CHAPTER IV

RESEARCH METHODOLOGY

The research methodology, questionnaire development, data collection method and data analysis strategy are presented in this chapter. The chapter begins with an overview of the main research design which is by a questionnaire-based survey instrument. The rationale for using the quantitative survey design is presented in the first section, while the second section describes the sampling frame, the sample, the unit of analysis and the respondents. In the third section, the development of the questionnaire and operationalization of the constructs are discussed. The data collection procedure is addressed in the fourth section followed by an explanation of the data analysis strategy and statistical methodology in the fifth section.

4.1 Survey Research

Survey research is one of the most popular research method used by information systems researchers (Claver et al., 2000; Orlikowski and Baroudi, 1991; Pinsonneault and Kraemer, 1993). Survey research is a systematic and impartial means of collecting information. Survey research should include units that are representative of the population under study, be guided by theory or relevant principles, should be replicable and should be generalizable to the population (Backstrom and Hursh-Cesar, 1981).

The survey research method was considered the most appropriate method for the study because of these reasons. It is the study's objective to collect EDI data usage. This study attempts to test the research framework and its hypotheses to gain a better understanding of the factors that influence the electronic data interchange adoption decision. It is crucial to employ a method that allows the model's theoretical propositions to be tested in an objective manner. This study is based on a positivist research perspective where the existence of a priori fixed relationships within phenomena is typically investigated with structured instrumentation (Orlikowski and Baroudi, 1991). Positivist studies serve primarily to test theory, in an attempt to increase predictive understanding of phenomenon. The criteria in classifying studies as positivist is the presence of formal propositions, quantifiable variables, hypothesis testing and the drawing of inferences about a phenomenon from the sample to a stated population (Orlikowski and Baroudi, 1991).

Survey research is used primarily when the researcher wishes to study the phenomenon in its natural setting without manipulating the independent and dependent variables of interest. Survey research is particularly suitable when the phenomenon to be investigated has occurred in the recent past or current time. Survey research is appropriate for answering questions about the phenomenon that include "What, How and Why is happening?". The criteria above are eminently suited for applying a cross-sectional survey research design (Pinsonneault and Kraemer, 1993). This research addresses the motives and perception of EDI adoption. Survey research is one of the most effective techniques available for the study of attributes, values, beliefs and motives (Sharma, 1983). Within the limits of time and resource constraints, survey research also offers the researcher a convenient, economical, efficient and quick method to collect reasonable sized sample data within a fixed time frame.

4.2 Sampling Frame, Sample, Unit of Analysis and Respondents

The sampling frame, sample, unit of analysis and respondents are presented in this section.

4.2.1 Sampling Frame and Sample

The sampling frame for this study consists of the manufacturing companies that are listed in the 2003, 2004 and 2005 Federation of Malaysian Manufacturers (FMM) Malaysian Industries directory. The purely service companies such as legal firms, banks etc. which represent approximately 5% of the companies listed in the FMM Malaysian Industries directory were excluded from the sampling frame because they are not directly involved in manufacturing. Based on these criteria, 2165 (95%) companies listed in the FMM directory (2003, 2004, and 2005) were included in the study.

4.2.2 Unit of Analysis and Respondents

An important step in survey research is the determination of the unit of analysis or the unit about which statements are being made. The unit of analysis for this study is the individual manufacturing companies because the research framework was modeled at the organizational level.

The survey was sent to the Chief Executive Office/General Manager/Director of the manufacturing companies. They were requested to either fill out the survey themselves or pass it to a senior manager of the company management who is most involved in the procurement, information technology or strategic planning. Informants who are knowledgeable about an organization can answer questions about generalized patterns of behavior such as technology usage and perception at the organizational level (Seidler, 1974). The Chief Executive Officer, the general manager or the director of a company is the most knowledgeable person in the company and is the best person to provide answers on the overall direction of the company. The top management or senior management in a company was identified as the most appropriate informants for this study.

4.3 Questionnaire Development

The exploratory study is conducted through a survey questionnaire which consists of three sections. Question 1 asks if the company is an EDI adopter or not. This question is to ensure that the adopters answer the questions in subsection 1A while the non-adopters answer the questions in subsection 1B. The questions in section 1 have been adapted from a number of sources which are referenced during the discussion of those questions.

Subsection 1A consists of 7 questions for EDI adopters and covers current EDI usage. Question 2 in subsection 1A is to find out the number of years that the organization has been an EDI user (Akbulut, 2003; Ang et al., 2003; Arunachalam, 1997; Henriksen, 2002; Hwang, 1991). This question allows us to determine if there is an increase in the number of new EDI over the years. Question 3 asks the main uses of EDI in Malaysian companies (Ang et al., 2003; Henriksen, 2002, Vijayasarathy and Tyler, 1997, Republic of Slovenia Statistical Office document, 2007, 2008). This question allows us to compare EDI main uses with main uses in other countries. Question 4 is on the document types that the company uses. This question measures EDI diversity (Ang et al., 2003; Li and Mula, 2009; Massetti and Zmud, 1996; McGowan and Madey, 1998; Vijayasarathy and Tyler, 1997). Question 5 is on the physical network that the company uses for its EDI transactions (Angeles et al., 2001; Hwang, 1991). This question allows us to compare the choice of networks preferred by the EDI adopters. Question 6 measures EDI breadth (Henriksen, 2002; Li and Mula, 2009; Masseti and Zmud, 1996). This question allows to determine the number of local trading partners that has EDI connections to the company. Question 7 also measures EDI breadth (Henriksen, 2002; Li and Mula, 2009; Masseti and Zmud, 1996). This question allows to determine the number of foreign trading partners that has EDI connections to the company. Question 8 asks the average daily number of EDI transactions of the company. This question allows to determine the number of daily transactions that is viable for EDI adopters (Vollmer, 2007; Seeburger, 2009).

Question 9 asks if the company has considered adopting EDI and leads to question 10 if affirmative and Question 11 if otherwise. Question 10 in subsection 1B asks non-EDI adopters the likelihood that they will adopt EDI within the next year (Chwelos et al., 2001). This question allows us to determine the adoption likelihood of non-adopters within our sample. Question 11 in subsection 1C is on procurement usage (Akbulut, 2003). This question allows us to determine if adopters and non-adopters differ in their usage of procurement practices and also to determine whether company size significantly influence procurement practices (Bajwa, 2005; Jeyaraj et al., 2006, Hwang, 1991; Laukkanen et al., 2005). Question 12 asks the EDI user to rate the importance of EDI benefits to the company's EDI adoption decision (Chwelos et al., 2001). Question 13 asks the EDI user to rate the importance of organizational factors to the company's EDI adoption decision. Question 14 asks the EDI user to rate the importance of environmental factors to the company's EDI adoption decision. Question 15 asks the EDI user to rate the importance of technological factors to the company's EDI adoption decision. Questions 12, 13, 14 and 15 are the main constructs to test the hypothesis of the technology-organization-environment research framework. These 3 questions allow us to test whether company size has an influence on the perception of adoption variables (constructs) and whether adopters and non-adopters differ in their perception of adoption variables (Bajwa, 2005; Jeyaraj et al., 2006, Hwang, 1991; Laukkanen et al., 2005). The operationalization of the organizational constructs in question 13, the environmental constructs in question 14 and the technological constructs in question 15 are discussed further in the next sections.

The second section requests for information on company profile such as industry sector, year incorporated, major products/services, legal status, ownership structure, number of employees, paid-up capital, annual sales turnover, annual procurement expenditure and annual investments in information technology.

The third section is for information on respondent profile. This section is important because if further clarification is needed contact information of the respondent such as telephone number, facsimile number, email and mobile phone number are available.

4.3.1 Operationalization of the Constructs

A great deal of care and effort was taken to ensure that the items chosen for each construct were not only minimal, but also sufficient to best represent that construct in the research framework The items were mainly derived from previously tested survey instruments to take advantage of well-tested psychometric measures (Straub, 1989). Most of the items representing the construct were derived by modifying these previously validated scales since direct use of the previous instruments was deemed not appropriate for this study. When previous instruments are not available, a common approach often followed by researchers is to develop new instruments based on relevant theory or literature (Grover, 1993). Such an approach was adopted for security and risk construct by developing new items based on commonly occurring statements in the literature, since previous suitable items were not available for use. To capture the underlying theoretical dimensions more effectively, all the constructs used for this study were measured using multiple indicators (Premkumar and Ramamurthy, 1995).

A 5-point Likert-type scale was used for the benefits, organizational, environmental and technological items in the questionnaire. Table 4.1 provides a summary of the operationalization of the constructs with its source references. Detailed discussion on how the constructs were operationalized is given next.

4.3.1.1 Operationalization of the Size Variable

Size has been defined in different ways in innovation research, for example as number of beds (Kimberley and Evanisko, 1981), number of employees (Ettlie et al., 1984; Bajwa et al., 2005), annual sales (Lind et al., 1989) and total revenues (Bajwa et al., 2005).

Company size can be measured by paid-up capital (Janggu et al., 2007). The Ministry of International Trade and Industry of Malaysia defines small size companies as those with paid-up capital (shareholder’s funds) of less than MYR500,000 and 20 workers and less, medium size companies as those with paid-up capital of MYR500,000 to MYR2.5 million and 21 to 99 workers and large size companies as those with paid-up capital of more than MYR2.5 million and more than 100 workers (Akauntan Nasional, 2001). Company size for this study is operationalized based on the Ministry of Trade and Industry of Malaysia definition since it is the most appropriate for our purpose.

4.3.1.2 Operationalization of the Benefits Construct

The benefits construct is operationalized by using items from or adapted from the following sources. Cost savings, improved customer services and reduced inventory were operationalized using the three-item measure used by Grover (1993) and Premkumar and Ramamurthy (1995). Closer trading partner relationship, competitive advantage, better data

Table 4.1: Constructs, Items and Questionnaire Cross-Reference

Constructs	Items	References
Benefits	Q12, Items 1-18	Chwelos et. al. (2001), Grover (1993), Iacovou et. al. (1995), Jimenez-Martinez and Polo-Redondo (2004), Kuan and Chau (2001), Love and Irani (2004), Philip and Pedersen (1999), Premkumar and Ramamurthy (1995)
Top Management Support	Q13, Items 1-6	Grover (1993), Premkumar and Ramamurthy (1995)
Information Technology Capability	Q13, Items 7-11	Kuan and Chau (2001), Premkumar and Ramamurthy (1995), Thong (1999), Zhu et. al. (2003)
Compatibility	Q13, Items 12-14	Akbulut (2003), Grover (1993), Premkumar and Ramamurthy (1995)
Internal Championship	Q13, Items, 15-18	Akbulut (2003), Grover (1993), Premkumar and Ramamurthy (1995)
External Pressure	Q14, Items 1-5	Chwelos et. al. (2001), Premkumar and Ramamurthy (1995)
Interorganizational Trust	Q14, Items 6-13	Hart and Saunders (1998), Nidumolu (1989)
Critical Mass	Q14, Items 14-16	Akbulut (2003), Bouchard (1993), Kuan and Chau (2001)
Legal Framework	Q14, Items 17-20	Markus and Soh (2002), Palacios (2003), Pattison (1997), Tarafdar and Vaidya (2004), Tigre (2003)
Costs	Q15, Items 1-7	Chau and Tam (2000), Kuan and Chau (2001), Premkumar et. al.(1994)
Risks	Q15, Items 8 – 22	Banerjee and Golhar (1995, 1997), Jamieson (1996), Sanderson and Forcht (1996)
Security	Q15, Items 23-28	Banerjee and Golhar (1995), Ratnasingham and Swatman (1997)
Complexity	Q15, Items 29-32	Grover (1993), Ratnasingham and Swatman (1997), Swatman (1993)
Size	Q6, Q7, Section 2	Bajwa et. al. (2005), Ettlie et. al. (1984), Grover(1993), Janggu et. al. (2007)

accuracy, improved communications with business partners were operationalized from 4 items used by Iacovou et al. (1995) and Philip and Pedersen (1997). A modified version of items used by Philip and Pedersen (1997) and Jimenez-Martinez and Polo-Redondo (2004) was used to measure the 4 items, i.e. new ways of doing business, reduced paperwork, better data security, and improved logistics. Improved corporate image was measured by a one-item measure used by Kuan and Chau (2001). A three-item measure used by Martinez and Redondo (2004) was modified to measure the 3 item, i.e. compressed production cycle and delivery times, improved profits and empowered employees. Improved efficiency and productivity was operationalized by modifying a one-item measure used by Philip and Pedersen (1997) and Chwelos et al. (2001). A modified version of a one-item measure used by Grover (1993) and Love and Irani (2004) was used to assess the item increased market share. Improved integration with existing systems is operationalized by modifying a one-item measure used by Chwelos et al. (2001) and Jimenez-Martinez and Polo-Redondo (2004).

The 18-item benefit construct was operationalized based on the commonly reviewed items in the adoption literature (Akbulut, 2003; Banerjee and Golhar, 1993; Bouchard, 1993; Huang, 2003; O'Malley and Matheson, 2002).

4.3.1.3 Operationalization of the Organizational Constructs

The operationalization of the organizational constructs of top management support, information technology capability, organizational compatibility and internal championship are discussed below.

The top management construct is operationalized by using items from or adapted from the following sources. The four items **(**effectively communicated its support to trade partners, communicated its support to company's employees, interested in EDI, and considers EDI with trading partners important) are operationalized by the three-item measure adapted from Grover (1993). The two items (willing to take risk and committed to provide adequate financial resources) are adapted from the two-item measure used by Premkumar and Ramamurthy (1995).

The information technology capability construct is operationalized by using items from or adapted from the following sources. The two items **(**IT support and EDI experience) is operationalized by the 2 items (provide IT support, experience in supporting EDI) adapted from Kuan and Chau (2001). A modified version of Thong (1999) one-item measure was used to measure the item, employee is computer literate. The item, EDI knowledge and expertise is adapted from an item (IT expertise) used by Zhu et al. (2003). A one-item measure used by Premkumar and Ramamurthy (1995) was modified to measure the item, good telecommunications infrastructure.

The organizational compatibility construct is operationalized by using items from or adapted from the following sources. A modified version of Akbulut (2003) one-item measure (electronic information sharing is consistent with our agency's needs) is used to measure the item, compatibility with company's needs. The item, compatibility with standard operating procedures is operationalized by an item (compatibility with existing operating practices) adapted from Premkumar and Ramamurthy (1995). The item, compatible with beliefs, values and experiences, is adapted from an item (compatibility with beliefs and values existing in the firm) used by Premkumar and Ramamurthy (1995) and an item (CIOS consistent with beliefs and values) used by Grover (1993).

The internal championship construct is operationalized by using items from or adapted from the following sources. The two items, support and promote internal championship are developed based on a one-item measure (influential individual support and promote initiative) used by Akbulut (2003) and a one-item measure (individual enthusiastically championed CIOS) used by Grover (1993). A one-item measure (individual enthusiastically championed CIOS) used by Grover (1993) and a one-item measure (person committed to introduce EDI) used by Premkumar and Ramamurthy (1995) was modified to measure the two items, show keen interest and create a favourable opinion.

The 6-item top management, 5-item IT capability, 3-item compatibility and the 4-item internal championship constructs were operationalized based on the commonly reviewed items found in the adoption literature (Akbulut, 2003; Grover, 1993; Huang, 2003; Kuan and Chau, 2001; Premkumar and Ramamurthy, 1995).

4.3.1.4 Operationalization of the Environmental Constructs

The operationalization of the environmental constructs of external pressure, interorganizational trust, critical mass and legal framework are discussed below.

The external pressure construct is operationalized by using items from or adapted from the following sources. A three-item measure (recommend to adopt EDI, request to adopt EDI, threats regarding detriments if organization did not adopt EDI) used by Chwelos et al. (2001) was adapted to measure the three items, mandate EDI use, recommend EDI use and request EDI use. The item, pressure as a standard purchasing practice, was operationalized by an item (industry pressure to use EDI as a standard purchasing practice) adapted from Premkumar and Ramamurthy (1995). A modified version of Premkumar and Ramamurthy (1995) one-item measure (pressure from loss of competitive advantage due to lack of EDI links to partners) was used to operationalize the item, loss of competitive advantage due to lack of EDI links.

The interorganizational trust construct is operationalized by using items from or adapted from the following sources. This construct is measured by eight items (adherence to agreements, consistency in business dealings, willingness to share information, reliability of computer systems, competency of trading partners, honesty in business dealings, delivering on promises, accuracy of deadlines met) used by Hart and Saunders (1998). The item, adherence to agreements and the item, willingness to share information (Hart and Saunders, 1998) were adopted from Nidumolu (1989) study.

The critical mass construct is operationalized by using items from or adapted from the following sources. A one-item measure (implementation is inevitable and essential) used by Akbulut (2003) was modified to measure the item, adoption is essential and inevitable. A one-item measure (important business partners/competitors using EDI) used by Bouchard (1993) and Kuan and Chau (2001) was modified to measure the item (using or soon using) and the item (company use EDI, others will follow).

The legal framework construct is operationalized by using items from or adapted from the following sources. The importance of the existence of e-commerce law for facilitating e-commerce adoption and its implementation is clearly stated in the following literature. Tigre (2003) found that the lack of business laws for e-commerce and inadequate legal protection for Internet purchases are barriers affecting e-commerce readiness and diffusion in Brazil. Palacios (2003) similarly cites the creation of a basic legal framework as an enabling factor for e-commerce in Mexico. Legal and regulatory framework, laws governing and regulating internet usage provide the external context in which firms make decisions regarding electronic commerce (Markus and Soh, 2002; Tarafdar and Vaidya, 2004). Pattison (1997) further argues that a digital signature is important as it is admissible in a court of law as a handwritten representation provided there is a law that makes it legally binding.

The four items of the legal framework construct were developed for this study following the different issues of legal framework affecting electronic commerce based on the prior reviewed literature and the specific e-commerce laws already enacted in Malaysia.

The item (protection of digital signature) is operationalized based on the protection offered by the Digital Signature Act which is a Malaysian e-commerce law. The item (protects both buyers and sellers) is operationalized based on principle of general protection offered by Malaysian e-commerce laws. The item (protection against computer crimes) is operationalized based on the protection offered by the Computer Crimes Act. The item (agreement protects both trading partners) is operationalized based on importance of trade agreements or contracts for both trade partners.

The 5-item external pressure, 8-item interorganizational trust, 3-item critical mass and 4-item legal framework constructs were operationalized based on the commonly reviewed items in the adoption literature (Akbulut, 2003; Chwelos et al., 2003; Hart and Saunders, 1998; Huang, 2003; Premkumar and Ramamurthy, 1995; Tigre, 2003).

4.3.1.5 Operationalization of the Technological Constructs

The operationalization of the technological constructs of costs, risks, security and technological complexity are discussed below.

The costs construct is operationalized by using items from or adapted from the following sources. A one-item measure (setup costs) used by Kuan and Chau (2001) is modified to measure the two items (consulting costs, installation costs). The item, training cost is operationalized by an item (training cost) adopted from Kuan and Chau (2001). The three items, **(**support staff cost, maintenance cost, telecommunications cost) are operationalized by modifying an item (running costs) adopted from Kuan and Chau (2001). A modified version of Chau and Tam (2000) one-item measure (migration cost) is used to operationalize item 5 (integration costs).

The risks construct is operationalized by using items from or adapted from the following sources. The item (EDI reduces full control) and the item (lack of signature for transactions) are developed for this study based on previous reviewed literature (Banerjee and Golhar, 1993; Sanderson and Forcht, 1996). 12 items of the 15-item risk construct are operationalized following the 12-items identified in Jamieson (1996) study. The individual measures are described fully below.

The item, lack of audit trails, is operationalized by modifying an item (audit problems) used by Jamieson (1996). The item, lack of an accepted standard for data transmission, is operationalized by modifying an item (interconnection problems) adopted from Jamieson (1996). A one-item measure (record retention problems) used by Jamieson (1996) was modified to measure the item, inadequate record retention. The item (lost messages) and the item (delayed messages) are operationalized from an item (non-delivery, delayed delivery) adopted from Jamieson (1996). The item (incomplete message) is operationalized from an item (inaccurate or incomplete transactions) used by Jamieson (1996). The item (risk of errors) is operationalized by modifying an item (incorrect data, tables or software) adopted from Jamieson (1996). The item (disclosure of EDI message) is operationalized by modifying an item (disclosure of transaction content) used by Jamieson (1996). Jamieson (1996) one-item measure (inaccurate or incomplete transactions) is modified to operationalize the item (risk of modification of EDI message). The item (unauthorized/non-authentic transactions) is operationalized from an item (non-authentic/unauthorized) adapted from Jamieson (1996). The item (repudiation of origin) and the item (repudiation of receipt) are operationalized by modifying an item (repudiation of origin or receipt) adopted from Jamieson (1996). A one-item measure (operator errors) adopted from Banerjee and Golhar (1993) is used to operationalize the item, operator errors.

The security construct is operationalized by using items from or adapted from the following sources. The three items authenticity, integrity and confidentiality are operationalized from items (authenticity, integrity, confidentiality controls) from Ratnasingham and Swatman (1997). The three items, digital signature, password and data encryption are operationalized from items (digital signature, password, data encryption) used by Banerjee and Golhar (1995).

The complexity construct is operationalized by using items from or adapted from the following sources. The item (difficult to use) and the item (complex transfer process) are operationalized by modifying items **(**EDI is difficult to use, EDI is a complex document transfer process) adopted from Grover (1993). The item, standards that are unclear, is operationalized from an item (unclear standards) used by Swatman (1993). A modified version of Ratnasingham and Swatman (1997) one-item measure (multiple standards) is used to operationalize the item, uses many different standards.

The 7-item cost, 15-item risk, 6-item security and 4-item complexity constructs were operationalized based on the commonly reviewed items in the adoption literature (Akbulut, 2003; Banerjee and Golhar, 1993; Huang, 2001; Jamieson, 1996; Kuan and Chau, 2001; Sanderson and Forcht, 1996).

4.3.1.6 Dependent Variable EDI Adoption

The dependent variable, EDI adoption was determined by a binary measure, i.e. adopters or non-adopters. Adopters are defined as the companies which are using or in the process of implementing EDI.

4.3.2 Content Validity and Pretest

Content validity is the degree to which items in an instrument reflect the content universe to which the instrument will be generalized (Cronbach, 1971; Rogers, 1983, 1995, 2003). Rungtusanatham (1998) defines content validity as "the extent to which an instrument captures the different facets of a construct". For an instrument to be valid in content, the measures or representative questions should be drawn from all possible measures of the properties under investigation (Straub, 1989). Content validity can generally be established through literature reviews and expert judges or panels (Boudreau et al., 2001; Straub, 1989).

Following the above recommendation, the survey instrument will be reviewed by domain experts in academia and practice. The domain experts were selected based on their knowledge about the topic, their availability and willingness to cooperate. The experts were asked to carefully examine the instrument and comment on the suitability of the content, clarity of the wording of the questions and to provide any feedback on the instrument in general. The domain experts included people with different areas of expertise: academic experts in methodology and statistics, computer science, information systems, management as well as practitioners from the manufacturing industries.

In the first phase of the pre-test, four academician from Universiti Malaya reviewed the questions, scales, instructions and the appropriateness and clarity of the questions and language for the intended respondents. Two of the academicians were from the business and accountancy faculty and economics and administration faculty. The other two academicians were from the computer science faculty. One of the academician is a statistician, while the other three are experienced in survey research and quantititative analysis. They provided valuable feedback on the instrument both in written and oral form. Their comments and views were incorporated in the revised and improved version of the survey instrument.

In the second phase of the pretest, practitioners from the manufacturing industries were requested to review the survey instrument to confirm the appropriateness and sensitivity of the questions, the language and the overall presentation of the survey. In addition, several other elements of the survey package including the cover letter, etc. were reviewed by an expert from a computer services company.

Attempts were made to interview senior management personnel from the manufacturing industry in the Klang valley for the pilot study. After many phone calls were made four managers expressed interest to meet with the researcher. Finally two managers decided not to participate in the pilot study due to company policy and work commitments.

The survey was pilot-tested in a face-to-face meeting with a production manager in a manufacturing company in the Klang valley. The production manager is not an IS staff but is knowledgeable in information systems as he is an experienced user of information systems in his company and has participated in information systems project development.

The survey was also pilot-tested with a senior systems analyst in another manufacturing company based in the Klang valley. The senior system analyst is an IS staff who has been with the company for 3 years, is knowledgeable and has implemented various information systems. The two practitioners provided valuable feedback on the instrument. The survey instrument was revised again using the feedback obtained from the practitioners. The changes that were made included clarifying some of the items and wordings, changing the format of the questionnaire and resequencing the questions.

The content validity of this study could be confirmed on both theoretical and practical grounds based on the previous procedures. The constructs have been operationalized based on well-established content domain drawn from both the theoretical and non-theoretical literature. Pretesting by domain experts was carried out to ensure that content validity is established for this study. Convergent and discriminant validity will be discussed in Chapter V.

4. 4 Data Collection Procedures

The administration of the mail-based survey questionnaire is discussed in this section.

4.4.1 Survey Questionnaire Administration

Dillman's (2000) "Tailored Design Method" (TDM) was adopted in the design and implementation of the survey questionnaire. The tailored design is the development of survey procedures that create respondent trust and perceptions of increased rewards and reduced costs for being a respondent. The overall goal is to increase the quality and quantity of the response as well as to reduce survey error. Dillman provides the researcher with an administrative plan that guides each step of the survey design and implementation.

1) Survey Package: The survey package was mailed to 2165 companies which have been identified earlier. The survey package included the following items.

a) Cover Letter: A cover letter was included which provided a brief explanation of the survey. The letter described the purpose and importance of the study, assured that responses are confidential and stated that participation was voluntary. The cover letters were personalized for each company and addressed directly to the Chief Executive Officer or someone with similar authority within the company. The cover letter which included the name and contact information of the primary investigator was signed by using a blue colored signature pen (Dillman, 2000). The cover letter also contained directions on how the survey results/findings could be requested.

b) The Questionnaire: The survey package consists of an 8-page paper questionnaire. Following the guidelines suggested by Dillman (2000), the goal of the survey design was to prepare a survey questionnaire that was attractive in appearance and was easy to complete.

The front page of the survey include the UM logo, the title of the survey and the name of the primary investigator. Instructions for completing the questionnaire and other general information including the definition of terms were included in the first page of the questionnaire.

The format and layout of the survey was designed to reduce the number of pages and therefore also reduce the time needed to complete the questionnaire. As recommended by Dillman (2000), the sections of the questionnaire were designed based on content and personal questions were placed at the end.

c) Reply envelope: The survey package included a 7” X 10” envelope for respondents to return the survey. The envelope was addressed to the primary investigator and was affixed with a correct value postal stamp.

d) Outside Envelope: The three components discussed above, i.e. the cover letter, the questionnaire and the return envelope were assembled and inserted into an envelope. The survey package was assembled in such a way as to ensure that all three enclosures would come out of the envelope together when the respondent opened it.

e) A small-value gift in the form of a bookmark was included to encourage more favorable response from the recipients.

2) Thank You/Reminder Postcard: Two weeks after the survey package was sent, thank you/reminder postcards were mailed to the companies. The reason for sending this postcard was to thank those respondents who had already returned their questionnaires and to remind the other respondents to complete and return the questionnaire as soon as possible.

A 5 ½ ” X 8 ½ ” ivory postcard was used. One side contained the UM logo and the primary investigator’s address. The names and addresses of the respondents were directly printed on the reverse side.

3) Replacement Questionnaire: Four weeks after the original survey package and two weeks after the thank you/reminder postcards were sent, a replacement survey package was

sent to those companies that had not yet responded. The replacement survey package was similar to the original survey package and included a follow-up cover letter, a replacement survey and a self-addressed postage paid reply envelope.

The format and content of the follow-up cover letter were similar to the original cover letter, except that it included some other elements to encourage the recipients to respond. For instance, it informs the recipient that other companies had responded. It also reemphasized the recipient's important contribution to the survey and implied that the accuracy of the results will improve with the return of the questionnaire.

4.4.2 Outline of Strategies to Increase Survey Response Rate

The following list summarizes the strategies used for increasing the survey response rate.

(a) The survey instrument was pre-tested by both academicians and practitioners. It improves both relevance and interest to the respondent.

(b) The survey questionnaire was reduced to the minimum number of pages. The average time to complete the questionnaire during pilot-testing was between 20-30 minutes.

(c) All the survey elements (survey questionnaire, cover letter, follow-up reminders) were personalized and were directly addressed to the Chief Executive Officer or a person with similar level of authority within the company.

(d) Self-addressed postage paid return envelopes were provided to the respondent to ensure that they would not incur any mailing costs.

(e) A small-value gift in the form of a bookmark was included in the survey package to encourage better response.

(f) A summary of the study results/findings was offered to the companies as an incentive for them to participate.

(g) Throughout the design and implementation process of the survey, the most relevant guidelines suggested by Dillman (2000) have been adopted.

4.5 Data Analysis Strategy and Statistical Methodology

The outline of the data analysis strategy is presented below. This is followed by a discussion of common method biases, construct equivalence and the statistical methodology used in this research.

Common method biases pose a major problem in behavioral sciences research. Method biases are one of the main sources of measurement error. Measurement error threatens the validity of the conclusions about relationships between measures. (Bagozzi and Yi, 1991; Nunnally, 1978; Spector, 1987). One of the main sources of systematic measurement error is method variance (Bagozzi and Yi, 1991). The main sources of common method biases are (1) Method effects produced by a common source or rater (2) Method effects produced by item characteristics (3) Method effects produced by item context and (4)Measurement context effects. Common method biases and the remedies taken are discussed at the end of chapter V.

The need to establish construct equivalence is especially important for cross-national comparative research to verify the reliability and validity of items used to measure theoretical constructs (Mullen, 1995). Conceptual equivalence and measurement (metric equivalence) are prerequisite for structural equivalence (Hui and Triandis, 1983; Labouvie, 1980). Structural equivalence refers to the fact that the causal linkages between a given construct and its causes and consequences are invariant across different situations such as culture. It should be noted that the 3 types of equivalence (conceptual, metric and structural) constitute a hierarchy in that metric equivalence assumes conceptual equivalence, whereas both are required to establish structural equivalence. The three issues related to structural equivalence would be better addressed within the framework of structural equation modelling (SEM). However, these issues cannot be addressed here because the research framework on which this thesis is based does not use the cause and consequence relationship of SEM.

The need to establish construct equivalence is of utmost importance when developing psychosocial measures across culture, race and gender. However, for this study the questions are of an objective and technical nature and the type of responses expected and the meaning attributed to each item will be little affected by culture, race or gender. Structural equivalence is difficult to establish even for cross national studies. It's exactly for these reasons that very few papers in the IS/IT research address this issue unlike papers published in the psychology discipline which are mostly based on psycho-social measures.

Analysis of missing data, analysis of non-response bias, Levene's test were first performed. FREQUENCIES was performed on the company characteristics. t-tests was performed to test differences in perception of adoption variables between EDI adopters and non-adopters. Reliability tests i.e., Cronbach α test, split-half reliability and composite reliability were performed to test survey instrument reliability. Convergent and discriminant validity were next performed to test survey instrument validity. Exploratory factor analysis was performed to identify the appropriate items for each construct. Multiple regression analysis was run for non-adopters.

This is followed by residuals analysis, multicollinearity test and test of linearity in the logit. The assessment of goodness of fit using pseudo R^2 and model χ^2 were then performed. Binary logistic regression was performed and the Wald statistics was used to test the research hypotheses. Hosmer and Lemeshow Goodness of Fit test was performed to test the hypothesis if there is no difference between observed and model predicted values of the dependent. Next, the logits were interpreted in terms of change in log odds and percent change in odds. Analysis of predictive efficiency, classification table, statistical significance and statistical tests of classification rate were performed.

4.5.1 Analysis of Missing Data, Analysis of Non-response Bias, t-tests, FREQUENCIES

Analysis of missing data to determine that non-randomly missing data do not pose a serious problem is first carried out.

This is followed by the analysis of non-response bias to determine that it is not serious in our sample. Levene's test for equality of variances and t-tests for equality of means for the organizational, environmental and technological variables are then run. Frequencies and descriptive statistics (means, standard deviation) that were used to describe the company's characteristics, respondent's characteristics and EDI usage are run.

t-tests to test difference in company's characteristics and EDI usage between adopter and non-adopter were performed. In addition, t-tests that were used to test for differences between EDI adopters and non-adopters on their perception of EDI adoption variables were also performed.

4.5.2 Reliability Tests

Cronbach α, split-half and composite reliability tests were performed to confirm the reliability of the survey instrument (Churchill, 1979; Nunnally, 1978). Cronbach's alpha assesses the reliability or internal consistency of each construct. Split-half reliability involves administering two equivalent batteries of items measuring the same thing in the same instrument to the same people. The Guttman split-half reliability measures a different dimension of reliability was also computed.

Reliability is defined as a measure of the internal consistency of the construct indicators and shows the degree to which these construct indicators represent the common latent construct.

Composite reliability which is derived from factor analysis and measures a different dimension of reliability is computed using the formula shown below.

$$\text{Composite reliability} = \frac{\left(\sum \lambda_i\right)^2}{\left(\sum \lambda_i\right)^2 + \sum \varepsilon_j} \qquad (4.1)$$

where λ_i is the factor loading for each indicator,

and ε_j is the measurement error for each indicator and is calculated as

$$\sum \left(1 - \lambda_i{}^2\right) \qquad (4.2)$$

4.5.3 Validity

Validity is the extent to which a scale or subset of measures accurately represents the concept of interest. A survey instrument is valid if there is proof of convergent and discriminant validity (Straub, 1989; Trochim, 2002). Convergent validity can be assessed by factor loading and average variance extracted (AVE). A factor loading greater than 0.70 is significant and proves convergent validity. Average variance extracted (AVE) measures the percentage of variance (in the indicators) captured by the latent construct relative to the amount of variance due to random measurement error (Netemeyer et al., 1990). AVE is calculated from the ratio of the sum of the variance captured by the construct and its measurement variance (Gefen et al. 2000, Hair et al., 1998).

The AVE equation is shown below:

$$AVE = \frac{\sum \lambda_i^{2}}{\sum \lambda_i^{2} + \sum \left(1 - \lambda_i^{2}\right)} \tag{4.3}$$

where

λ_i is the factor loading for a variable that measures a construct,

λ_i^2 is the variance captured by the construct

and

$(1- \lambda_i^2)$ is the error variances

Extracted values with higher variance show that the indicators are truly representative of the latent construct. If the average variance extracted is less than 0.50, then the construct cannot be valid because the variance due to measurement error is greater than the variance due to the construct itself.

Discriminant validity is the degree to which two conceptually similar concepts are distinct. Some researchers use r = 0.85 as a cutoff for assessing discriminant validity while other researchers use the criterion that the correlations testing convergent validity should be higher than that testing discriminant validity based on the rationale that items measuring the same thing should correlate more highly with themselves than with other things. Discriminant validity can be tested by comparing the average variance extracted (AVE) values associated with each construct to the correlations among the constructs (Anderson and Gerbing, 1988; Jarvenpaa and Staples, 2000).

Discriminant validity is also tested using correlation analysis and is achieved if an item correlates more highly with items that measure the same factor than with items used to measure a different factor. Discriminant validity is determined by counting the number of times an item has a higher correlation with an item from another factor than with items in its own factor. Campbell and Fiske (1959) suggested that a count of less than one-half is acceptable as valid (Chau and Tam, 1997).

4.5.4 Factor Analysis

Factor analysis is used to identify the factors of the structure and to determine the extent to which each variable is explained by each factor. The factor analysis procedure in this study follows the 7 stages recommended by Hair et al. (1998).

The objectives of factor analysis are identified in stage 1 while the factor analysis design is specified in stage 2. Tests of the critical assumptions e.g. departures from normality, homoscedasticity and linearity which affect the correlations are performed in stage 3. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity are run in stage 3.

The factors are extracted using principal component analysis in stage 4. Factors with latent roots or eigenvalues > 1 are significant and are retained. The use of the eigenvalues for determining a cutoff is most reliable when the number of variables is between 20 and 50 (Hair, 1998, p. 103).

The factors extracted are interpreted in stage 5. Factor analysis is validated in stage 6. A split-sample of the original data was used to assess the degree of generalizability of the results to the population. The original sample was split into two random subsets of 50:50 proportions of cases for the validation test. In the factor analysis validation tests, the sample in two subsets was chosen so that the ratio of EDI adopters to EDI non-adopters was the same as that in the original sample, i.e. approximately 30 EDI adopters for every 100 EDI non-adopters. After the two subsets were selected, the factors were extracted using varimax rotation.

Data reduction of variables obtained from factor analysis completes stage 7. The reduced variables can be used for statistical analysis such as logistic regression. The technological variables were reduced by creating 4 summated scales (composite measure). The scales are the average of the following variables, i.e. risks, costs, security and complexity. The organizational variables were reduced by creating 3 summated scales. The scales are the average of the following variables, i.e. top management support, information technology capability and internal championship. The environmental variables were reduced by creating 3 summated scales. The scales are the average of the following variables, i.e. inter-organizational trust, external Pressure and legal framework.

4.5.5 Binomial Logistic Regression

The binomial (binary) logistic regression technique was used in this study because the dependent variable is nonmetric and dichotomous and the independent variables are ordinal and interval. Logistic regression is used to predict the group membership of a dichotomous dependent variable based on the independent variables and to rank their relative importance.

Statistical tests for binary logistic regression (with dichotomous outcome) were performed using the checklist by Tabachnick and Fidell (2001: 562).

The checklist includes the following tests:

1. Adequacy of expected frequencies (if necessary)

2. Residuals analysis to test for outliers

3. Multicollinearity

4. Evaluation of overall fit. If adequate:

    a. Significance of tests for each predictor

b. Parameter estimates

5. Odds ratio

6. Classification of prediction success table

7. Interpretation in terms of means and /or percentages

4.5.6 Residuals Analysis

Residuals analysis is used in logistic regression to identify cases for which the model works poorly or cases that exert more than their share of influence on the estimated parameters of the model (Menard, 2002). Residuals analysis is performed using Studentized residual, leverage statistic and dbeta statistic. Studentized residuals is a form of a Student's t-test, with the estimate of error varying between points. This is an important technique in the detection of outliers. Studentized residuals with values less than -3 and greater than +3 deserve closer attention; values less than -2 or greater than +2 may be of concern. The leverage statistic, h, is used to identify cases which influence the logistic regression model more than others. The leverage statistic varies from 0 (no influence on model) to 1 (completely determines the model). The leverage of any case is $p = (k + 1)/n$ where k is the number of independents and n is the sample size. Leverage values several times the value of p deserve closer attention. The dbeta statistic, dbeta is used to identify cases which are poorly fitted by the model. Dbeta measures the change in the logit coefficients when a case is dropped. A criterion for identifying cases which fit poorly is those with dbeta > 1.0.

4.5.7 Multicollinearity Tests

Multicollinearity is a problem in logistic regression that produces standard errors of the regression coefficients which results in regression coefficients that appear to be unreasonably high (Menard, 2002). If multicollinearity occurs, then the relative importance of the independent variables will be unreliable (Hair et al., 1998).

Tolerance and Variance Inflation Factor (VIF) are tests of collinearity.

Tolerance is defined as:

Tolerance = $1 - R_x^2$ (4.4)

where R_x^2 is the variance in each independent variable x, explained by all of the other independent variables.

A tolerance of less than 0.20 is a cause for concern while a tolerance of less than 0.10 indicates a serious collinearity problem. The VIF value, which is the inverse of tolerance, i.e. VIF = 1/tolerance is computed. A very low tolerance and hence high VIF value denote high collinearity. A common cutoff threshold is a tolerance value of 0.10 which corresponds to a VIF value of above 10. This also corresponds to a multiple correlation of 0.95.

4.5.8 Test of Linearity in the Logit

The logistic regression model has a linear form if the change in the dependent variable logit(Y) for a one-unit change in X is constant and does not depend on the value of X. The change in logit(Y) for a one-unit change in X is then equal to the logistic regression coefficient. The Box-Tidwell transformation (Hosmer and Lemeshow, 1989, 2000) is used to test for nonlinearity in the logit. A statistically significant coefficient for this variable implies there is evidence of nonlinearity in the relationship between logit(Y) and X.

4.5.9 Goodness of Fit Tests

The goodness of fit is tested using pseudo-R^2, the log likelihood criterion (-2LL , model chi-square and the Hosmer-Lemeshow goodness of fit test.

The likelihood ratio R^2 is defined as

$$R_L^2 = \frac{G_M}{D_O} = \frac{G_M}{(G_M + D_M)} \qquad (4.5)$$

where

G_M is the model chi-square,

D_M is -2LL statistic (or deviance) for the full model

D_O is -2LL statistic (or deviance/initial chi-square) for the null model

R_L^2 is a proportional reduction in -2LL or a proportional reduction in the absolute value of the log likelihood measure.

The contingent coefficient R_C^2 is a pseudo-R^2 measure proposed by Aldrich and Nelson.

$$R_C^2 = \frac{G_M}{G_M + n} \qquad (4.6)$$

where

n is the number of cases

The R_C^2 measure cannot attain a value of 1 even for a perfect model fit. Hagle and Mitchell (1992) proposed a correction for Aldrich and Nelson's pseudo-R^2 that allows it to vary from to 0 to 1. In this study, the Hagle and Mitchell (1992) correction uses the modal category of EDI non-adoption of 70% and a multiplier of 1.82 to give the pseudo R-Square formula of

$$R^2 = \frac{G_M}{G_M + n} * 1.82 \qquad (4.7)$$

Researchers should use these measures as rough guides without attributing great importance to a precise figure because there is no consensus on the single best pseudo-variance measure (Pampel, 2000; pp. 50).

Model chi-square, G_M is computed as -2LL for the null (initial) model minus -2LL for the researcher's model (i.e. $D_0 – D_M$). G_M provides a test for the null hypothesis that $\beta_1 = \beta_2 = \ldots = \beta_K = 0$ in the logistic regression model. When the probability or significance of the G_M <= 0.05, we reject the null hypothesis that knowing the independents makes no difference in predicting the dependent in logistic regression. A well fitting model should have a p value (significance) of 0.05 or lower.

4.5.10 Wald Statistic

The Wald statistic (test) is used to test the significance of the logistic regression coefficient of each independent variable. The significance of the regression coefficients is used to determine support for the research hypotheses. The Wald statistic is computed as the ratio of the unstandardized logit coefficient to its standard error squared, i.e. $\left(\frac{B}{S.E.}\right)^2$.

Variables which are significant should have Wald statistic values greater than 1.

4.5.11 Hosmer and Lemeshow Goodness-of-Fit Test

The Hosmer and Lemeshow's (H-L) goodness-of-fit test divides the subjects into deciles based on predicted probabilities and computes the chi-square from observed and expected frequencies. If the H-L goodness-of-fit test statistic is <= 0.05, the null hypothesis that there is no difference between observed and model-predicted values of the dependent is rejected. If the H-L goodness-of-fit test statistic is > 0.05, we fail to reject the null hypothesis that there is no difference which implies a well-fitting model.

4.5.12 Interpretation of Logits

Logit coefficients (logits) which are the natural log of the odds are interpreted. Logits are used in binomial logistic regression equation to estimate the log odds that the dependent equals 1. When the dependent variable is dichotomous, then if the logistic coefficient for a given independent variable is b_i, a unit increase in the independent variable is associated with a b_i change in the *log odds* of the dependent variable.

The percent change in odds, $\frac{p}{1-p}$ is interpreted. If b_x is the logistic coefficient for independent variable x and the odds ratio e^{b_x} is z. When the independent variable x increases by one unit, the odds that the dependent variable = 1 increase by a factor of z, when all the other independent variables are controlled. Each additional unit of x increases the odds of being an adopter by about (z-1)*100 %, controlling for other variables in the model.

The change in log odds of the dependent variable is interpreted next. For a dichotomous dependent variable, if the logistic coefficient for a given independent variable is b_x, then a unit increase in the independent variable is associated with a b_x change in the log odds ($\ln \frac{p}{1-p}$) of the dependent variable.

4.5.13 Predictive Efficiency

Predictive efficiency which provides summary measures for classification tables is defined below.

$$\text{predictive efficiency} = \frac{\text{(errors without model) - (errors with model)}}{\text{(errors without model)}} \qquad (4.8)$$

where

errors without model is defined below,

errors with model is the number of cases misclassified when using the model

Equation (4.8) provides a basic form for indices of predictive efficiency. The predictive efficiency is a proportional change in error (PRE) formula. A positive value for predictive efficiency shows an improvement in prediction with the model.

The expected error without the model term for predictive efficiency in a classification model is

$$\text{errors without model} = \sum_{i=1}^{n} f_i \left[(N - f_i) / N \right] \qquad (4.9)$$

where N is the sample size,

f_i is the number of cases observed in category i

n is the number of categories

Lambda-p (λ_p), tau-p (τ_p) and phi-p (φ_p) which are indices of predictive efficiency are discussed next. These indices are used to show the percentage of improvement or otherwise when the model is applied rather than by random guessing or guessing based on the most frequent class.

lambda-p formula is given by

$$\lambda_p = \frac{f - e}{f} \qquad (4.10)$$

where

f = smallest row frequency

e = total number of observed errors

Lambda-p (λ_p) is a proportional reduction in error (PRE) measure like R^2 when it is positive. Lambda-p is an adjustment to classic lambda to assure that the coefficient will be positive when the model helps and negative when the model actually leads to worse predictions than simply guessing based on the most frequent class. The range of possible values for lambda-p with N cases is from 1 – N to 1.

Klecka's index is referred to as tau-p. A value of 1 for tau-p indicates that all cases are correctly classified. A negative value of tau-p indicates that the model performs worse than expected. Phi-p is a proportional change in error measure. Phi-p is equal to 1 when all cases are correctly predicted, otherwise phi-p is less than 1.

The normal approximation to the binomial test which is an analogue to the F test is used to test for statistical significance.

The binomial d statistic is given by

$$d = \frac{(P_e - p_e)}{\sqrt{P_e(1 - P_e)/N}} \qquad (4.11)$$

where

P_e = (errors without model)/N ,

p_e = (errors with model)/N ,

N = sample size

The P_e (errors without model) is defined differently for the binomial d statistic. It is the same as the smallest row frequency. The binomial d test is to determine whether the proportion predicted incorrectly with the model differs significantly from the proportion predicted incorrectly without the model.

4.5.14 Classification Rate

The accuracy of the classification rate can be determined through the statistical significance of the overall classification rate and the classification rate for each group. The test statistics z_g (Huberty, 1984) for assessing the statistical significance of the classification rate for any group is

$$Z_g^* = \frac{(o_g - e_g)\sqrt{n_g}}{\sqrt{e_g(n_g - e_g)}} \quad (4.12)$$

$$e_g = \frac{n_g^2}{n} \quad (4.13)$$

where

o_g is the number of correct classifications for group g,

e_g is the expected number of correct classifications due to chance for group g,

n_g is the number of observations in group g,

The test statistics z for assessing the statistical significance of the overall classification rate for the total sample is

$$Z^* = \frac{(o - n)\sqrt{n}}{\sqrt{e(n - e)}} \quad (4.14)$$

$$e = \frac{1}{n}\sum_{g=1}^{G} n_g^2 \quad (4.15)$$

where

o is the total number of correct classifications;

e is the expected number of correct classifications due to chance for the total sample and

n is the total number of observations

Huberty (1984) proposed the *I* index to measure improvement over classification due to chance.

$$I = \frac{o/n - e/n}{1 - e/n} x100 \qquad (4.16)$$

The *I* in the above equation gives the percent reduction in error (PRE) over chance classification that would result if a given classification method is used.