MEASURING END-USER COMPUTING SOPHISTICATION IN SMALL-MEDIUM ENTERPRISES

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ABSTRACT

This paper describes research on measurement of end-user computing sophistication in small-medium enterprises. It aims to define and identify an objective measure for EUC Sophistication that can be used by SMEs to assess the extent they are capable of developing their own applications. Measurement for EUC Sophistication was formulated using 3 dimensions of End-User Sophistication, Usage Sophistication and Application Sophistication that form the EUC Sophistication constructs. Using data from an EUC survey study, an instrument was developed to measure EUC Sophistication Index based on sophistication constructs. Stepwise regression analysis was used to predict measurement variables based on data points from the survey using the sophistication index as the dependent variable. Results show that the constructs were valid measurement for EUC Sophistication and among the EUC applications found to be significant are word processing applications, accounts/finance, spreadsheet applications, sales/purchase order, personnel, inventory control, customer, telecommunication, database and decision model.

Key words: User-Developed Applications, End-User Development, Sophistication Index, End-User Sophistication, Usage Sophistication and Application Sophistication

1.0 INTRODUCTION

Today, as more and more firms are adopting IT, the use of IT is no longer perceived as a luxury but rather a necessity even for small businesses. This means that the proliferation of IT has brought the computerization of business activities within reach of many small firms. Recent findings have shown that SMEs are now

going international with the help of IT, especially the Internet, to enable e-commerce (Westhead et al., 2002). This trend is likely to continue as more and more firms appreciate the potential benefits of IT to business in terms of increased competitiveness, increased productivity, improved efficiency in activities and work processes, enhanced marketing effectiveness, better management of information and record-keeping, and improved quality of products and services. This suggests that small firms are becoming more sophisticated in their use of IT, either through the means of third-party development, acquiring off-the-shelves packages, or developing their own, or some combination of these. It is the firms' own development of applications, better known as End-User Computing (EUC), that is of interest in this paper. Three reasons were identified.

Firstly, extensive literature search showed that studies on EUC have been mainly confined to large organizations. This is evidenced from a study by Brancheau and Brown (1993) in which out of almost 100 articles examined across a ten-year period, only two articles are associated with EUC in small business. Studies such as Raymond (1990) and Ein-Dor and Segev (1978) showed that significant differences exist between large and small firms in terms of their structures, characteristics and organizational behavior. Attewell and Rule (1992) caution that it would be foolish to expect IS studies carried out in large firms to be applicable for the general working population, yet small firms account for more than 90% of all businesses and more than half of the workforce employment (Joyce et al., 1996). Hence with few studies of EUC in small business, little is known regarding the extent small firms are capable of developing their own applications.

Secondly, small firms are generally financially constrained (Blackburn and Jennings, 1996), therefore, the hiring of external services will not be within reach of many small firms. Moreover, buying ready-made packages may not always meet the business requirements and firms may be forced to tailor applications to suit their individual needs, which again could be very expensive. Hence there is an urgent need to assess the extent small firms are capable of developing their own applications so that firms would be in a better position to adopt IT and make full use of their available computing resources.

Thirdly, it has been generally recognized that it is difficult to find a small firm with internal IT expertise due to the high demand and limited supply of IT professionals. Firms wanting to adopt IT or to continue to benefit from IT would be forced to be dependent on external sources for their IT resources. This would again be a problem financially constrained firms and even if they could afford it, they would tend to depend heavily on the vendors who may have their own interest to pursue. Again, EUC can play an important role here in encouraging firms to be independent in their IT adoption.

Until more studies are done in this area in which the EUC phenomenon within the context of small firms could be better understood, small firms will face an uphill task against overcoming the anxiety and risks of adopting IT, and worse still, in developing their own applications. This paper therefore aims to increase our understanding of the capability of SMEs in developing their own applications by constructing an EUC Sophistication instrument that can be used to measure the SME's capability to implement information systems by developing their own application.

2.0 END-USER COMPUTING

The term End-User Computing (EUC) in its broadest sense can be defined as the tasks of using computers and IT resources to retrieve data and programs by managers, professionals and other knowledge workers in order to help facilitate their work. Until today there is no standard definition of EUC and many studies have provided various definitions depending on the scope and focus of study. This is supported by Nord and Nord (1994) who observed that EUC is defined in a number of ways with no widely accepted definition. As a result different terms have emerged with similar connotations including User-Developed Applications, End-User Development, and Business User Development.

Perhaps the most widely used and classical definition of EUC came from a study by Rockart and Flannery (1983) who introduced six distinct categories or end-user typology in the order of increased sophistication of interaction with the computer. *Non-programming* End-Users are those who interact with the computer through limited menu-driven interfaces to access data. *Command level* End-Users are those who access and manipulate data on their own through writing of simple queries, formulae, and using report generators to create simple reports for their own purpose. *End-User Programmers* are those who use procedural languages and other third generation languages to develop applications for their own use as well as for other users. *Functional Support* personnel are sophisticated programmers developing applications for other end-users within their particular business functions. *EUC Support* personnel provide EUC support for the whole organization and are usually located in Information Centers and/or the IS departments. Lastly, *DP programmers* are IT professionals who develop the more complex and sophisticated organizational information systems.

Within the context of small businesses however, the six end-user typology may no longer be relevant as small firms are characterized as having no formal IS structure (Palvia et al., 1994) and no IT expertise (Gupta and Harris, 1989). Furthermore developing applications today may no longer require the writing of even a single line of programming code. The above typology therefore was modified following

a study by Dahalin and Golder (1998) who suggest a simpler typology consisting of three levels, namely Simple End-User, Command level End-User and End-User Developer. The first two levels are similar to the corresponding Rockart and Flannery's typology. End-User Developers are those sophisticated end-users who are capable of developing their own applications independently and are also able to use the system's advanced features to create procedures and/or documents as application modules. In addition, this level of end-users would require sound business knowledge coupled with good development methodology and tools to become effective end-user developers.

The development of applications by end-users has continued to receive much attention from both the IS academics and industry ever since the idea of EUC began in the early 1980s. The concept of End-User Application Development therefore takes its origin from EUC and the concept of EUC is a manifestation from traditional IS development where the IS function can no longer cope with the increased demands for computerization by user departments. Together with the proliferation of inexpensive microcomputers and user-friendly software, coupled with the increasing awareness of the benefits of IT adoption to reduce costs, improve service and sustain competitiveness, the trend in EUC will continue to grow.

Among studies in the EUC area, studies on EUC sophistication are comparatively much fewer and relatively more recent. There is a need to assess the EUC phenomenon in firms in order to examine the extent to which end-users develop their own applications, both in terms of the nature of the applications itself and the capabilities and behaviors of the end-users. This concept of EUC sophistication was initially limited to focusing on the nature of end-users themselves. Earlier studies examined characteristics of end-users and the complexity of EUC activities they performed as described in the Rockart and Flannery's typology earlier. Later this was combined with the behavior of end-users and their abilities forming a concept commonly known as End-User Sophistication (Cotterman and Kumar, 1989; Marcolin et al., 1993). However, according to Blili et al. (1996) End-User Sophistication is not the same as EUC Sophistication but forms part of the EUC Sophistication construct. The authors contend that EUC Sophistication consists of three dimensions namely End-User Sophistication, Application Sophistication and Usage Sophistication.

Zinatelli et al. (1996) defined EUC Sophistication as the capability of end-users to perform EUC activities and suggest four dimensions as measurement for EUC Sophistication. Two dimensions are similar to Blili et al. (1996) namely application utilization (application sophistication) and end-user type (end-user sophistication). Two other dimensions identified are breadth of end-user skills and knowledge, and finesse in terms of capability to learn to use new software. These latter dimensions

could be categorized as the characteristics of end-users in terms of their abilities and behavior, and using the preceding arguments should also belong to the end-user sophistication dimension.

End-User Sophistication follows the typology introduced by Rockart and Flannery (1983), referring to the end-user's technical capability as described earlier. Application Sophistication concerns the nature and type of applications developed by end-users. Applications are seen as having varying degrees of complexity with certain types of applications believed to be more sophisticated than others. Kagan et al. (1990) adopted an objective approach to studying application sophistication in small business by developing an instrument to measure the software sophistication level. Since the level of application sophistication is very subjective as argued by the authors, an index representing opinions from computer professionals and academics was used to rate each software product to indicate the level of sophistication implicit in its use. A similar objective technique will be adopted to calibrate the EUC Sophistication measurement instrument and will be described in the next section of this paper. Finally, Usage Sophistication refers to the frequency of use of such applications with the more frequently used applications being claimed to be more sophisticated.

3.0 RESEARCH METHODS

For the purpose of constructing the measurement instrument, a questionnaire was designed to get relevant information on EUC presence, the types of applications developed, development tools used, number of end-users, sources of development, and the names of the applications. The questionnaire was pilot tested for content validity before the actual survey took place. A total of 980 questionnaires were posted to small firms within the vicinity of Birmingham, UK, and 222 responses were received. A check on each returned questionnaire revealed 36 questionnaires were deemed unusable due to exceeding the 100 employees limit as defined by DTI (DTI, 1995), incomplete responses, and those that have moved or ceased to operate. This brings the final figure to 186 firms with a response rate of 23.5%. This is considered acceptable as studies have shown that responses of between 10%-20% are not uncommon involving surveys of small firms (Palvia et al., 1994; Lai, 1994; Raymond and Bergeron, 1992).

Data entry was carried out using SPSS within which a database of the returns was created. Additional variables were added on multiple item questions and combinations of more than one question appearing in different parts of the questionnaire. These include 'totals' for the number of IT products, systems software, applications software, and number of user-developers. Variables were also created using combinations of items and questions such as End-User Typology

using combinations of development tools, types of software and applications developed. EUC Sophistication index was based on pre-defined application mean scores where the index was re-calibrated using additional items and variables. A step-wise regression analysis was done to determine the adjusted scores and formulate the re-calibrated measurement index.

3.1. Development of The EUC Sophistication Measurement

On the basis of the literature review it appears that application sophistication is a common factor used to measure EUC-related sophistication. As discussed in the preceding section, an instrument developed by Kagan et al. (1990) to measure software sophistication in small firms was adopted. The sophistication index representing opinions of computer professionals and academics is accumulated for each software product and mean scores are computed giving the weighted average scores for all the products.

Table 1 below shows the results of the mean scores from the computer professionals' and academics' opinions survey and the sophistication construct developed by Kagan et al. (1990). The results show that Word Processing, being the most widely used software (Zulkhairi, 2001), was also judged to be the least sophisticated in terms of application usage. Spreadsheet, which is the other common software used, was also perceived to have lower levels of application sophistication. On the other hand, database applications along with decision support applications and telecommunication and networking applications are rated as highly sophisticated.

The Sophistication Index Construction shown in the lower half of Table 1 was used to compute the software sophistication level of the firm. The score represents the total mean scores of all corresponding software products used by the firm. Since the original opinions were expressed on an interval scale ranging from 1 to 10, where 1 is rated as the least sophisticated and 10 rated as the most sophisticated, the total mean scores (ie. Raw scores) are transformed so that their values fall within the range 1 to 10.

Table 1: Computer Professionals' and Academics' Opinions Applications Mean Scores and Sophistication Index Construction.

Application	Mean Score
Word Processing	1.65
Payroll	3.26
Spreadsheet	4.03
Ordering	4.03
Pricing (invoice and billing)	4.08
Employee/Personnel	4.19
Inventory Control	4.64
Fixed Asset (branch inventories)	4.75
Data applications	5.16
Telecommunications	5.74
Database	6.13
Decision Models	7.87

Sophistication Index Construction

$Score = \sum_i Application_i * Mean\ Score_i$

For i = 1 to number of applications

Where each application is a binary variable (1 for Yes, 0 for No)

Software Sophistication Index

The score is transformed such that its value is between 1 and 10 which is consistent with the system professional's survey. The transformation formula is:

$$SSI_j = (score_j + a) / b$$

Where SSI_j is the software index of firm j after transformation. a and b are chosen such that $1 < SSI_j < 10$, and determined by solving the following equations:

$$10 = (max + a) / b$$
$$1 = (min + a) / b$$

Where max and min are the maximum and minimum sophistication, respectively.

Example, if $Firm_j$ has Word Processing, Spreadsheet and Database, SSI_j is computed as follows:

$Score_j$ = 1.65(Word Processing) + 3.26(Payroll) + 4.03(Spreadsheet) + 4.03(Ordering) + 4.08(Pricing) + 4.19(Employee/Personnel) + 4.64(Inventory Control) + 4.75(Fixed Asset) + 5.16(Data Applications) + 5.74(Telecommunication) + 6.13(Database) + 7.87(Decision Models)

= 1.65(1) + 3.26(0) + 4.03(1) + 4.03(0) + 4.08(0) + 4.19(0) + 4.64(0) + 4.75(0) + 5.16(0) + 5.74(0) + 6.13(1) + 7.87(0)

= 1.65 + 4.03 + 6.13

= 11.81

Assuming that min is 1.65 and max is 55.54, therefore a = 4.34 and b = 5.99

Substituting into the SSI formula above,

SSI_j = (11.81 + 4.34) / 5.99

= 2.70

Firm j therefore has a Software Sophistication Index of 2.70 in the scale 1 to 10, where 1 is the least sophisticated and 10 the most sophisticated.

The idea was to obtain a sophistication index similar to the original scale so that the same interpretation for the level of sophistication can be applied. Kagan et al. (1990) named this transformed score the Software Sophistication Index (SSI). In this way, Kagan et al. (1990) developed an objective measure of sophistication based on the opinions of experts in the field of IT.

For End-User Sophistication, a modified end-user typology was used for small business application development. As discussed in the preceding section, the end-user typology developed by Rockart and Flannery (1983) (also used by Blili et al., 1996 and Zinatelli et al., 1996) was not applicable in small business characterized by lack of formal IS structure, no IT expertise and limited end-user support. For example, *Functional Support Personnel* (sophisticated programmers), *EUC Support Personnel* and *DP Programmers* defined in the Rockart and Flannery (1983) typology would not be relevant in this context. This is exemplified in the Zinatelli et al. (1996) study where none of the most sophisticated end-user typology identified in all the firms studied has even reached the *Functional Support Personnel* category. The rationale is that a "non-programming end-user" can become a sophisticated end-user developer using today's 4GLs and application development generators to develop fairly sophisticated applications. Therefore, as suggested by Dahalin and Golder (1998) three types of end-users were identified, namely *simple end-users, command level end-users,* and *end user-developer* to much more represent the small business context.

A third construct, number of users using the applications, was used as a measure for Usage Sophistication. This is because previous studies have consistently found that the number of employees or users contributes to the firm's use of IT and IS success (Raymond, 1987; Kagan et al., 1990; Lai, 1994). It is suggested that the larger the number of end-users using the applications developed by themselves, the greater the degree of usage of the applications in terms of duration, frequency and number of end-user activities.

Either measurement developed by Blili et al. (1996) and Zinatelli et al. (1996) could not be used in this study to measure EUC Sophistication. Using either measurement would require changes to the aim of the study, the scope of research, data collection techniques and research strategy. This is necessary in order to accommodate individual end-users' responses as opposed to organizational context, large firms with established DP and IC support structures (Blili et al., 1996), and a measurement based only on evidence from observation (Zinatelli et al., 1996).

Blili et al. (1996) based their study on large firms (five financial institutions with averages of 18,240 employees and $48 billion assets) and some of the measurement variables were not applicable in a small business set up. Example,

the inclusion of mainframes in DP department set ups, ICs to support EUC, and application developed by vendors and internal IT specialists as part of the measurement variables are clearly not relevant in this study. Moreover Palvia (1996) contends that measurement used for large organizations are not applicable to small businesses.

Whilst Zinatelli et al. (1996) used small firms to measure EUC Sophistication, the measurement variables used were based on earlier works by Blili (1992) and Marcolin et al. (1993). The latter, according to Blili et al. (1996) refers to the study of end-user's competence (i.e. user aptitude and abilities) at a given time. This, according to the author, is more applicable to the concept of EUC maturity (or evolution) than EUC Sophistication. This was later confirmed by Munro et al. (1997) who extend their earlier notion of End-User Sophistication to measuring user competence. In addition, Zinatelli et al. (1996) themselves contend that their model could not be generalized since their findings were based on case study evidence.

Under these circumstances it was thought appropriate that a new measurement for EUC Sophistication in small business should be developed where its construct should be based on related studies such as Blili et al. (1996), Zinatelli et al. (1996), and Kagan et al. (1990) discussed earlier. The three EUC Sophistication constructs that were used in this study are summarized as shown in Figure 1 below. Though the constructs are consistent with the Blili et al. (1996) model for measuring EUC Sophistication, the actual measurements were taken from different sources to adapt to the small business environment. Whilst Blili et al. (1996) made use of a sample from large businesses, sources for all three constructs used in this study are based on samples taken from small firms. This is to ensure that the EUC Sophistication constructs used in this study is representative and relevant to small business.

In the Application Sophistication construct of Figure 1, the Software Sophistication instrument developed by Kagan et al. (1990) discussed earlier will be used. However, a re-calibrated measurement will be used that will only be based on applications developed by end-users. Operationalization of the sophistication index and formulation of the re-calibrated instrument will be discussed in the next section.

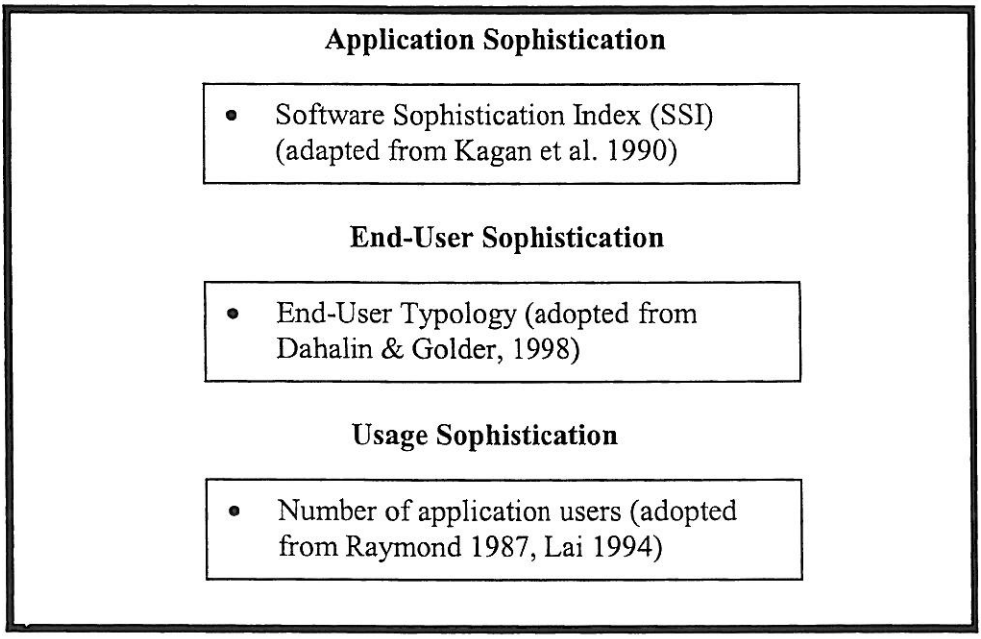

Fig. 1: EUC Sophistication Measurement Construct for Small Business

For End-User Sophistication construct, the three types of end-users mentioned earlier were used. For each firm that has EUC presence, the most sophisticated end-user will be determined based on predefined criteria present in the questionnaire. This includes the development tools used, types of software to develop the application and the nature of the application being developed. The information gathered was matched against the category of end-user that best fits the end-user typology description discussed previously.

Finally, the Usage Sophistication construct as discussed earlier was based on the total number of end-users using the user-developed applications.

3.2. Operationalization of the Sophistication Index

The source of data for operationalization of the sophistication index came from results of the survey. The measurement for EUC Sophistication Index (EUCSI) was based on the Software Sophistication Index (SSI) developed by Kagan et al. (1990) as described previously. Using the application mean scores from the original Kagan's SSI construct as tabulated in Table 1, raw scores were calculated for all firms based on the Sophistication Index Construction formula. However, since the raw scores were based on the list of 12 IT products (see Table 1) used by Kagan et al. (1990) in their study, they may not accurately represent the firm's

overall level of sophistication in this study. This is because there were more IT products and applications developed by end-users (EUC applications) included in the sample survey compared to the Kagan list. If Kagan's list were to be used, those IT products and applications that have not been accounted for may also have some effect on the level of sophistication. This is not desirable, as the firm's level of EUC sophistication would have been misrepresented.

Hence, Kagan's weighting scheme has to be extended to cover all variability. To achieve this, the sophistication index for EUCSI measurement will need to be re-calibrated. Furthermore, modifications need to be made to Kagan's formula since two other sophistication constructs, namely End-User Sophistication and Usage Sophistication were also included to accurately represent the definition of EUC Sophistication as suggested by Blili et al. (1996) and Zinatelli et al. (1996).

It is important that such index be re-calibrated particularly since Kagan's index has been in existence for more than a decade. The rapid growth of IT and development methodology may have changed the degree or order of the sophistication index. Hence the "new" index should reflect the current sophistication so that it would more accurately represent the current context. The "new" index could also allow comparisons to be made by observing trends that could have changed with respect to the sophistication of IT products and user-developed applications. In addition, the "new" index would also take into account other emerging technology that may not have existed or was less significant when Kagan et al. (1990) did their study. This reasoning was supported by some of the findings presented in the next section.

To find a new re-calibrated EUCSI measurement, open-ended questions were used in the survey to produce the EUCSI instrument. As mentioned previously three constructs were identified based on the one developed by Blili et al. (1996). These are:

i. Application Sophistication
ii. End-User Sophistication
iii. Usage Sophistication

Whilst the aim of this study is to produce an objective measurement to understand the extent small firms are capable of developing their own applications, Blili et al. (1996) did not used their measurement to calculate sophistication index. The authors used their construct to aid large firms seeking to promote EUC sophistication and they identified a number of variables for this purpose but did not construct a single index. It was therefore decided to adapt the index construction approach of Kagan et al. (1990) to the construct space proposed by Blili et al. (1996) as presented earlier in Figure 1. Two options have been considered. (1) to repeat the scoring technique used by Kagan et al. (1990) by consulting a panel of

experts, and (2) to use statistical fitting techniques to estimate the weights of the EUCSI using Kagan's scores. To perform (1) would require additional financial resources for the survey exercise and availability of suitable experts. Hence (2) was chosen, though option (1) should be considered in the future to much more accurately represent opinions of experts.

Recall that for the Application Sophistication construct, the re-calibrated measurement will be based on applications developed by end-users (EUC applications). For End-User Sophistication construct a single variable, type of end-user, will be used based on a modified end-user typology by Dahalin and Golder (1998). Usage Sophistication construct is also a single item variable based on the number of users using the applications developed by end-users. The variable, Number of Users, is used to keep a transformed value of the actual number of end-users in the range 1 to 10 since it is possible for a small firm to have the maximum number of end-users equivalent to the maximum firm size. If this were to be allowed the overall EUCSI of the firm will be invalid, as the Usage Sophistication score will dominate the sophistication index. The same transformation technique as described in Table 1 was used for this purpose.

The sample data keeps track of all the EUC applications, the types of end-users and number of end-users in each individual firm that has EUC presence. Data and variables for the 3 constructs were taken from responses to the question as shown in Table 2 below. Table 2 represents the reply grid where the source of data were analyzed and re-coded in the form of the three sophistication constructs.

Table 2 Reply Grid

(A)	(B)	(C)	(D)	(E)
Development Tool	**Type of Software**	**No. of Users**	**Developer**	**Name of Application**
Spreadsheet Database Word Processing Programming Language Others				

For Application Sophistication, the names of all applications as shown in column E were analyzed. As open answers were collected, similar answers were grouped to produce categories of EUC applications. The following are examples of the data that was grouped into categories of EUC applications collected from the survey responses:

Table 3 Data Responses grouped into categories of EUC Applications

EUC Application	Data Responses
EUC Accounting/Finance	Cash Flow, Costing, Budget, Accounting, Payroll etc.
EUC Personnel	Personnel, Staff, Manning level
EUC Customer Data	Customer Information, Customer Inquiry, Customer Addresses
EUC Production Operation	Production Planning, Production Development

With spreadsheet, database and word processing applications cross-checked with the Type of Software (Column B of Table 2), a total of 13 EUC applications made up the Application Sophistication list as presented in Table 4. The list of types of EUC Applications were included as separate variables in the sample database. Each type of EUC application used by the firm was coded as '1'. Otherwise a '0' was coded to indicate the firm did not develop EUC application of the type.

For End-User Sophistication, the data collection column 'Developer' (column D of Table 2) was synthesized to give the most appropriate End-User Typology on the scale "simple end-user", "command level end-user", and "end-user developer". Criteria used as guidelines to help in the synthesis include:

"Simple End-User" :	Generally word processing based, with no evidence of creating macros.
"Command Level End-User"	Typically using spreadsheet or database tools, and tends to work individually or in a small group (1-2 people).
"End-User Developer"	Typically using database and/or programming language development tool. Also depends on the application developed (as in column D of Table 2) using Kagan's sophistication index as guidelines.

Where a range of end-user types exists, the overall end-user sophistication was characterized by the highest level typology. Whilst no specific guidelines or criteria were mentioned by Blili et al. (1996) or Zinatelli et al. (1996) in their studies, the above guidelines seem consistent with the typology defined by Rockart and Flannery (1983) and Dahalin and Golder (1998). In constructing the numerical End-User Typology index, the values were coded in the order, 1, 2 and 3.

In the case of Usage Sophistication, the column "No. of Users" (column C of Table 2) was summarized for each firm to produce a single "Total Number of Users". The intention was not to know the actual number of users, but the degree of usage of the applications. The rationale is that the more applications are being used, the higher the usage and greater number of user activities covered. This will also affect the number of man-hours applications are being accessed, hence longer duration of usage. This rationale appears to be consistent with Usage Sophistication as defined by Blili et al. (1996). Alternatively, a more specific measure that could be used was to seek detailed information covering each application being used in terms of the number of user activities it covers, duration of use and frequency of use.

Using Kagan's Sophistication Index instrument, an Application Sophistication Index score was calculated for all firms in the sample based on the EUC application code. A variable, KASI (for Kagan's Application Sophistication Index) was created to store the value. Since the EUCSI should consist of 3 constructs as defined previously, unweighted End-User Sophistication and Usage Sophistication scores were added to Application Sophistication (KASI) to give a prototype EUCSI value. A variable, PEUCSI was created to store the value in the sample database. This becomes the dependent variable for the stepwise regression procedure. Note that not all Kagan's 12 IT products matched the list of EUC applications. Two IT products, *Pricing* and *Fixed Asset*, were not found in the EUC Application list. Hence the dependent variable PEUCSI was based on 10 IT products plus 2 variables each from End-User Sophistication and Usage Sophistication.

The 13 EUC applications identified from the survey together with the two End-User Typology and Number of Users variables (i.e., the 15-item EUC variables) were tested to identify the predictors to Kagan's original index (PEUCSI). This was done by performing stepwise regression using the survey data on all the 15-item EUC variables against the dependent variable PEUCSI. The idea was to predict which of the 15 EUC variables (independent variables) best fits the prototype EUCSI (dependent variable PEUCSI). Variables that fail to fall along the data points that form a linear relationship between the dependent and independent variables at a pre-defined significant level will be removed by the stepwise regression procedure. Using the appropriate statistical analysis as will be explained later, the new EUC Sophistication ranking was found to be consistent with Kagan, and therefore was used to measure the new EUCSI for the firms in the sample. It also generated two new constructs, End-User Sophistication and Usage Sophistication, which could not have otherwise been included in the index.

4.0 ANALYSIS OF FINDINGS

The regression analysis found 12 variables to be significant at the 0.001 level. The unstandardized beta coefficients (regression coefficients) produced by the analysis were used as the new weighted scores. Table 4 presents the result of the regression analysis on the EUC variables along with the coefficients, *p* value and the corresponding Kagan checklist to indicate the application is also included in the Kagan original list.

Table 4 EUC Sophistication Variables

EUC Construct/ Applications	Unstandardized Beta Coefficient	Significance (*p* value)	Kagan's Checklist
Application Sophistication			
1. **EUC Word Processing application**	1.525	0.001	
2. EUC Mailing application	-0.002	0.812	
3. **EUC Account/Finance**	3.466	0.001	
4. EUC Graphics application	-0.005	0.643	
5. **EUC Spreadsheet Application**	3.994	0.001	
6. EUC Sales/Purchase Order	3.245	0.001	
7. **EUC Production Operation**	0.005	0.632	
8. **EUC Personnel application**	4.179	0.001	
9. EUC Stock/Inventory Control	4.890	0.001	

10. **EUC Customer Data**	3.811	0.001	
11. EUC Telecomunication	6.075	0.001	
12. **EUC Database application**	6.176	0.001	
13. EUC Decision Model	7.863	0.001	
End-User Sophistication			
1. **End-User Typology**	0.979	0.001	
Usage Sophistication			
1. **Number of Users**	1.085	0.001	

The 12-EUC variables (in bold letters above) became the variables used in the re-calibrated EUC sophistication index. All application sophistication variables found to be significant in the regression analysis are similar to the Kagan software checklist. This may suggest that there seems to be little change in terms of the types of applications used by end-users in the small firms in the last 10 years. This could also be the reason for the popularity of developing such applications since they are useful to small business. The regression procedure excluded Mailing, Graphics and Production Operation applications since they were not significant even at the 0.05 level. The two variables, End-User Typology and Number of Users are included and were found to be significant predictors for the re-calibrated EUC sophistication index.

Table 5 below shows the weighted score and ranking between the re-calibrated and the Kagan mean scores. Note that for the sake of comparison, only those software/EUC applications that appear in both the scores are included in the table. Comparing the weighted scores between the re-calibrated scores and Kagan's mean scores, most of the re-calibrated scores are in agreement with Kagan's mean scores. However, two EUC applications, Order Processing and Customer Services differ most significantly with the corresponding Kagan scores compared to other applications in the list. The rest of the scores differ only slightly and are approximately equivalent in weight. The overall ranking also appears to be approximately the same.

As expected Word Processing applications were ranked the least sophisticated. Word Processing applications usually involve the creation and maintenance of simple documents such as forms, letters, quotes, mail shots, manuals and contracts. The simplicity of developing these applications has also made it possible for other

less sophisticated end-users such as administrative and clerical staff to develop these applications.

Table 5: EUC Sophistication Score Ranking Comparison

Kagan's Score			Re-calibrated Score		
Rank	**Software**	**Weighted Score**	**Rank**	**EUC application**	**Weighted Score**
1	Word Processing	1.65	1	Word Processing	1.53
2	Accounting & Finance	3.26	2	Order Processing	3.25
3	Order Processing	4.03	3	Accounting & Finance	3.47
4	Spreadsheet	4.03	4	Customer Services (Data)	3.81
5	Employee/Personnel	4.19	5	Spreadsheet	3.99
6	Inventory Control	4.64	6	Employee/Personnel	4.18
7	Data Application (Customer)	5.16	7	Inventory Control	4.89
8	Telecommunication	5.74	8	Telecommunication	6.08
9	Database	6.13	9	Database	6.18
10	Decision Model	7.83	10	Decision Model	7.86

The next lowest ranked application is Order Processing, which also carries less weighted score than the corresponding Kagan mean score. This suggests that the automation of order processing in small firms involves simple data entry to capture customer order and printing of order receipts. Such automation would involve simple development work that can be carried out by less sophisticated end-users. Customer Services application was also ranked much lower (fourth lowest compared to fourth highest in Kagan's list) with the most difference in their weighted scores. This may suggest that the level of sophistication of both applications be viewed from different perspectives with the one in the Kagan list viewed as general DP applications. Since customer information is important to businesses, capturing of customer data could be the minimum task that can be developed in a Customer Service application. This is supported by the moderately

lower rank of the Customer Services application that may involve the capturing of customer data where a fairly simple data entry application can be developed. On the other hand, the moderately higher ranking of the Data Applications (Customer) as in Kagan's list may involve fairly sophisticated processing of customer data such as maintenance of customer ratings, customer credits, and other DP activities. Other EUC applications were ranked and rated consistently with that of Kagan's and together with the statistical analysis presented next, suggest the reliability of the re-calibrated scores.

Using the EUC Sophistication score ranking of Table 5, the reliability of the re-calibrated score can be determined by performing the Spearman's Rho Rank-Order Correlation test. Rankings from both Kagan's and the re-calibrated lists are fitted into the Spearman's Rho formula. Result of the Spearman's Rho Correlation produces a coefficient of 0.879 at the 0.001 level of significance. This means a strong relationship exists between Kagan's score and the re-calibrated EUC application score ranking suggesting consistency between the two scores. This suggests that the re-calibrated EUC Sophistication scores are reliable and therefore represent good predictors of the opinions of the IT experts with a high level of confidence.

5.0 CONCLUSION

EUC Sophistication is measured according to the capability of end-users to develop applications, the degree of usage of the application in the organization in terms of the number of users, and the complexity of the applications developed. This study has formulated a measurement of EUC sophistication using the 3 dimensions: End-User Sophistication, Usage Sophistication, and Application Sophistication. This instrument can be used to measure the extent of a small firm's capability to implement IS by developing their own application.

A low sophistication index implies that the firm lacks end-user developers with adequate skill, but can produce simple reports and queries with spreadsheet and word processing capabilities, and the applications tend to be used by a small group or on an individual basis. On the other hand, firms with high EUC sophistication index tend to have experienced and skilled end-user developers who tend to develop more complex organizational information systems for use by larger groups of users spanning across departments within the firm. The EUC Sophistication measurement can therefore help small firms to assess their own EUC presence and take appropriate actions to improve their capability with respect to application development in particular and IT adoption in general. The usefulness of the sophistication index can be summarized as follows:

- Provide objective measure for comparison.

  The index and its application variables represent an objective measure where relative comparison can be made to identify a firm's level of sophistication in relation to others. A small firm could feel more confident of its ability to develop end-user applications as the index represents an objective guide.

- Facilitate assessment of IT adoption and EUC presence.

  Small firms are able to assess their own levels of sophistication in formulating their IT/EUC strategy. The index can be used to show the firm's current position and where appropriate actions can be taken to increase their level of sophistication. This can also be useful for Small Business Advisory and Consultancy services to get quick assessment of the firm's EUC presence and IT adoption.

- EUC application guideline.

  The index and its application variables can be useful for small firms planning to adopt IT or start on EUC. The applications can act as a checklist to guide the firms on the range of applications suitable for their own adoption or development. The degree of sophistication of individual applications would give the firms a feel of the complexity involved. Though this guideline may come in handy, it should not be a substitute for proper IS planning. The guideline can become a suitable aid to encourage small firms to plan for their IS.

- Towards a standardized index.

  As there are currently no standardized sophistication indexes, it will be difficult for small firms to assess their current level in relation to the industry. With a standardized index, firms could be more sensitive to their IT and EUC needs and this could promote better and healthier competition in terms of IS usage. Working towards a standard index requires replicating the current study in other areas of small business.

- Further research.

  There are potentials for the sophistication index to be used in future research. For example the study of EUC in firms with different levels of sophistication would help to address specific small business problems pertaining to a particular level of sophistication. This could even be extended to a particular sector of the industry. Recall earlier that small business makes up over 90% of

all businesses and studying specific category of firms would be worthwhile and can still make a significant contribution.

This study has made a first attempt to develop a sophistication construct for EUC in small business. The EUCSI measurement formulated in this study is only in its initial stage. More studies will help improve the index for more confident use by small firms, small business support services, and other researchers. Studies should also be conducted to re-evaluate the sophistication index. Though this study employed the re-calibrated sophistication index by re-evaluating existing measurement based on previous studies, independent studies should also be done to compare the findings with this and other previous studies with the aim of developing a standard sophistication index. This could also lead to future studies that can compare sophistication indexes between small, medium and large businesses.

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