CHAPTER 3

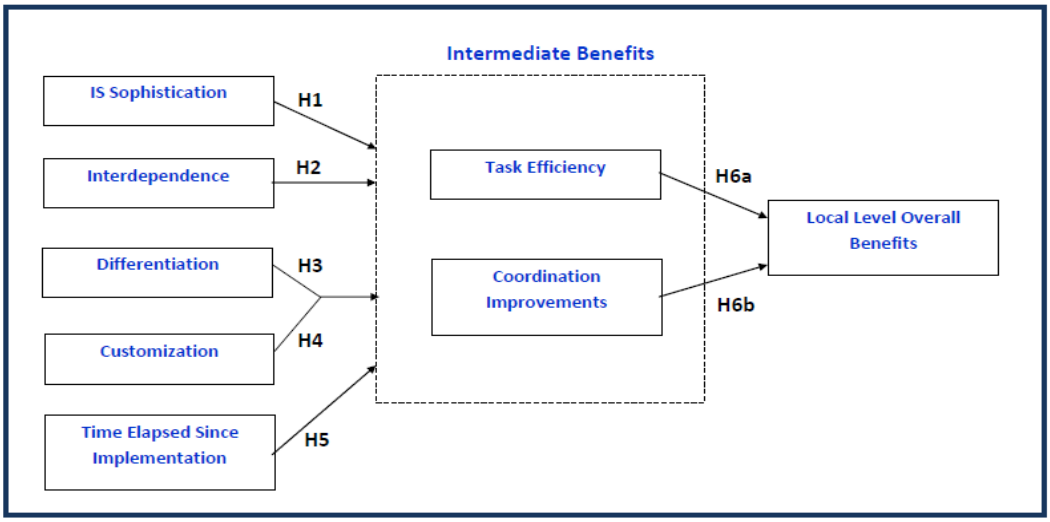
HYPOTHESES AND MEASUREMENT DEVELOPMENT

3.0 Introduction

This chapter discusses a number of empirically testable hypotheses from the research models developed in Chapter 2. The chapter begins with the development of hypotheses by describing the relationship between IS Sophistication, Interdependence, Differentiation on intermediate benefits and the relationships between intermediate benefits (i.e., Task Efficiency and Coordination Improvements) and the overall benefits. This chapter also describes the development and operationalisation of each of the constructs contained within the survey instrument.

3.1 Hypotheses Development

Figure 3.1. Research Propositions



Based on the foregone discussion of the research model the following hypotheses were developed.

3.1.1 IS Sophistication and Intermediate ERP Benefits

Several studies conducted by IS researches has found that IS Sophistication have positive impact on organizational performance (De Burca et al., 2006; Heine et al., 2003; Raymond and pare 1992). By proving that such relationship exists, the study can indicate how the different dimensions of IS sophistication affect different dimensions of performance measurement at the local plant level. This study devised a research proposition by adapting the scales for IS Sophistication developed and rigorously validated by Raymond and Pare (1992).

H1a	In a plant/department within an ERP implementation, the greater the IS Sophistication of one plant with other plants/departments in the organization, the greater the ERP related task efficiency accrued by that plant/department.
H1b	In a plant/department within an ERP implementation, the greater the IS Sophistication of one plant with other plants/departments in the organization, the greater the ERP related coordination improvements accrued by that plant/department.

3.1.2 Interdependence and Intermediate ERP Benefits

Goodhue et al (1992) has proposed this perspective in his studies with the following proposition:

"***All other things being equal, as the interdependence between subunits increase the benefits of data integration will increase and the amount of data integration in rational organization should also increase.***"

This is a two-part proposition. Wybo and Goodhue (1995) investigate the second half of the proposition (e.g. the greater the interdependence should lead to greater data integration) with the assumption that the first half was correct. However, in their initial study, they found no significant relationship. To apply this issue to ERP, Thomas F. Gattiker and Goodhue (2002, 2005) conduct several studies explicitly testing the first half of Goodhue et al. (1992) proposition in order to find out the validity of the proposition. In this study, we will adopt the proposition suggested by Thomas F. Gattiker and Goodhue (2005).

H2a	In a plant/department within an ERP implementation, the greater the interdependence of one plant with other plants/departments in the organization, the greater the ERP related task efficiency accrued by that plant/department.
H2b	In a plant/department within an ERP implementation, the greater the interdependence of one plant with other plants/departments in the organization, the greater the ERP related coordination improvements accrued by that plant/department.

3.1.3 Differentiation and Intermediate ERP Benefits

In this study, we will adopt the proposition suggested by Thomas F. Gattiker and Goodhue (2005). In general, when differentiation (product and market-related differences) between plants is greater, it is less likely that a system that standardizes data and processes among plants will meet all plants' needs equally well. Thus, differentiation moderates the degree to which benefits from implementing an ERP are realized

H3a	In a plant/department within an ERP implementation, the greater the differentiation of one plant with other plants/departments in the organization, the lower the ERP related task efficiency accrued by that plant/department.
H3b	In a plant/department within an ERP implementation, the greater the differentiation of one plant with other plants/departments in the organization, the lower the ERP related coordination improvements accrued by that plant/department.

3.1.4 ERP Intermediate Benefits and Overall Benefits at the Local Level

We adopt Gattiker and Goodhue by choosing sub unit (plant level) as our level of analysis in order to understand the intermediate variable (interdependence and differentiation) at functional level. The benefit of ERP will impact both local and global. There are 3 important intermediate benefits through which ERP could deliver overall plant level benefits to firms:

- Better Information (Data Quality)

- More efficient internal Business Processes (Task Efficiency)
- Better coordination between different units of the firm (Coordination Improvements)

In this study, we will focus on the Task Efficiency and Coordination Improvements intermediate benefits.

H6a	In a plant/department within an ERP implementation, greater task efficiency is associated with greater local (plant) level overall benefits from ERP.
H6b	In a plant/department within an ERP implementation, greater improvements in coordination with other subunits are associated with greater local (plant) level overall benefits from ERP.

3.2 Development of Measurement

We have listed and searched literatures mainly from international journals that reflect the topic of the study. A comprehensive review of the above literature was the basis for assuring the content validity of the instrument used in this

3.2.1 IS Sophistication

The intensive progress of IT Hardware and software since the mid-1990 has resulted in computer-based tools for formal and informal communications being now available and accessible widely to all the industries.

IT Sophistication was derived from the Nolan's "Stages of EDP Growth" theory used to evaluate computer activity and the degree of IT maturation over time.

Norlan (1973) was among the first who attempted to characterize IT Sophistication. Norlan identified four stages of growth (Initiation, Expansion, Formalization and Maturity). In Norlan's Model, the notion of IS Maturity is closely related to the organizational information system. It represents the growth from early stages when the computers is used to meet the basic organizational needs to the later stages and the computer-based applications are fully integrated.

Nolan's Stage theory has been used in many studies as theoretical foundation, which includes the criteria or benchmark variables approached from the two distinct perspectives of IS usage and IS management. The measures of IT sophistication were developed from Norlan's Growth model in business firms.

Recently, many researches has been conducted to investigate the different criteria of IS maturity and IT Sophistication. Among others, Cheney and Dickson (1982) investigated the relationship between "Technological" sophistication, "Organizational" sophistication and System Performance. Technological sophistication reflects the diversity of Information Technology used by firm in various domains in the form software application, development tools, hardware appliances and the nature of software and hardware application (Lehman, 1985; Cheney and Dickson, 1982). Organizational sophistication reflects the information resources for management activities. Further studies conducted by Raymond and Pare (1992), Jaana M, Ward MM, Pare G, et al (2005) define IT sophistication as a multi-dimensional construct. 2Raymond and Pare (1992) define IT sophistication as a construct which refers to the nature, complexity and interdependence of IT usage and management in an organization. The concept integrates not only the aspects related to IT usage (i.e. technological and informational) but also IT management (i.e. functional and managerial).

Technological sophistication reflects the number or diversity of IT used. Informational context is characterized by the nature of its application portfolio. Functional dimension relates to the structural aspects of the IS Function and IT Implementation process and Managerial dimension of IT Sophistication relates to the mechanisms employed to plan, control and evaluate present and future applications. Three major dimensions of sophistication have been conceptualized: Extent of use of IS; Intensity of use of IS and IS Integration.

Table 3.1. IS Sophistication Constructs Development

Original Dimensions	Criterion Variable	Empirical Support	Adapted instrument (Louis Raymund and Guy Pare, 1992 Noor Akma Mohamad Salleh, 2009)
IS Sophistication			
Technological	• Variety of IT used • Hardware Characteristics • Development tools • Man-machine interface • Processing mode • Type of operation	Lehman (1985) Lehman (1985) Saunders & Keller (1983) Ein-Dor & Segev (1982) Cheney & Dickson (1982) Lehman (1985) Cheney & Dickson (1982) Lehman (1985) Raymond (1988) Lehman (1985) Tuner (1981) Raymond (1988) Saunders & Keller (1983)	Extend of use : • Inventory department • Procurement • Shipping/Distribution • HR System • Marketing and Sales • Account Payable • Account Receivable • Firm Supply Chain Intensity of Use • Enterprise data maintained within database management system • Application developed by our own staff is using fourth generation languages • Microcomputers linked by LANs • Documents maintained using imaging technologies • Business transaction conducted with supplier/customers using EDI
Informational	• Application Portfolio • Integration of applications	Raymond (1988) Mahmood & Becker (1985) Saunders & Keller (1983) Cheney & Dickson (1982) Eom-Dor & Segev (1982) Cheney & Dickson (1982)	Integration : • Data can be shared easily among various internal systems (eg. Finance, Accounting, Purchasing) • Order changes are automatically reflected in downstream processes or systems • Our system can easily transmit, integrate and process data from suppliers and customers • Our systems allow continuous monitoring of order status at various stages in the process • Employees can easily retrieve information from various databases for decision support (e.g., cost information, reporting tools) • All product-related information is available on line (e.g., catalog, product description, detail specification, price, discount, etc) • Customers can customize their orders online without phone / fax or face-to-face interactions

3.2.2 Interdependence

The early OIPT theorists (Galbraith, 1973; Thompson, 1967) focused on the firm uncertainty at the company level. Tushman and Nadler (1978) moved the focus to subunit level. According to OIPT Organization information processing theory (Galbraith, 1973; Thompson, 1967; Tushman and Nadler, 1978), risk arises in organization due to uncertainties. The organization copes with such uncertainties in two ways. The first is where buffer is built in to cope with such uncertainties. An example is excess capacity in production floor to cater for a surge of demand of products during Christmas season. The second is to improve information sharing within departments in an organization thus reducing uncertainties. The organizational information processing theory explains how an organization is structured to cope with uncertainties. In brief, based on Tushman and Nadler (1978) OIPT theory, organizations can be view as a sub unit or departments. Over time, each of the sub units evolves and differentiates itself by its respective specialization, taking advantages of economies of scale at the same time; the sub units are interdependent in terms of sharing the same pool of scares resources. Thus, organizations must resolve uncertainty not only at the company level but must also focus at the subunit level.

Interdependence is the degree to which sub-units must exchange information or material in order to complete their tasks (J.E. McCann, D.L. Ferry, 1979). ERP systems can be viewed as one of the Information Processing mechanism that can help firm to fit the particular uncertainties. According to D.P. Cooke and W.J. Peterson (1998), one of the main reasons many firms have implemented ERP is due its ability in managing interdependence and improving the flow of information across sub-units. ERP is able to facilitate the process of exchanging information and materials between sub-units. Hence, improve the coordination between one sub-unit and others in the business. However, the degree of the benefits is varying among organizations and even among sub-units because the inter-dependence varies among them. Tushman and Nadler (1978) suggest that the impact of the integrative coordination mechanism on a sub-unit, such as a plant, may depend on the level of interdependence between that plant and other plants in the organization. When interdependence is low, simple coordination modes is sufficient. By contrast, high interdependence increases the need for a common formalized language in order to enable the exchange of information among sub-units (J.D. Thompson, 1967). In addition to improving coordination, ERP is more likely to enhance task efficiency. When interdependence is high, it provides instant access to information, making employees more efficient. By contrast, without the integrated systems, interdependence subunits need to resort to relatively time consuming methods of sharing information with one another (Email, Fax, telephone).

Table 3.2. Interdependence Constructs Development

Original Dimensions	Criterion Variable	Empirical Support	Adapted instrument (Gattiker and Goodhue, 2005)
Interdependence			
Inter-dependence	• Level of interdependence among subdivisions	Galbraith (1973) Thompson (1976) Tushman and Nadler (1978)	• To be successful, this plant must be in constant contact with these other plants • If this plant's communication links to these other plants were disrupted things would quickly get very difficult • Close coordination with these other plants is essential for this plant to successfully do its job • Information provided by these other plants is critical to the performance of this plant • This plant works independently of these other plants • The actions or decisions of these other plants have important implications for the operations of this plant.

3.2.3 Differentiation

Daveport (1998) stated that ERP systems tend to impose standard processes and data on organizations and on the plants in those organizations. Upon the ERP software selection, company will try to identify the software vendor that can meet the needs of the overall company and its plants. Once company have chosen a particular ERP vendor and system, the implementation team will try to define and design the standard processes and data definitions in order to meet the needs of the overall company and its plants. Many companies may consider this type of intra-company consistency is beneficial to the company and its subunits (Cooke and Peterson 1998; Kumar et al. 2002; Mabert et al. 2000).

However, according to Tushman and Nadler (1978) when a subunit's local task characteristics or its local external environment is different from other organizational subunits this unit may cause some problems as that certain unit might need a unique and non-standard systems which does not comply with other units. On the other hand, OIPT predicts that the costs of a standardized system, such as ERP, increases in proportion to the degree of subunit differentiation, which is the uniqueness of tasks, technologies, environment, goals, etc. across subunits (P.R. Lawrence and J.W. Lorsch, 1986).

Manufacturing plants often exhibit high differentiation level. Thus, it is consider as a good domain for studying the impact of differentiation on ERP implementation. The manufacturing strategy literature provides several very similar frameworks for characterizing plants and thus for comparing them in order to assess differentiation among them (R. Hayes, S. Wheelwright, 1979; T. Hill, 2000). According to their study, plants within an organization often have a significant and noticeable differentiation in products produced, technologies employed, and markets served. These characteristics include volume and standardization of outputs. The manufacturing technologies (e.g. general purpose versus specialized level of automation) that plants employ internally should be consistent with these output characteristics. Furthermore, W.L. Berry, T. Hill (1992) suggest that, in order to be successful, manufacturers must match these characteristics with the configuration of their computerized planning and control systems, including ERP. For example, job and batch approaches require features like detailed order tracking, while these features impede productivity for repetitive and process manufacturers. This line of thinking has strong implications for ERP. A particular ERP implementation imposes a particular set of computerized planning and control system characteristics (configuration decisions that are made when implementing ERP modules like material requirements planning, master scheduling and purchasing) on a manufacturing plant. This configuration is usually determined at the divisional or company-wide level. Thus a particular ERP configuration may be a good fit for the majority of plants in a company but may be a bad fit for one plant (or a few plants) that differs substantially from the others. Moreover, the current literature on ERP shows that there is a possibility that a low level match or fit may exist between ERP and individual plant's business conditions. When the particular ERP seller is chosen by the organization, the system should be configured according to the overall corporate needs. This may only happen if the organization has defined the standard processes, and data definitions to meet the overall needs of the company and its plants. Relevantly when most of the plants of the organization share the same processes and one plant is very different from others, that certain plant might face difficulty as ERP gives little room for flexibility. For example, a high-volume repetitive manufacturing plant that was part of an ERP implementation in a division that mostly consists of job shops. The ERP system apparently was configured mainly to fit the needs of the job shops. Using the system created substantial operational problems for the "oddball" plant (Gattiker 2002).

When an ERP system does not match a plant's unique business processes, making do might compromise performance. Or plant personnel might revert to informal, nonintegrated systems that meet local needs but do not facilitate coordination beyond plant boundaries (Gattiker and Goodhue 2004; Soh et al. 2000). Either way there is a performance drop. Such misalignments are a serious problem (Berry and Hill 1992). Sia and Soh (2002) categorize ERP misfits as: *surface* (having to do with user interface and the like) or *deep structure* (fundamental misfit between the model/package and reality) and as pervasive (exogenous, stemming from external sources) or non-pervasive Misfits that are both deep-structure and pervasive are the most problematic. Clearly many misfits between an ERP configuration and a manufacturing facility are deep structure misfits because they deal with fundamental processes (i.e., physical transformation processes). Furthermore, many are pervasive because many plant-level business processes are tied to the products and markets for which the plant is responsible and these are determined by company-level strategy (Berry et al. 1991; Miller 1981). Not all misfits are deep structure and pervasive. Certainly some intra-company process differences result merely from managerial preferences or divergent evolutionary drifts (for example, there are rarely fundamental grounds for two plants to use inconsistent part numbering systems). In order to make our focus on deep structure and pervasive misfits clear, let us define *differentiation* as between-plant differences that are related to products produced and markets served.

Table 3.3. Differentiation Constructs Development

Original Dimensions	Criterion Variable	Empirical Support	Adapted instrument (Gattiker and Goodhue, 2005)
Differentiation			
Differentiation	• Individual Subunit's local task characteristic • Unique, nonstandard systems at individual subunit • Level of Fit between and ERP and individual subunits	Tushman and Nadler (1978) Tushman and Nadler (1978) Somers and Nelson (2003) Gattiker and Goodhue (2002) Jacobs and Bendoly (2003)	• Volume : Number of units produced monthly per model or configuration or formulation (item dropped) • Variety : The number of different model numbers, configurations or formulations produced • Part Number Complexity : The number of different active part numbers or material code numbers, excluding finished goods part numbers or finished goods code numbers • BOM Complexity : Number of levels in the typical bill of materials • Postponement Strategy : The degree to which products are made to customer specifications, instead of to stock • Design Stability : The average number of design changes per month • NPI's : The number of new design introductions per month • Mfg. Cycle Time : The average amount of time that passes between the time an order is put into production and the time it is completed • Lot Control : The need to identify or segregate material by individual piece or lot rather than merely by part number • Dominant Technology: Amount of production activity dedicated to processing (blending, purifying, converting, etc.) as opposed to assembly or fabrication.

3.2.4 Intermediate Benefits of ERP

Most of the ERP study focuses on a macro view (overall firm level analysis and overall benefit). In order to have a thorough understanding, Barua and others proposed to dwell deeper, to a more detailed microscopic level of analysis which means to change the level of analysis from firm level to functional level. Barua and others says that a better understanding of success and failure of ERP implementation can be obtained via sub unit analysis. He argues that much of the study or ERP implementation is loss when we take a macro view (i.e. organization as a unit of analysis).

By taking a departmental view, we can scrutinize factors such as

(1) characterize the role of different departments

(2) understands the importance (weightage) of the department in achieving firm's objective

(3) understands the interdependence (relationship) between departments

(4) understand the characteristics of different departments

What this means is that when we study the implementation of ERP, we would study the impact that ERP bring towards these factors. On the other hand, by drilling down to such level of analysis, it is inevitable that there might be certain bias and degradation of reliability of data as it would requires a general manager (that understands an overview of the whole organization) or at least an operation manager to provide us such information. It is chosen that the level of analysis would be the overall individual sub units in the organization.

For a model to support the functional level analysis, Barua also proposed to have an intermediate benefit variable that arises from the results of functional level analysis. The overall intermediate benefit would add-up to the firm's aggregate benefits. Example of Functional Level Benefits: ERP provides a systematic and consistent manner of storing and retrieving data and managing work flow thus improving the quality of work.

Example of Firm's Aggregate Benefits: Due to the systemic method way of work on the local level, local benefit contributes substantially towards global benefit.

The model recommended by Barua provides us an understanding of the intricacy of how ERP benefits certain firm more than the other as it affects different function differently. For an example, a software development firm implements the rule for programmer to document their work (as analogous to implementing ERP system). For the programmers, it would seem that their work load has increases (negative benefit) but for the end product, it would see a dramatic improvement in terms of product quality, reliability, company image (intermediate benefits) and thus profit (overall benefit). For an ERP system to be effective (long lasting transformational effect) to a firm, it must affect more on the firm's core business activities rather than its none-core activities. For example, a contract manufacturer firm with an ERP system would benefit the firm more if it largely improves and streamline on its operational activities rather than its HRM (human resource management) activities (Barua et al., 1995). As the focus of this research is on manufacturing, we would focus on manufacturing's core activities such as manpower, machinery, scheduling and material planning (Vollmann et al., 1992). Based on OIPT organization information processing theory (Tushman and Nadler, 1978), organizations can be viewed as a sub unit or departments. Over time, each of the sub units evolves and differentiates itself by its respective specialization, taking advantages of economies of scale at the same time; the sub units are interdependent in terms of sharing the same pool of scarce resources.

3.2.5 ERP Overall Benefits

It is important to determine the ERP benefits because it provides firms with the basis and guideline on how ERP system will resolve their operational issues. Firms can use this information as a basis for the alignment on the business needs and what ERP system can do. The overall local (plant) level ERP benefit is the ultimate dependent variable in this study and is defined as the overall business impact of ERP on that plant or branch. Our model proposes that the overall benefits at the plant level will come substantially through the intermediate benefits of task efficiency and coordination improvements.

3.2.6 Customization

ERP systems are large complex modular enterprise systems or ultimately ERP systems are packaged software. As described by Gross and Ginzberg (Gross and Ginzberg, 1984), the issue with packaged software is the uncertainty about package modification time and cost, vender viability, and the ability of the package to meet the user needs. Changing packaged software to meet user needs is the essence of customization. This is also supported by study on ERP systems conducted Devenport (1998) wherewith business processes must be changed or the ERP system has to change when there is a misfit between the organization and the packaged software. When Organizations recognizes that the process options within its ERP system are not well aligned with the business process it desires, the organization has a variety of options which are detailed in Table 3.4.

Table 3.4. ERP Misfit Resolution Strategies (adapted C. Soh at el., 2000)

	ERP Misfit Resolution Strategies
1	Adapt to the new functionality in ERP (adopting the new operating processes embedded in ERP)
2	Accept shortfall in ERP functionality (compromising on the requirements of the organization)
3	Workarounds to provide the needed functionality without touching the ERP scripts
	• Manual (“by hand” rather than using a computer system)
	• ERP alternative (finding an alternative way to perform the function with the package
4	Customization to achieve the required functionality
	• Non-core customization (interfacing with add-on module or through query/report writer

According to the insight from Lucas et al (Lucas, 1998), it is either the organization has to change its procedures, compromise on processing needs satisfied, or modify the package to fit into the organization needs. In general, options 1 through 3 refer to adoption of the systems approach according to the software requirements. This means, the firm will change their existing operation procedures and workflow in accordance to the system nature and best practices. It can be carried out at the discretion of the plant, but may entail costs associated with "making do" with a suboptimal process and/or sacrificing some of the potential functionality of the ERP (Soh et al. 2000). Options 4 refers to the changes to the system and make it fit to the operational and functional needs. This option is typically requires global-level authorization and resources (e.g., endorsement from the company's IS management, programming expertise from the company's IS department) because this approach entails customization to the ERP itself. Customization (option 4 in the table) may be a response to a lack of fit between the organization's business processes and those envisioned by the ERP package designers. Customization could potentially also be used to bring the ERP into line with the requirements of a nonstandard plant. Customization may, therefore, be an effective strategy for dealing with the unique needs of the extremely different plants discussed in the previous section (Soh et al. 2000; Goodhue, 2005). Since we have a theoretical interest in differentiation, our model needs to include customization as the control variable.

3.2.7 Time Elapsed Since ERP Implementation

Throughout the pass researches, there are several relevant theories and process models suggest that ERP impacts on the organization may improve with time (Markus and Tanis 1999; McAfee 2002; Ross and Vitale 2000). According to a survey conducted by CIO Magazine (CosgroveWare 2003), it revealed that most companies that have implemented ERP do not achieve the anticipated benefits after one year. However, the majorities do realize and reap the benefits in subsequence year. Thus, Rose and Vitale, (2000) suggest that, generally it appears that companies and its subunits might not experience the expected performance improvement and yet may experience a performance dip initially after implementation. Instead, the performance improves thereafter. We expect this improvement to apply to both of local intermediate benefits: Coordination Improvements and Task Efficiency. Although time elapsed does not relate directly to our OIPT theoretical framework, it is an important control variable.