis	8	5.40
Value analysis	7	4.70
Time series analysis	6	4.02

Table XI. Top modelling techniques

executives, friendly user interfaces, and friendly output formats. Table XIV shows the complete list.

Discussions and conclusions

The use of information technology in developing countries has been under-explored. The results from this study have provided much insight into the application of DSS/EIS in Taiwanese companies. In general, we found that

Table XII.
Top modelling tools

Software tool	Frequency	Percentage
Microsoft Excel	7	36.84
SAS	4	21.05
SPSS	2	10.53
SIGMA	1	5.26
Others	6	31.58

Table XIII.
Major reasons for not using models

Reasons	Frequency	Percentage
Lack of knowledge of model development	25	67.57
Hard to identify proper models	24	64.86
Do not understand model usage	21	56.76
Feel no immediate needs	20	54.05
Lack of model builders	19	51.35
Hard to present the problem	14	37.84
Lack of hardware/software environment	13	35.14
Problems are simple	12	32.43
Lack of user support	10	27.03
Lack of data support	10	27.03

Table XIV.
Critical success factors

Success factors	Frequency	Percentage
Experienced model builders	12	63.16
Support from chief executives	12	63.16
Friendly user interface	10	52.63
Friendly output formats	10	52.63
Credibility of model outputs	10	52.63
Proper user training	8	42.11
User's experience	7	36.84
Maturity of IS applications	5	26.32

major DSS/EIS users were large companies having a longer history in information systems applications. This may be because large companies have more resources for developing high-end application systems.

Although the survey shows that only about 71 percent of the firms used DSS/EIS in Taiwan, 87 per cent of the respondents considered DSS/EIS to be important to their competitiveness. In an earlier study, Hsieh *et al.* (1992) found that only 28 per cent of the firms in Taiwan used DSS in 1991. The significant increase from 28 per cent to 71 per cent in recent years implies that the application of DSS and EIS will become more popular in Taiwan in the future.

Middle- and lower-level managers have been the major users of DSS and EIS in Taiwan. This finding is contradictory to the findings of Hogue and Watson (1985), where higher-level managers were found to be major users in the USA. A reason for this phenomenon may be due to the recent intention of Taiwanese firms to build "everybody information systems", which encourages every member of the company to use available information.

Concerning the functions in use, information aggregation and what-if analysis are popular. Linear programming, PERT/CPM, and regression are the top three modelling techniques adopted in their DSS. Finance and production management are the top two application domains. The most popular tool for implementing models is Microsoft Excel. Other tools include SAS and SPSS for statistical analysis.

The major problem for developing DSS and EIS is the difficulty in determining information requirements. This is consistent with the existing findings from other countries (Keen, 1980; Rainer and Watson, 1995a; Volonino and Watson, 1990; Wetherbe, 1991). However, other concerns such as user resistance to using computers and lack of user commitment are not found in the USA. This is probably because, compared with most US companies, Taiwanese companies are less mature in using computers. Another possible explanation is the cultural difference. In a study, Hofstede (1984) found that the Chinese had higher power distance and uncertainty avoidance, whereas the Americans had higher individualism. Higher power distance and uncertainty avoidance are more likely to create higher resistance to using computers.

In summary, the study has explored the current status of DSS/EIS applications in Taiwan. Although some findings are consistent with the results from previous research conducted in the USA, deviations suggest that cultural differences do play a role in using DSS/EIS in different countries. More cross-cultural studies in information systems are useful in the age of globalization.

Since the research was conducted in mail surveys, several limitations may exist. First, terms in the questionnaire were used without formal definitions. Respondents with different professional backgrounds might have different interpretations. Second, most items included in the research were measurable. Qualitative attributes such as system quality were not investigated. Finally, the research did not take into consideration the difference that might exist in system implementations, such as whether two claimed what-if analyses were similar functionally.

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