The Impact of Electronic Data Interchange Implementation with Business Process Reengineering

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A Thesis
In
The Faculty
Of
Commerce and Administration

Presented in Partial Fulfillment of the Requirements
For the Degree of Master of Science in Administration at
Concordia University
Montreal, Quebec, Canada

June 1998

0-612-39468-9

ABSTRACT

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The employment of electronic data interchange (EDI) is growing increasingly quickly and is expanding internationally, since certain types of benefits are expected from the adoption of EDI. However, it is found that not all companies can obtain all the benefits as expected. Some studies suggested that EDI should be implemented with business process reengineering (BPR) in order to gain the full potential benefits. In view of that, the research is proposed to better understand how the ways of EDI implementation will affect the benefits gained, so as to reduce the risk of EDI adoption. Specifically, this research combines qualitative case analysis methods with process modeling techniques to study the relationship between EDI and BPR. Case analysis is used to examine EDI implementation (e.g., motivation, approach, and level of integration) and its subsequent effects. Process modeling (mapping & simulation), on the other hand, is used to study the potential effects of BPR.

ACKNOWLEDGEMENTS

I am grateful to my supervisor, Dr. Mohamed Khalifa, for his guidance, expert advice, encouragement, and valuable contribution throughout the research.

I am likewise indebted to all the research participants for their valuable time and support in my research.

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INTRODUCTION

Information technology has dramatically affected the way we live and work. Everything is faster, more complex, global, and electronics driven. Especially in the business world, information technology is playing an important role. Organizations use IT as a strategic weapon rather than as a supporting tool only. As it can be learnt from the contemporary business and computer publications, electronic commerce (EC) is now a very popular concept in the business environment.

Electronic Data Interchange (EDI), the core of electronic commerce, has been growing quickly in recent years. Its fast growth is due to its high potential benefits to the adopters. There are operational and strategic benefits regarding the implementation of EDI (Massetti and Zmud, 1996). Operationally, EDI is used to reduce cycle time and costs in standard document exchanges. Strategically, EDI has enabled some organizations to shape their new ways of doing business. Although there are high potential benefits from the adoption of EDI, the efforts progress slowly in U.S. firms (Eckerson, 1990) and the expansion of EDI is not as rapid as expected (Sokol, 1995). Companies found that they do not necessarily gain a competitive edge from the adoption of EDI (Sokol, 1995). EDI is not a panacea, after all. Although some successful examples of EDI applications could be found, only minimal benefits could be gained from EDI if not used properly (Clark and Stoddard, 1996; Lummus, 1997). Venkatraman (1994) pointed out that the benefits from IT deployment are marginal if only superimposed on existing organizational conditions. It has been noted that the adoption of EDI with some kind of business process rearrangement could bring significant benefits to companies (Clark and Stoddard, 1996;

Iacovou et al., 1995; Lummus, 1997; Riggins and Mukhopadhyay, 1994; Short and Venkatraman, 1992; Sokol, 1995; Venkatraman, 1994; Vlosky et al., 1994). Recently, EDI has been regarded as a pivotal technology for business process reengineering (BPR) (Massetti and Zmud, 1996).

This research examines cases of EDI implementation to shed some light on the potential effects of the integration of EDI with business processes. It is believed that different results could be reached depending on the level of integration and reengineering performed in the implementation of EDI.

Specifically, this research combines qualitative case analysis methods with process modeling techniques to study the relationship between EDI and BPR. Case analysis is used to examine EDI implementation (e.g., motivation, approach, and level of integration) and its subsequent effects. Process modeling (mapping & simulation), on the other hand, is used to study the potential effects of BPR.

This study's main objectives include the following:

- To better understand the relationship between BPR and EDI implementation
- To examine how process mapping and simulation techniques can help to evaluate and improve EDI implementation
- To develop some guidelines for EDI implementation

EDI IN THE BUSINESS WORLD

WHAT IS EDI?

Electronic data interchange is the intercompany computer-to-computer communication of standard business transactions in a standard format that permits the receiver to perform the intended transaction (Sokol, 1995). It is important to note that there are four characteristics of EDI: intercompany, computer-to-computer, standard business transactions, and standard format. Without any one of the four characteristics, any data exchange between companies would not be classified as EDI. The four characteristics are described as follows:

Table 1 – Four characteristics of EDI (Sokol, 1995)

Characteristics	Descriptions
Intercompany	It refers to the electronic data transmission between companies. Actually, EDI is a particular type of electronic commerce. It deals with business-to-business transactions rather than business-to-consumer ones. Although some big companies implement EDI by direct connections, most of the EDI adopters accomplish it through a third-party service provider or value-added network (VAN).
Computer-to-computer	The most basic form of EDI is to transmit data from computer to computer with human intervention at each end, the sender key-entering data and the receiver printing it. But this type of EDI provides little benefit. The goal in EDI surpasses simply transmitting data between companies and is to provide the link between sender and receiver business applications with no human intervention at the receiving end. In other words, the data are to be fed into the receiver's computer application automatically.
Standard business transactions	EDI is not used to transmit free-form messages. Its transactions are to replace printed business forms, which are designed for the receiver to perform day-to-day transactions such as to process an order or to bill a customer.
Standard format	The data transmitted through EDI must be in predefined format in order to be fed into the receiving computer application automatically. There are company-specific, industry-specific, and international standards.

THE USE OF EDI

The use of EDI has been expanding. The number of registered EDI users in U.S. went from 21,000 in 1991 to 37,000 in 1993, as reported by Data Interchange Standards Association, Inc. (DISA) (Kappelman et al., 1995). In 1996, there were about 100,000 firms using EDI in U.S. and 5,000 in Canada as reported by Electronic Commerce Institute (formerly EDI Institute of Quebec) (Anonymous, 1998). Internationally, some governments are aggressively motivating and pushing the adoption of EDI. For example, Singapore launched TradeNet in 1989 as the first nationwide EDI, which links public-sector agencies related to international trade, traders, intermediaries (e.g. freight forwarders), financial institutions, and port and airport authorities (Teo et al., 1997). By the end of 1994, almost 99 percent of all trade declaration documents handled by the Trade Development Board of Singapore Government had been processed by TradeNet. Another example is Australian Custom Service who also reports extensive use of EDI to communicate with European and other countries (Kappelman et al., 1995).

EDI is widely employed because of certain advantages expected. According to Sokol (1995), two types of benefits are available from EDI: direct and indirect. Direct benefits refer to the immediate results of implementing EDI. For example, companies can cut costs on salaries for data entry by receiving EDI purchase orders from customers. Indirect benefits, however, are realized in a long-term basis; and usually are gained by combining EDI with business process reengineering. For example, the timely information contributes to better decision making. Yet, it may take a longer time for a company to rework and adjust the connected computer programs before they can "cooperate" well with the incoming EDI messages. Generally, companies expect the following benefits from EDI:

- Reduced costs for manual business transactions
- Increased speed in information exchange and processing
- Shrinking of the order-receipt-pay business cycle
- Improved trading partner relationships
- Improved intracompany flow of information

On the other hand, there are some difficulties for companies to implement EDI. Eckerson (1990) reported that EDI is faced with political and bureaucratic difficulties. Lack of top management support is the biggest hurdle to EDI (Jenkins and Lancashire, 1992). Top management tends to pay more attention to more immediate concerns, such as shareholder issues, labor troubles and hostile takeover attempts. Since the indirect benefits of EDI are achieved in the longer run, management may not recognize the urgency of implementing EDI. Moreover, the instantaneous results of EDI are usually not significant enough to arouse the top management interest.

High costs could be another barrier to EDI. The initial costs of implementation may be low, but the full implementation costs could be much higher than expected (Jenkins and Lancashire, 1992; Riggins and Mukhopadhyay, 1994). This is because the EDI initiators may need to educate their trading partners and to provide them with software in order to accomplish the EDI projects. These costs could add up quickly when multiple trading partners start to be involved in the implementation. In such a case, the cost justification of EDI could be difficult.

Furthermore, the integration of EDI with internal systems is usually a difficult and risky endeavor (Jenkins and Lancashire, 1992). In addition to redeveloping some of the internal application software, EDI integration also necessitates the rearrangement/reengineering of business procedures.

Successful and Unsuccessful EDI Implementation

Many companies implement electronic data interchange as part of their customer-supplier partnerships. Both customers and suppliers expect to gain operational and competitive benefits. However, not all of them could gain all the benefits they expected. Inconsistency can be found in the literature regarding the benefits of EDI and other similar interorganizational systems. Some studies proclaim cost savings and competitive advantages through the use of electronic data interchange, while others indicate little or no effect of these systems on organizational performance (Clark and Stoddard, 1996).

There are some success stories quoted in the literature. For example, Bedford Industries reported EDI benefits such as reduction or elimination of paper flow between trading partners, less administration in order processing, higher business volume with the same number of employees, more efficient production, and total customer satisfaction and a more competitive company (Snow, 1994). Also, the integration through EDI has benefited one of Bedford's retailer customers in the following ways:

- The retailer has improved customer satisfaction by achieving a first-time fill rate of more than 99 percent, up from the previous 54 percent.
- Excluding floor samples, merchandise inventory turns have increased to more than 200 a year from the previous four turns a year.
- The retailer has reduced its inventory carrying costs by CDN$1 million and freed up 200,000 sq. ft. of warehouse space.
- The retailer has also reaped savings by eliminating shrinkage, reducing the costs of handling product, reducing the costs of employee benefits, and eliminating the replenishment effort.

Some other success stories include GM Canada, Procter & Gamble Inc., Provigo Distribution Inc., and J. M. Schneider Inc. (Jenkins and Lancashire, 1992).

On the other hand, not-so-successful implementation of EDI can also be found. In the case study carried out by Lummus (1997), a midsize Midwestern supplier company received only minimal benefits from its EDI installation. There is an increased level of risk associated with Interorganizational Systems (IOS) as compared with traditional information systems projects, because IOS cross company boundaries and are not within the control span of IS managers. It results in limitations on how firms control costs and realize benefits from these systems. Sometimes, EDI managers are frustrated by their trading partners when implementing the pilot EDI projects (Riggins and Mukhopadhyay, 1994).

It is difficult to estimate the rate of success in implementing EDI, as unsuccessful implementation of EDI is usually not publicized. Companies are usually reluctant to tell their failure.

POSSIBLE EXPLANATIONS FOR THE INCONSISTENT RESULTS

It is believed that different impact is brought to the organizations with different ways/motivation of EDI implementation. Some authors (Sokol, 1995; Zack, 1994) contend that EDI is not just a technical project. While there is a technical component to it, EDI is predominately a business initiative and requires companies to change the way they currently conduct day-to-day business. That is to say, it is more likely to gain the anticipated benefits when EDI is integrated with the internal information systems. Many other authors have also noted that interorganizational connectivity via EDI must involve changes in internal business processes to realize the savings enabled by this technological innovation (Clark and Stoddard, 1996). The former director of EDI in Provigo, pointed out that "implementing EDI within your business increases its benefits, while the integration of EDI into the business process maximizes its benefits." (Jenkins and Lancashire, 1992).

Iacovou, Benbasat, and Dexter (1995) developed a model to identify major factors that influence the adoption and impact of EDI in the small business context. Impact refers to the actual benefits adopters receive from utilizing EDI. They argue that the integration level of EDI is positively related to the benefits that an adopter can receive given its EDI capability. In this context, EDI integration is the process during which a firm alters its business practices and applications so that they interface with its EDI applications. Two dimensions of integration are considered: internal and external. Internal integration refers to the variety of applications interconnected through EDI, and external integration refers to the number of EDI trading partners involved. Usually, non-integrated EDI systems will offer adopters limited direct benefits only, such as lower transaction costs and better cash flow. Integrated systems, on the other hand, will offer both high direct benefits and indirect benefits, such as increased operational efficiency, better customer service, improved trading partner relationships, and increased ability to compete. Lummus (1997) identified 6 stages regarding EDI implementation and suggested that benefits increase as the stage of EDI implementation increases. The framework is used in this study and will be described in more details in the "Methodology" section.

Clark and Stoddard (1996) provided qualitative and quantitative data to support the proposition that technological and process innovations are interdependent and that both are needed to capture the potential benefits of EDI implementation through interorganizational process redesign. Usually, it is found that buyers (initiators) are more proactive and suppliers (followers) are more reactive in EDI implementation (Vlosky et al., 1994). This is probably because the initiators are motivated to reengineer the business procedures for a higher integration. On the other hand, the followers are forced to adopt EDI by the initiators. They simply meet an initiator's requirement to exchange information with the old ways of doing business. Therefore, suppliers usually get minimum benefits. In addition, the followers may even hinder initiators' ability to realize benefits (Riggins and Mukhopadhyay, 1994). The reason is that followers will not participate actively in the new mode of business because of little benefits perceived. This in turn will affect the initiators' possible additional benefits gained from the reengineering of interorganizational business procedures, which requires efforts from both organizations.

In fact, companies are facing the same situation when utilizing any other information technology. IT-adopter organizations usually overestimate the contribution of IT projects. There is no proof that IT is improving productivity or other measures of business performance (Venkatraman, 1994). Venkatraman (1994) suggests that the benefits from IT deployment are marginal if only superimposed on existing organizational conditions, and successful businesses will not treat IT as either the driver or the magic bullet for providing distinctive strategic advantage. Rather, companies should treat IT as an enabler for business transformation (Short and Venkatraman, 1992; Venkatraman, 1994).

The fundamental error that most companies commit when they look at technology is to view it through the lens of their existing processes (Hammer and Champy, 1993). By computerizing the processes only, companies achieve feeble performance improvements. It is necessary for companies to use inductive thinking when applying new technology in order to gain dramatic positive results. Information technology is playing an enabling role for business process reengineering (BPR). Clark and Stoddard (1996) define BPR as the combination of technological and process innovation. An example of BPR enabled with EDI is the continuous replenishment (CRP) for grocery channels. The combination of EDI with channel process and policy changes enables a new form of channel structure and relationships leading to lower transaction costs and increased information sharing. EDI ordering alone does not represent a significant change in channel processes and will only reduce costs and errors, even if the EDI systems are integrated into the internal systems and processes of the EDI partners. EDI with CRP, on the other hand, involves a complete redesign of existing processes between retailers and manufacturers and will reduce inventories, transportation costs, and stockouts in the channel (Clark and Stoddard, 1996).

In the following section the relationship between BPR and EDI is discussed further.

THE RELATIONSHIP BETWEEN EDI AND BPR

Business process reengineering is formally defined as:

"*the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed*" (Hammer and Champy, 1993)

The core of BPR is discontinuous thinking – identifying and abandoning the outdated rules and fundamental assumptions that underlie current business operations. Companies could not gain satisfying results from heavy investments in information technology largely because they tend to use technology to mechanize old ways of doing business. They leave the existing processes intact and use computers simply to speed them up (Hammer, 1990). In fact, many of our job designs, work flows, control mechanisms, and organizational structures came from different competitive environment, before the advent of computers. Doing business the old way with advanced technology makes little contribution to the performance.

As mentioned in the previous section, companies should use EDI and BPR together to gain maximum benefits. EDI alone can only provide minimal benefits (Clark and Stoddard, 1996; Iacovou et al., 1995; Lummus, 1997; Riggins and Mukhopadhyay, 1994; Sokol, 1995; Venkatraman, 1994). "Automating existing processes with information technology is analogous to paving cow paths" (Hammer and Champy, 1993). Automation without reengineering results often times in doing the wrong kinds of things in a more efficient way.

Information Technology (IT) is the agent that enables the reengineering companies to break their old rules and to create new process models. IT acts as an enabler that allows organizations to do work in radically different ways (Hammer and Champy, 1993). In the context of business situations that offer excellent EDI opportunities, EDI can be an important element in the companies' reengineering efforts.

General Motors (GM) is an example of using IT as an enabler for BPR (Hammer and Champy, 1993). GM lets its component suppliers access the internal on-line manufacturing database. Without receiving purchase orders from GM, the suppliers deliver appropriate parts to the assembly plant by consulting the carmaker's production schedule. Nobody in GM has to instruct the vendor explicitly to send the parts. In that process, no purchase orders or invoices are transmitted. After the parts are shipped, the vendor sends an advanced shipment notice by EDI describing what parts are in the shipment. When goods arrive, the receiving clerk simply scans the bar code on the box and knows where to place the goods. The scanning also initiates payment to the vendor. In this case, the production schedule database and EDI are the information technology which has enabled GM and its suppliers to operate like a single company, to eliminate overhead in both organizations, and to break one of the oldest rules: Treat vendors as adversaries.

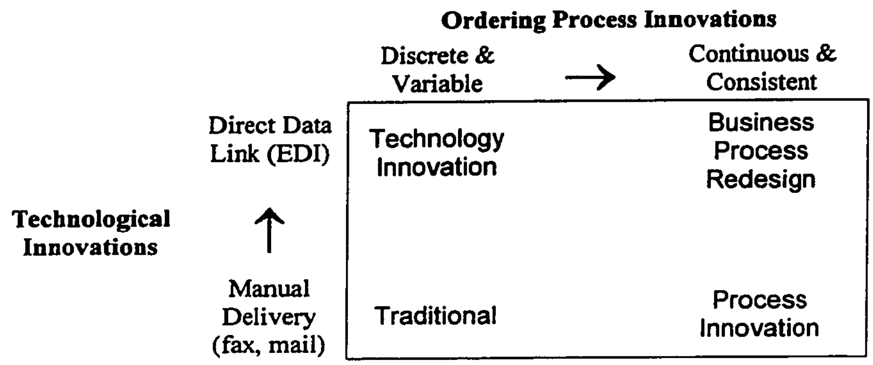
PREVIOUS RESEARCH

Some research has been conducted to study the impact of EDI implementation in relation to BPR.

Iacovou et al (1995) developed a model portraying the factors affecting EDI integration and adoption, and in turn the EDI impact, based on case studies. Variables in their research included capability to transact via EDI, internal and external integration, actual direct and indirect benefits received, awareness of direct and indirect benefits, financial and technological resources, and competitive pressure and imposition by partners. However, the relationship between EDI integration and EDI impact has not been empirically verified. The level of EDI integration was used as a surrogate measure to estimate the expected EDI impact.

Clark and Stoddard (1996) constructed a framework to examine the relationship between information technology and process innovations. Their targets of study were grocery channels. A model was developed to explain the inconsistency of EDI benefits in previous literature. Case studies with 2 large manufacturers and 2 large retailers were used. In addition, a survey was done to confirm the findings in the case studies. Their framework is shown below:

Figure 1 – Technological and Process Innovation Framework (Clark and Stoddard, 1996)



Lummus (1997) conducted a case study to see why a midsize Midwestern supplier received minimal benefits from EDI. The author found that only few changes occurred in the procedures within the company.

Riggins and Mukhopadhyay (1994) studied the relationship between the EDI benefits and the partner reengineering effort. They found that suppliers were usually reluctant to invest in business process redesign and thus hindered the buyers' ability to realize benefits. Two empirical studies were carried out and regression models were developed for the study. Reduction in cycle time and error rate are the dependent variables of the studies.

In the first empirical study, an automatic vending system in an electronic company was studied. The authors expected EDI would reduce the cycle time in the initiator company but not in the supplier companies. The major models used are as follows:

$$TOTINT = \alpha_0 + \beta_1 OPTION + \beta_2 OTHER + \beta_3 LNPRICE + \beta_4 CCODE1 + \ldots + \beta_{22} CCODE19 + \varepsilon;$$

$$SUPQ = \alpha_0 + \beta_1 OPTION + \beta_2 OTHER + \beta_3 LNPRICE + \beta_4 CCODE1 + \ldots + \beta_{22} CCODE19 + \varepsilon;$$

Where: TOTINT = total internal processing time

SUPQ = time spent in supplier's queue for the processing of "Request for purchase"

OPTION (indicator variable) = option existed to use automatic vending system?

OTHER (indicator variable) = historical price data or supplier is on the automatic vendor list?

LNPRICE = log of the value of the order

CCODE1, ..., CCODE19 = commodity codes

As expected, the authors found that OPTION (with a negative coefficient) was significant at $p<0.05$ level to TOTINT but not significant to SUPQ. It means the use of EDI in the form of an automatic vending system can shorten the internal cycle time only.

In the second empirical study, the receipt of advanced shipping notices (ASNs) by an automotive company was studied. The authors expected that there would be lower error rate in the ASNs sent by suppliers which have higher level of integration of EDI with their internal systems. Specifically, the statistical model used is as follows:

$$ERRMSG = \alpha_0 + \beta_1 MONTHS + \beta_2 VRSN + \beta_3 PCTAUTO + \beta_4 QCK + \beta_5 LNSLS + \beta_6 LVLINTGT + \varepsilon;$$

Where: ERRMSG = errors per ASN

MONTHS = number of months of experience with the ASN transaction set

VRSN (indicator variable) = newer version of the X.12 standard?

PCTAUTO = percentage of the supplier's sales to the automotive company

QCK (indicator variable) = designated as a "quick response" supplier?

LNSLS = log of supplier's recent annual sales

LVLINTGT(indicator variable) = supplier's EDI integrated with its internal systems?

The analysis result showed that LVLINTGT (with a negative coefficient) was significant at $p<0.1$ level, indicating that the suppliers who had integrated EDI systems with their internal information systems had lower error rate in their ASNs.

The previous work discussed above gave some indications of the role that BPR can play in reaping the benefits of EDI. More research is, however, needed to understand better the relationship between BPR and EDI. This research proposes to have a more in-depth study on the effect of the coupling of EDI with BPR, using process modeling techniques.

USE OF PROCESS MODELING IN BPR

Business process modeling is to create a model of a business enterprise (Anonymous, 1996, p. 20). It usually deals with different views of a company and can be applied in different areas (Scholz-Reiter and Stickel, 1996). For example, it can be used for quality management, strategic business planning, process cost analysis, or workflow management. There are also various tools and techniques (e.g. flowchart and simulation) available for business process modeling. In this research, process mapping and process simulation are selected as the tools for process modeling. They are used to analyze and redesign the target processes.

The concept of process mapping is to use workflow diagrams to describe every vital step in the business procedures (Hunt, 1996). It is important to remember that the objects of reengineering are processes, not organizations (Hammer and Champy, 1993). Process maps can assist in displaying a clear and comprehensive picture of the work within an organization. They also help people to think differently from the traditional way about the individual departments, which hinders the progressing of BPR. Process mapping can be used to identify the current "As-Is" business processes and provide a "To-Be" roadmap for BPR. By looking at the workflow diagrams, the non-value-added process activities can be located. In addition, it helps to recognize the redundant or duplicated resources spent in the system. As a result, a set of "To-Be" diagrams can be developed by removing those non-value-added activities, thereby lowering the process costs, such as resources consumed and cycle time.

Reengineering gurus have criticized traditional process analysis techniques for requiring volumes of data and for taking too long. A common pitfall is the temptation to over-analyze a process. The goal must be to understand the process and proceed quickly to redesign. Rapid modeling tools such as simulation software can be used to quickly capture and model existing processes and prepare them for the reengineering effort (Ardhaldjian and Fahner, 1994; Macarthur et al., 1994). Simulation is a tool that can provide both accurate analysis and visualization of alternatives.

BPR fundamentally deals with mapping and measuring business practices in order to have a better understanding facilitating in their redesign. Since simulation models are tools used to describe systems and their dynamic behavior in iterative ways, they should be more widely used in BPR efforts (Ardhaldjian and Fahner, 1994). Because simulation software keeps track of statistics about model elements, performance of a process can be evaluated by analyzing the model output data.

Some successful applications of simulation in BPR can be found. A manufacturer used a simulation tool to evaluate the effect of automation and kaizen in its plant (Lyu, 1996). Although the two approaches are quite different, the company could find a way to combine them for process reengineering. An optimum solution for improving the manufacturing process could then be obtained. Another telecommunication company used simulation for BPR to gain dramatic results on their service process (Lee et al., 1996). The company used the total average cycle time as a key performance measure. The results of the simulation provided important managerial guideline to the company.

The use of process mapping with simulation is particularly useful in this context. Some simulation tools provide animation capabilities that allow the process designer to see how work objects flow through the system. The dynamic properties are often of greatest interest to process improvement (Hunt, 1996). With simulation, process designers can have a relatively low-cost means to examine process improvement before substantial funds are invested in a new product or process improvement effort. In this research, CACI's SIMPROCESS is chosen as the tool for process mapping and simulation.

METHODOLOGY

In order to have an in-depth investigation of the effects of the integration of EDI with business processes, case studies will be used in this research.

CASE STUDIES

Case studies can provide in-depth information through the different data collection methods such as records, documents, and interviews, which are not usually included in other types of research (Whitley, 1996). Because of that, case studies can usually take into account the environmental, social, and historical factors while other research strategies cannot. According to Benbasat et al. (1987), there are three reasons why case study research is a viable research strategy, especially in the context of information systems research:

1) The researcher can study information systems in a natural setting, learn about the state of the art, and generate theories from practice.

2) The researcher can answer "how" and "why" questions because the case method allows to understand the nature and complexity of the processes taking place.

3) A case approach is an appropriate way to research a new area where there have been few previous studies. As the information systems field evolves rapidly, it is useful to gain insights for newly emerged topics.

The three reasons listed above can just state well why a case study strategy is suitable in this particular research:

1) The current study deals with business process reengineering. According to Hammer and Champy (1993), the implementation of reengineering is so complicated that it "goes beyond the scope of a single book" (p. 216). Therefore, a natural setting is needed for the investigator to reveal environmental, social and historical factors behind the theory.

2) As reengineering is a complex issue, case study method allows the researcher to understand how the reengineering is carried out in the organizations selected.

3) Although some researchers has suggested to use dynamic modeling to assess EDI investments (Streng and Sol, 1992), and some others has suggested to use simulation to evaluate alternatives in BPR (Ardhaldjian and Fahner, 1994; Giaglis and Paul, 1996; Lee and Elcan, 1996; Lyu, 1996; Macarthur et al., 1994), few previous studies were specifically on the topic that using process modeling to study the relationship between BPR and EDI implementation. This topic is rather new, thus case study method allows the researcher to gain insights into it.

Therefore, in this study, case studies are used to achieve the research objectives by:

- Comparing different ways of implementing EDI (as related to integration and BPR) and the subsequent impact, without losing sight of the environmental, social and historical factors
- Exploring factors influencing adoption and ways of implementation
- Analyzing the potential EDI benefits/drawbacks with the aid of process modeling based on the level of EDI integration.

PROCESS MAPPING AND SIMULATION

As described earlier, process mapping and simulation are useful in understanding the current processes as well as in assisting the development of better processes. Therefore, it is used in this study to:

- Assess the impact of EDI. (Because comparison between EDI transactions and manual transactions within the same company can be made.)
- Compare alternative implementation (with different levels of reengineering) to better understand the effects of coupling EDI with BPR.

SAMPLE

For practical reasons, the sample is chosen among the EDI adopter organizations with offices in Montreal. Facsimiles were sent to request for initial interviews with the IT or electronic commerce managers within the companies. Two companies were identified after the screening interviews, based on the characteristics of the companies, such as availability of data, EDI adoption motivation and extent of reengineering. They are selected to provide the basis of comparing the effects of EDI in different situations involving different levels of reengineering.

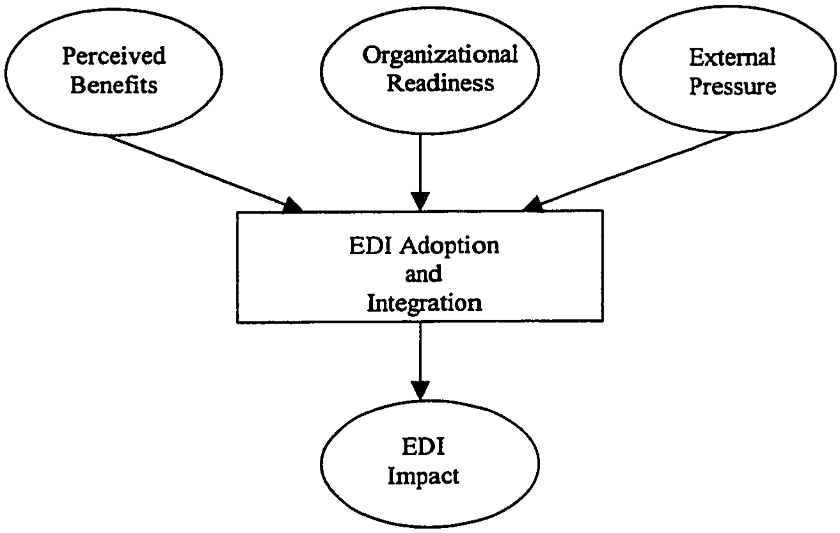
FRAMEWORKS

In order to classify the cases according to factors relevant to the objectives of the study, several frameworks validated in previous research are used.

A model of EDI adoption

Iacovou et al. (1995) developed a model to examine the factors affecting EDI adoption and integration, and in turn, the impact. The authors identified three factors affecting adoption/integration, as shown below:

Figure 2 – Proposed Small Business EDI Adoption Model (Iacovou et al., 1995)



Although this model was proposed for small businesses, the authors suggested to test it in the context of larger organizations in future research.

Perceived EDI benefits refer to the level of recognition of the relative advantage that EDI technology can provide the organization. The higher the level of recognition of the EDI advantage, the more resources the organizations are likely to allocate for EDI implementation.

Organizational readiness, according to the authors, refers to the level of financial and technological[1] resources of the firm. The availability of these resources affects the ability of the organization to implement and integrate EDI with the internal applications successfully.

External Pressure refers to influences from the organizational environment. This factor will affect the adoption of EDI only, according to the authors.

Unlike what Iacovou et al. (1995) did in their research, only EDI-adopters will be selected in the sample in this research, since the relationship between EDI integration and the corresponding impact is the main concern here. By using the case study strategy, the variables in the framework can be rated according to the information collected from various data collection methods. Later, with the aid of process modeling, further evaluation of the potential EDI impact will be studied by monitoring the simulation results. The independent variables and the dependent variables of the framework are summarized in the following table:

Table 2 – Summary of concepts and variables in the Iacovou et al. model (1995)

Concept	Variables	
Perceived Benefits	Awareness of direct benefits Awareness of indirect benefits	
Organizational Readiness	Financial resources Technological resources	(Independent)
External Pressure	Competitive pressure Imposition by partners	
EDI Integration	Internal integration External integration	(Dependent)

Scale of variables:
High / Low

[1] Technological resources include hardware, expertise and a competent project leader.

Measurement of the EDI usage

Massetti and Zmud (1996) proposed a scheme to measure the extent of EDI usage in complex organizations. The measurement provides a comprehensive context in which to conceptualize, understand, and measure EDI usage. The scheme consists of four facets of EDI usage:

Table 3 – The Four Facets of EDI Usage (Massetti and Zmud, 1996)

Facets	Definition
Volume	The extent to which a firm's document exchanges are handled through EDI connections.
Breadth	The extent to which a firm has developed EDI connections with each of its trading partners.
Diversity	The extent to which different types of a firm's business document are handled through EDI connections.
Depth	The extent to which a firm's business processes are intertwined with those of its trading partners through EDI connections.

The four facets described above can assist in assessment of the level of usage of EDI, as well as the level of internal and external integration. The measures of the four facets are listed in the following table:

Table 4 – Measures of EDI Usage (Massetti and Zmud, 1996)

Facet	Measures	Interpretations
Volume	% of organization's documents exchanged via EDI	Intensity of EDI activity within the organization
Breadth	% of organization's trading partners linked via EDI	Organization's openness to EDI relationships with partners
Diversity	Number of functions using EDI; Number of document types exchanged via EDI	Extent of electronic document integration and exchange within the organization
Depth	% of EDI linkages at each depth level*	Permeability of an organization's boundaries

* There are three depth levels according to the authors:

File-to-File – Documents are sent electronically but re-entry of data into receiver's software applications is needed.

Application-to-Application – Documents are automatically generated, sent, received, acknowledged, and processed by receiver's software applications. No re-entry of data is needed.

Coupled Work Environment – Computer-based applications of one, or both, trading partners can directly access data maintained within the computer-based systems of the other trading partner.

Lummus' six-stage of EDI implementation

Lummus (1997) identified 6 stages of EDI implementation and suggested that benefits increase as the company reaches the higher stage of implementation. The 6 stages are:

1) EDI is used with only one customer for a small number of transactions. Electronic documents are manually entered into other internal systems.
2) EDI is used with two or more customers for a small number of transactions.
3) EDI is integrated into other internal systems. No additional data entry is needed.
4) EDI is used with suppliers in addition to customers.
5) EDI is integrated with customers. Inquiry of a customer's database for information such as inventory status and shipments is obtainable.
6) EDI is integrated throughout the organization. EDI transactions could be found in all functions of the business organization such as quality control, engineering, manufacturing, marketing, and accounting.

This framework is used in this study to determine the stage of EDI implementation of the two cases.

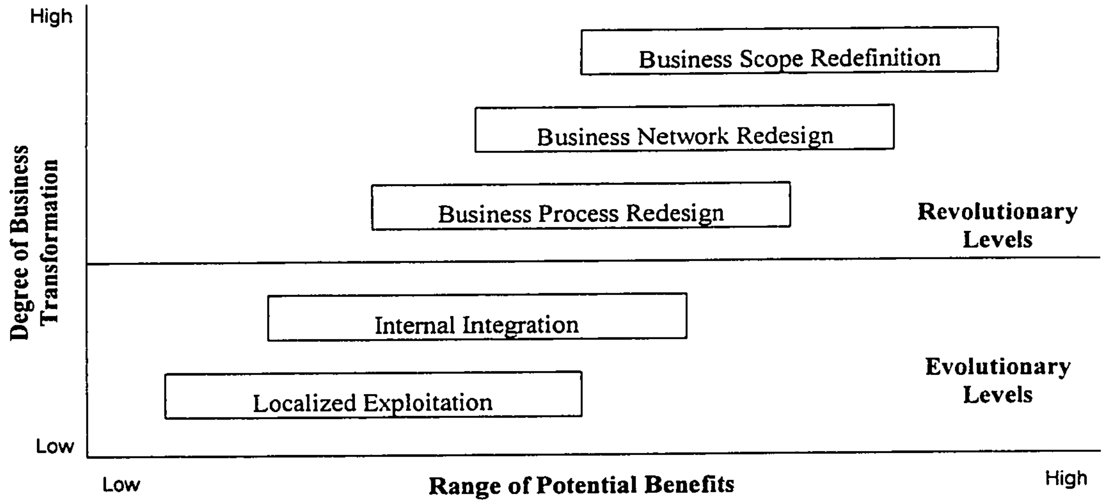
Venkatraman's five-level IT-enabled business transformation

Venkatraman (1994) suggested that limited benefits could be gained from IT deployment if only superimposed on existing organizational conditions. Changes in the way of doing business are required for achieving potential benefits. He then classified the level of organizational transformation into five levels. The higher the level of transformation an organization can go, the greater the benefits it can obtain. The five levels and the respective range of potential benefits are shown in the following table and figure.

Table 5 – Five Levels of IT-Enabled Business Transformation (Venkatraman, 1994)

Level	Description	Distinctive Characteristics
Localized exploitation	Localized exploitation of technology to existing business processes	Leveraging of IT functionality to redesign focused, high-value areas of business operations
Internal integration	Internal integration of IT capabilities across an entire existing business process	Leveraging of IT capability to create a seamless organizational process – reflecting both technical interconnectivity and organizational interdependence
Business process redesign	Use of IT as a lever for designing an organization's core business process	Redesigning the key processes to derive organizational capabilities for competing in the future as opposed to simply rectifying current weaknesses; use IT capability as an enabler for future organizational capability
Business network redesign	Exploitation of IT to redesign process extending beyond one organization to a network of organizations	Articulating the strategic logic to leverage related participants in the business network to provide products and services in the market-place; exploiting IT functionality for learning from the extended network as well as for coordination and control
Business scope redefinition	Use of IT to redefine the organization's business scope	Redefining the corporate scope (e.g., what's done inside the firm, what's obtained through special partnerships and related arrangements, etc.) that is enabled and facilitated by IT functionality

Figure 3 – Potential Benefits of the Five Levels Transformation (Venkatraman, 1994)



Since the current research is to study the impact of EDI integration with business processes, the framework above can be used to classify the organizations in the current level of EDI integration with business processes and to see what further transformation can be made in order to obtain possible greater benefits.

DATA COLLECTION

Multiple data collection methods are used in this research. The use of triangulation can increase the reliability of the research (Benbasat et al., 1987; Whitley, 1996). Three sources of qualitative data are used: interviews, site observations, and documentation. For quantitative data, process mapping/simulation will be used to evaluate the EDI implementation.

Interviews are the primary source of data collection in this research. The data collected will be used for process mapping, understanding the factors affecting EDI adoption and integration, and evaluating the EDI usage and implementation stage. Two types of interviews (structured interviews and unstructured interviews) are used depending on the data to be collected.

Unstructured interviews are useful for collecting data about the EDI systems. The main objective is to understand the EDI-enabled processes within the companies. Interviewees are suggested by the key informants of the companies. The interviewees are the process experts regarding the EDI implementation and application. Both technical and business persons are included. As mentioned earlier, EDI is not a technical issue only and requires changes in the way the businesses operate (Sokol, 1995). Data on both technical aspect and business aspect should be collected in order to evaluate the EDI implementation and integration. The outcomes of the unstructured interviews should be the input for the process mapping and simulation, and give some ideas about the factors affecting EDI adoption/integration.

Structured interviews are useful for collecting the data regarding the environmental factors as well as the extent of EDI usage. Questions should be developed based on the measures of the frameworks discussed earlier in the "Frameworks" section. The structured data collected allow comparisons between the two cases. Interviewees are basically the key informants of the companies, or other persons suggested by the key informants. The qualified interviewees should be knowledgeable about the history of the EDI development within the companies and familiar with all the EDI projects and plans in the companies. In this research, structured interviews were done primarily by e-mails, followed by phone calls if necessary. (Refer to Appendix 1 for the structured questions used.)

Site observations and documentation reading are used to support the data collected from interviews. With site observations of the processes, the flows of data from beginning of the processes to the end are validated. The documentation regarding the organizational structure, EDI implementation and procedures can be used to serve the same purpose.

CACI's SIMPROCESS will be used as the simulation software to map the current process. It is regarded as a BPR tool for its data analysis capability. Data points such as the arrivals of orders per day can be fed into the data analysis tool of SIMPROCESS to automatically find out the best fit standard statistical distribution function, or to create a user-defined distribution function. Another advantage of using SIMPROCESS is its application of activity-based costing (ABC) which allows the comparison of transaction costs in different experiments without additional software.

For both of the companies, the process of "order fulfillment" will be the targeted process to be studied. The cycle time and the resources allocated (such as human intervention and costs allocation) will be used to evaluate the performance of the current system by the various reports provided by SIMPROCESS. From the process maps created, the difference between paper orders and EDI orders can be checked. The next step is to find out possible improvement by redesigning the process arrangement of the current system. This will be accomplished by searching for delays or inefficient resource allocation in the current system.

Preliminary Data Analysis For Simulation

In order to analyze the order fulfillment processes of the two companies by using simulation, a preliminary data analysis is required to get statistical distribution functions for the events such as arrivals of purchase orders, time of processing, and rate of errors. The simulation model is tried to simulate the real situation as much as possible. However, some data are inaccessible or would required unreasonable amount of resources to collect. Therefore, the scale of the model is adjusted to accommodate the available data sets. For example, daily frequency of purchase orders is used instead of hourly frequency although hourly rate would provides a more realistic simulation.

Data are fed into the data analysis tool in SIMPROCESS to find suitable distribution functions. Standard distribution functions are preferable to user-defined ones because:

1) they have well-defined characteristics
2) they provide a means for cross-case comparisons
3) they give an idea about the shapes of the distributions to the readers

For those cannot be matched with standard distribution functions, tabular (user-defined) distributions are used.

PROCEDURES FOR THE STUDY

The procedures listed below were carried out for the study:

1) Select cases (two companies have been identified.)
2) Collect data by interviews, site observations, and documentation. Multiple interviews are needed.
3) Classify companies by the frameworks suggested above.
4) Use data collected to develop process maps.
5) Verify process maps with companies.
6) Check process performance by simulation statistics.
7) Look for possible redesign of the process mapped, and develop "To-Be" maps.
8) Evaluate the "To-Be" process performance by simulation statistics.
9) Report findings.

VALIDITY AND RELIABILITY OF THE RESEARCH

Several methods are used to enhance the validity and reliability of the current research:

- Multiple sources for data collection are used.
- Both qualitative and quantitative measurements are used to enhance objectivity.
- Multiple measurements are used to measure the level of EDI usage/integration.
- The two cases used are heterogeneous rather than homogenous; (one company has a much more sophisticated EDI system than the another does.)

ANALYSIS OF THE CASES STUDIED

Two cases are selected for this research. They are heterogeneous rather than homogeneous because one company seems to be much more advanced in EDI implementation than the another based on their EDI resources. While one is more an initiator and has long history in using EDI, the another is more a follower and has an experience of using EDI for around 3-4 years. Table 6 provides a quick description for the two cases selected. More details will be shown later in the individual case analysis.

Table 6 – A quick description of the two cases

Cases	Case 1	Case 2
Industry	Spirits and wine brands production	Railway transportation
Number of employees	400	21,000
Number of IT employees	15	470
EDI experience	3-4 years	Around 30 years
EDI application	EDI is applied mainly on receiving P.O. and payment from customers.	EDI is applied to a wide range of business processes with customers, suppliers, customs and other business partners.

THE SELECTED PROCESS TO BE STUDIED

For both of the companies in this research, the "order fulfillment" process is selected to be studied. It is not uncommon that companies choose the order fulfillment process to be the first EDI application because of the nature of the process. There is room for improvement in this particular business activity by using EDI as an inter-organizational system. Two quick direct benefits are generally expected in EDI implementation: cost savings and cycle time savings. For a well-integrated EDI implementation, data are transferred from the sender's internal data processing system through EDI to the receiver's internal data processing system without human intervention during the process.

Thus, the receiver can save costs on salaries and fringe benefits for data-entry clerks. Besides, cost savings include savings on materials and physical delivery, for example, postage, courier, cost of stationery, and envelopes (Kimberley, 1991).

In terms of cycle time savings, the following two diagrams illustrate how EDI can help in reducing cycle time of the order fulfillment process.

Figure 4 – Order Placement to Payment Receipt Cycle (Kimberley, 1991, p. 177)

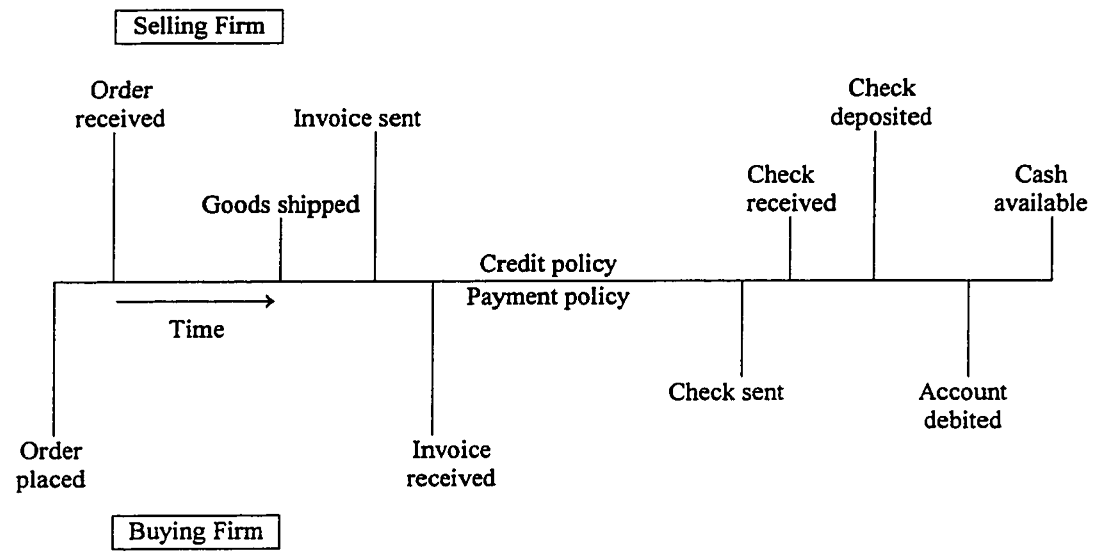
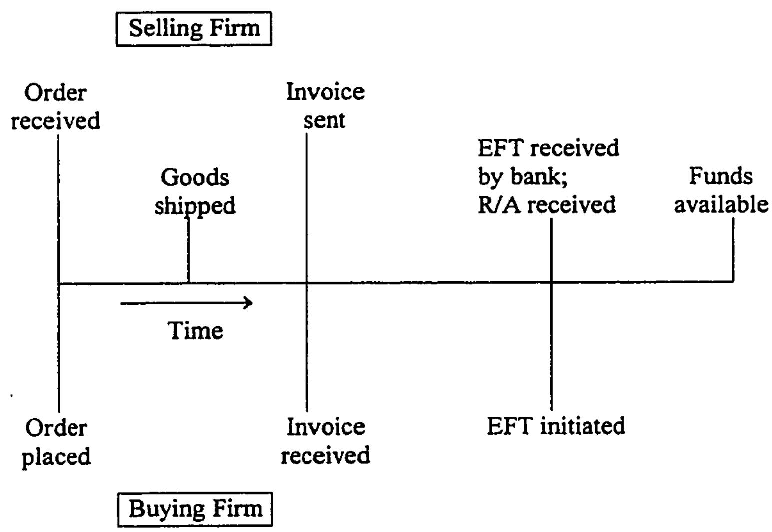


Figure 5 – Order Placement to Payment Receipt Cycle (with EDI and EFT) (Kimberley, 1991, p. 177)



As it is shown in the two diagrams, the cycle time can be reduced by using EDI and EFT (electronic fund transfer) in the process. The time savings would benefit both the buying firm and the selling firm. However, how much can EDI help in the order fulfillment process is not well-understood. As mentioned in the "Introduction" section of this thesis report, the costs and cycle time reduction are expected to be significant, if EDI is well-integrated with the internal processes. This is because the human intervention in internal processing is kept to be minimum. In order to better understand the relationship between EDI integration and benefits gained, detailed examination of the two cases is employed.

CASE 1

The company for Case 1[2] is a spirits and wine brands producer. It has the responsibility for all production, brand management and marketing, sales and distribution of its beverage alcohol brands in North America. In this research, only the Canadian region (i.e. a business sub-unit) of the company is studied. (In the following, "Company A" is used to represent the Canadian region of the Case 1 company.)

Company Background

Industry	Spirits and wine brands production
Revenue	C$2.56 billion for the whole company in 1997 (the figure for the Canadian region only is not available)
Total employees	400
IT employees	15
EDI development and support employees	1
Competitors	Other Canadian companies producing wines, champagnes, and coolers are competitors. There are 3 main competitors in Canada.
Customers	The 12 liquor distribution branches (10 provinces and 2 territories) in Canada
Suppliers	Around 150 – 200 suppliers for product ingredient, packaging material, transportation services.

[2] For confidentiality, the name of the company is not disclosed in this research report.

EDI History

Company A launched its EDI implementation since 1993 because one of the customers, British Columbia Liquor Distribution Branch (BCLDB), started to require its suppliers to accept EDI purchase orders (PO) and release purchase orders (RPO). The company had to comply with the request or it would lose the business with that customer. Later, in 1994, another customer (New Brunswick Liquor Control, NBLC) also began to send EDI PO to the company. Recently, in early 1997, one major customer, Liquor Control Board of Ontario (LCBO, 45% of the purchase orders received by Company A are from this branch) stepped further and expanded the usage of EDI in the order-delivery-payment cycle. LCBO not only sends EDI PO to the company but also pays the company by EFT.

For the time being, Company A only uses EDI to receive PO and RPO from three customers, and collect EFT payment from one customer. There is no other application of EDI within this company. The company seems to play a more passive role rather than an active role in adopting EDI, because it only complies with what customers request rather than searches for process improvement opportunities by using EDI.

At present, Company A finds some problems in its current EDI processes. For example, the acknowledgement of PO is sent without validation. However, the company has some other tasks-to-do with higher priority. Nevertheless, it has a plan to expand the current EDI process and to have more EDI customers.

Classification of Case 1 By Frameworks

Iacovou et al. model

The variable classification and the corresponding reasons are given in the following table.

Factors	Classification	Reasons
Perceived benefits:		
Direct	H	Benefits like time and error reduction in data-entry are emphasized.
Indirect	L	Benefits like increased efficiency are taken as indirect benefits. No other benefits regarding the effects of EDI on effectiveness and process transformation were mentioned by the EDI coordinator.
Org. readiness:		
Financial	H	The company has enough financial resources for IT and EDI development, as perceived by the EDI coordinator. However, only 1% of the IT development budget is allocated for EDI development every year.
Technological	H	The company has enough technological resources for IT and EDI development because there is a team of 15 IT employees. Also, many operations are computerized already, e.g. order administration system, accounting system, inventory system with bar-code management. However, only 1 person is responsible for the EDI development. Besides, the internal applications in different standards (e.g. some on PC Visual BASIC, some on PC MS-Access, and some others on mainframe) may make the integration of EDI difficult.
External pressure:		
Competitive	H	"Many businesses now need to be EDI capable if they want to survive in the open market," said the EDI coordinator.
Imposition by partners	H	The company has to comply with what the customers request or will lose the business with them.
Integration:		
Internal	L	EDI is linked with the Order Administration System. But manual processes are still involved in the order fulfillment process. The EFT is linked with the accounting system by downloading EDI data weekly. The company expects to integrate EDI further into business in the future.
External	L	Three out of 12 customers (i.e. 25%) are linked with EDI. Expanding existing EDI sets to other customers is expected in the future.

From the table above, Company A can be classified as an "unmotivated adopter" according to the framework of Iacovou et al. (1995). The company is pressured into EDI, but with little benefits anticipated. The reason to adopt is to survive. Therefore, minimum resources are spent to enhance the EDI investments although enough resources are possessed by the company. As a result, both internal and external EDI integration are low under this environment. The actual impact of the technology within this company is expected to be very limited.

Massetti and Zmud's measurements

Facet	Measures
Volume	37% of PO from customers and 100% of RPO from customers; 45% of invoices to customers (Around 2% of organization's total documents are exchanged via EDI.)
Breadth	25% of customers; 50% of banks (Around 2% of organization's trading partners are linked with EDI.)
Diversity	2 functions: marketing and finance; 4 Document types: 850, 855, 820, 997; 857 is being developed. More EDI sets are expected in the future plans.
Depth	Application-to-application: marketing and finance

The company does not use EDI in a very great magnitude. If EDI can bring benefits to the company, it would be trivial only; because most of the work remains to be manually performed.

Lummus' six-stage of EDI implementation

Based on Lummus' six-stage classification, Company A has reached Stage 3 (EDI is integrated into other internal systems. No additional data entry is needed.) In this company, the EDI system is linked with the internal order administration system. The EDI PO data are fed directly into the internal processing system without re-keying. However, some manual processes are still involved. For example, for almost 100% of the time, the shipping clerk needs to enter the "Ship Date" for the shipment which is calculated by subtracting "Days-in-transit" from "Delivery Date." Furthermore, many paper documents are still used in processing purchase orders. It seems that there is still a long way to go for the company to be fully-integrated.

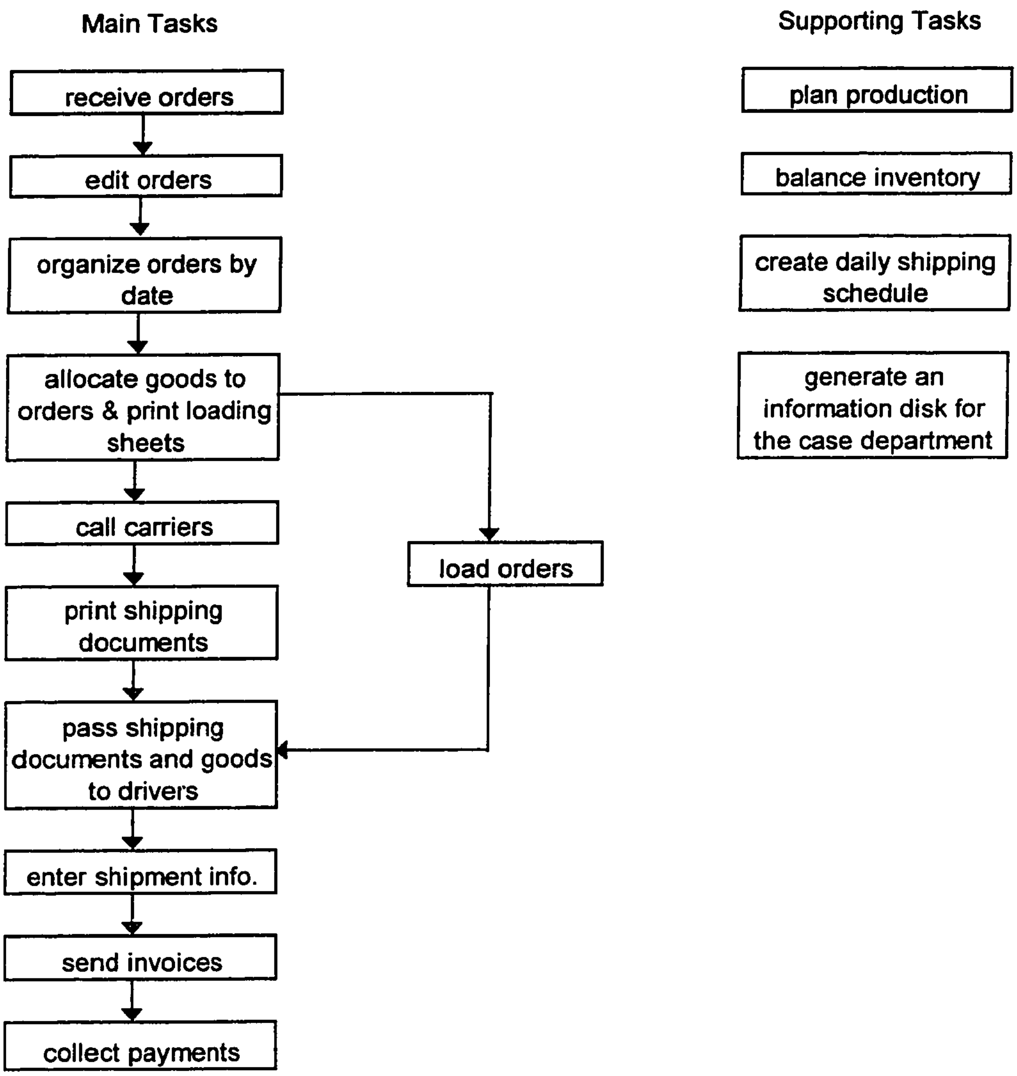
Venkatraman's five-level IT-enabled business transformation

Although the company has employed EDI which may involve some changes in the communication process between the company and its customers, it is still in Level 1 business transformation (localized exploitation) according to Venkatraman's framework (1994). EDI is simply used to replace the physical paper P.O. and to gain benefits like reduced transaction costs and time. No big change in the order fulfillment process. For example, the shipping clerk has to do the daily manual works such as balancing inventory and writing shipping schedules. On the other hand, although the data of EDI P.O. are fed into the company's order administration system (OAS), the company cannot be classified as in Level 2 (internal integration) because OAS is not linked with the accounting system which is involved in the later stages along the same order fulfillment process. The accounting clerk needs to download the data weekly from OAS to the accounting system. Furthermore, the shipping department and the accounting department are still working independently rather than interdependently. In Venkatraman's model (1994), both technical interconnectivity and organizational interdependence are required for Level 2 transformation.

Analysis of the Order Fulfillment Process

Description of the process

Figure 6 – Order fulfillment process in Company A



The simplified flow chart above tells how an order is fulfilled in the company. On the left hand side are the main tasks which show the sequence of steps for processing purchase orders received from customers. On the right hand side are the supporting tasks which show what needed to be done regularly on a daily basis in order to guarantee the main tasks working. No matter whether the orders are received by fax, e-mail, or EDI, they are processed in a similar way.

Main tasks:

Manual orders are received by fax, or e-mail (for internal orders) in the shipping department. The shipping clerk enters the orders into the order administration system (OAS). EDI orders are downloaded from VAN and are translated five times daily according to the schedules set by customers. Everyday the shipping clerk needs to check and print the EDI orders for possible transmission errors. Next is to read and edit the order data in the OAS because most of the time the ship date has to be entered manually. Then, all the orders are put and processed together in the same manner. The shipping clerk is responsible to check for any content error in the orders. She may need to contact customers for the correction of errors found.

All the orders are organized by ship date. Everyday, the shipping clerk fills the orders (with the ship date as the next day) in batch. Goods are allocated to the orders and a loading sheet is generated for each order. Then, the loading sheet is sent to the foreman for the picking of goods. While the fork-lift drivers are loading the orders, the shipping clerk or the foreman call the carriers to confirm the shipment for the next day, so that truck drivers from designated carriers are guaranteed to come and to pick up the shipments. The shipping clerk also needs to print the required shipping documents which include a bill of lading and a form called B60 required by the government for tax purpose. The shipping documents are handed to the corresponding truck drivers and go along with the shipment to the customers.

After the truck drivers have picked up the shipments, the shipping clerk enters the data to mark the shipments as "shipped." The corresponding invoices which have been printed earlier with the shipping documents are passed to the mailing clerk who accumulates and sends the invoices on Mondays.

Payment collection is done by the account receivables clerk in the accounting department. Every Monday, the A/R clerk downloads the invoice data from the OAS to the account receivables system (A/R system). One of the customers pays by electronic fund transfer (EFT). Every Tuesday, the A/R clerk downloads the EFT data from VAN service and the A/R system is updated automatically. When other payments are received, the A/R clerk enters the data to close the accounts. Checks received are deposited to the bank by internal mailroom service on the same day. In addition, the A/R clerk needs to input the data for the general ledger system (G/L system), because the G/L system is not linked with the A/R system.

Supporting tasks:

In addition to the main tasks described above, the shipping clerk needs to do some other supporting tasks which are not part of the sequence of the order fulfillment process but are necessary for keeping the main tasks going. Normally, those tasks are done in batch once a day:

- "Plan production" is to generate a production planning sheet daily based on the outstanding orders currently in the OAS. The planning sheet is to tell the planner in the production department about what needs to be produced. In response to the planning sheet, the planner notifies the shipping clerk on the next day the actual amount of goods produced on the previous day. Then, the shipping clerk enters and updates the inventory data in the OAS.

- "Balance inventory" is to manually calculate the actual balance of the goods in the inventory. The actual balance is not kept in the OAS because the OAS balance are deducted once goods are allocated to an order even before shipment. The actual balance calculated is compared with that in the inventory system maintained by the case department[3]. If they do not match each other, the shipping clerk has to find out the errors manually. Sometimes it may take a whole day or even several days to find an error.
- "Create daily shipping schedule" is to manually write a summary of the shipments for one day to the foreman.
- Since the OAS in the shipping department and the inventory system in the case department are not linked to each other. A disk is generated daily by the shipping clerk to the case department in order to link the information between the two systems. Basically, this is to tell the case department about what the planned shipments for the next day are.

Documents used in the process

Although EDI is applied in the order fulfillment process in the company, many paper documents are still used, processed and circulated along the process. Since the adoption of EDI in the company, minimum changes have been made to the old process. Substantial amount of manual tasks remains in the process. This is an indicator of not very well-integrated EDI implementation. In this case, limited impact from the EDI adoption is expected.

The following table gives a closer look to the documents flowed along the process.

[3] The case department is responsible for the management of the warehouses and the inventory.

Table 7 – Analysis of the documents used in Company A

Document Type	Info. from	System	Human intervention / Personnel responsible	Format	Description
PO	Customers		Edited by the shipping clerk	Fax / e-mail/ EDI	Customers send PO to order goods. No matter which format is used, a hard-copy is kept for each PO
Loading sheet	PO	OAS	Generated by the shipping clerk daily in batch	Paper	This is to tell the foreman about what goods to be picked up for shipments on the following day.
Shipping schedule	PO		Written by the shipping clerk	Paper	A summary of the shipments on a day
B60	PO	OAS	Generated by the shipping clerk daily in batch	Paper	It is required by the Government to go with the shipment for tax purpose. Customers send it back for confirmation of goods received.
Bill of lading	PO	OAS	Generated by the shipping clerk daily in batch	Paper	This is to order the services from carriers. It includes the shipment specification.
Invoice	PO	OAS	Generated by the shipping clerk daily in batch	Paper	Generated along with B60 and bill of lading. It is given to the mailroom for mailing.
Planning sheet	Outstanding PO's / inventory balance	Plan-ning sys.	Generated by the shipping clerk daily in batch	Paper	This is to tell the planner about what needs to be produced.
Inventory balance sheet	Shipments / inv. bal. / new production		Generated by the shipping clerk	Paper	Manually generated. This is the reconciliation of the balances in the OAS and in the case department.

Preliminary data analysis for simulation

Distribution functions for the model parameters are found by using the SIMPROCESS' data analysis tool, as already described in the "Data Collection" section. Details of the preliminary data analysis for this company are as follows.

The data items such as number of orders per day, number of items per order, date received, and date delivered for manual and EDI purchase orders for the year 1997 are extracted from the database of the OAS. Since one of the customers was switching from sending fax purchase orders to sending EDI ones at the beginning of the year, the data for the first two months are dropped to avoid any instability of the daily frequencies of the PO's from fax and EDI. During the preliminary data analysis for the PO frequency, it is found that the daily volume of the PO's follows a cyclical pattern weekly, e.g., more PO's are received on Fridays than on other days of the week. Therefore, 5 different distributions (from Monday through Friday) are set up for the manual PO's and the EDI PO's respectively.

Assumptions on the processing times are made because the company does not keep detailed statistics about the times needed to enter the data, to make a phone call to customers, and to fill an order. Therefore, the distribution of the processing times are mainly collected by interviews with the clerks responsible who give estimations on the minimum times, the maximum times, and the most likely times. Triangular distribution functions are used for those processing times because only a vague idea about the shapes of the distributions is obtained. For those processing times are likely related to the number of items in each PO, e.g. the data-entry time for an order, functions of item number are used. That means the more the number of items in a PO, the longer the processing time.

Simulation results

Four scenarios are set up for simulation in order to evaluate the impact of EDI implementation in the company order fulfillment process. The four scenarios are summarized in the following table. (Refer to Appendix 2 for process maps.)

Table 8 – Summary of the four scenarios for Case 1

Scenario	Description
1	Current situation
2	Better external integration only: the current EDI solution is extended to the remaining customers, i.e., the current total amount of purchase orders is received by EDI only.
3	Better external and internal integration: the EDI solution is extended to the remaining customers and is modified to be better integrated with the internal processes, i.e., the current total amount of purchase orders is received only by EDI, and some changes are made in the process.
4	Better internal integration only: the EDI solution is modified to be better integrated with the internal processes, i.e., the amount of fax and EDI purchase orders received is as that in current situation, but some changes are made in the process.

The four scenarios are simulated and tested by looking at the key performance measures of the models, which are cycle times and processing costs. These two basic measures should show the operational impact of EDI in the process studied. The models are simulated for a period of 3 months (from January 5 to April 5, i.e., 13 weeks) with 5 replications.

Key performance measures

Time spent on each sub-process is the first key performance measure for evaluating the process in this context. Because long processing cycle would mean slow customer responses or services, and particularly EDI is supposed to reduce the cycle time of processes. Therefore, the time spent on each sub-process is examined.

Another performance measure, cost, is also very important in evaluating the sub-processes. The cost of each sub-process is calculated automatically by SIMPROCESS using activity-based costing. The costs are allocated to the sub-processes in terms of resources spent, which include percent of clerks' salaries and fringe benefits, paper consumption, telephone and VAN charges directly related to the sub-processes.

In addition, the shipping clerk is a key person in the order fulfillment process in this company. Most of the sub-processes are performed by her. It is also advantageous to monitor the utilization rate of the shipping clerk.

Since the sub-processes from the receipt of purchase orders to the delivery of shipments are very time critical to the company and any delay of any part of the sub-processes would defer the services to the customers, the performance measures on the sub-processes before the delivery of shipments are carefully checked in this analysis. A simplified diagram is shown below:

Figure 7 – Sub-processes before the delivery of shipments (Case 1)

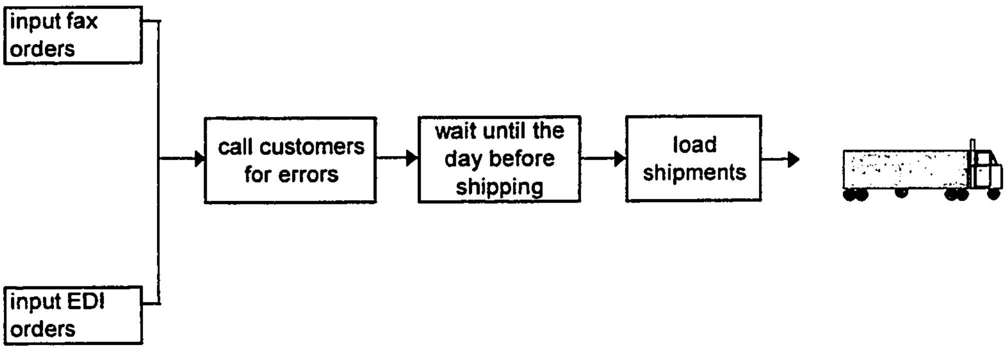


Table 9 – Description of the sub-processes before the delivery of shipments (Case 1)

Sub-process name	Description
Input fax orders	This is to input the fax orders received into the OAS.
Input EDI orders	This includes the sub-processes of downloading data from VAN, translating data into the OAS, printing the orders, checking transmission errors, and editing the orders. Editing the orders means an operator is needed to manually edit the contents of the orders.
Call customers for errors	In case of content errors found in the orders received, an operator calls customers for inquiry. Corrections are made directly into the OAS at the same time.
Wait until the day before shipping	This is not really a sub-process. The orders are organized in file folders according to the ship dates. The time spent in this sub-process is the time spent on waiting to be proceeded to the next step.
Load shipments	This includes the sub-processes of allocating goods to the orders, calling carriers for the shipment pick-ups, printing shipping documents and invoices, and loading the goods.

In addition to the main tasks listed above, the times spent on supporting tasks within the same department (the shipping department) are also carefully monitored, because the supporting tasks compete for the same resources (the shipping clerk). Reduction in the processing time on supporting tasks would accelerate the main task processing, because of less delay due to unavailability of the resources.

The key performance measures for the four scenarios suggested are summarized in tables on the following pages. Each scenario statistics summary is followed by interpretation showing the rationale behind the simulation results.

Scenario 1

Table 10 – Key performance measures on tasks for Scenario 1 (Case 1)

	Replication					Average
	1	2	3	4	5	
Number of fax orders processed	916	885	908	804	839	**870.4**
Number of EDI orders processed	494	374	507	479	571	**485**
Average time on main tasks (hours/order)						
Input fax order	5.07	4.48	6.76	5.06	5.84	**5.44**
Input EDI order	9.16	6.69	8.88	7.40	8.94	**8.21**
Call customers for errors	0.95	0.75	2.03	1.14	1.65	**1.30**
Wait until the day before shipping	70.81	73.15	74.70	76.99	81.04	**75.34**
Load shipments	10.33	9.26	12.56	10.70	10.11	**10.59**
Average time on supporting tasks (hours/daily task)						
Plan production	4.44	3.72	5.47	4.37	4.45	**4.49**
Balance inventory	27.92	9.22	72.50	12.24	15.53	**27.48**
Create daily shipping schedule	3.316	2.91	4.53	3.22	3.78	**3.55**
Generate information disk	3.686	2.83	4.95	3.46	3.79	**3.74**
Average cost on main tasks (dollars/order)						
Input fax order	0.75	0.72	0.74	0.75	0.76	**0.74**
Input EDI order	0.91	0.91	0.91	0.91	0.91	**0.91**
All sub-processes from calling customer to loading shipment	3.85	3.83	3.85	3.89	3.87	**3.86**
Average cost on supporting tasks (dollars/daily task)						
Plan production	19.49	19.27	18.81	19.34	19.59	**19.30**
Balance inventory	8.85	9.23	10.21	9.73	9.62	**9.53**
Create daily shipping schedule	4.88	5.20	5.04	5.10	5.13	**5.07**
Generate information disk	1.81	1.81	1.80	1.82	1.81	**1.81**

Table 11 – Utilization of the shipping clerk for Scenario 1 (Case 1)

	Replication					Average
	1	2	3	4	5	
Shipping clerk utilization (%/day)*	88%	81.2%	88.4%	83.2%	89%	**85.96%**

*Note: It is the percentage of working hours when the shipping clerk is occupied with the tasks. E.g., 88% means, on the average, the shipping clerk is 88% busy during her working hours (from 7a.m. to 12p.m., and from 1p.m. to 3p.m.)

Interpretation:

The tables above show the performance of the process for the current situation. Surprisingly, the results show that it is long to input a fax order (5.44 hours) or even an EDI order (8.21 hours) on the average. By looking into the simulation report in more details, these are the total duration in process and most of the time in process is spent on waiting for the resources (i.e. the shipping clerk). As it can also be found in Table 11, the shipping clerk utilization rate is high around 86%. This is agreeable to what the shipping clerk herself told the interviewer that she was very busy and stressed everyday. Since the shipping clerk is occupied with other works while the purchase orders arrived, she is not available to input the orders right away upon receipts. That is why the cycle time for input is long. On the other hand, it is found that about 34% of fax orders are rush orders which are of the highest priority and should be shipped right away, while only 2% of EDI orders are in urgent condition. (These may be due to the policies of the customers. It seems that the customers with fax orders are more likely to send rush orders than those with EDI ones.) Therefore, fax orders take less time on waiting for the shipping clerk on average.

Besides, two other technical factors would influence the simulation statistics.

1) Unlike those in the real situation, all the purchase orders in the simulation are assumed to be received at the beginning of the day. In real life, the average time of input may be less because some orders are received during any time of the day, i.e., less time spent on waiting resources.

2) The shipping clerk works 7 hours per day. Sometimes, it is possible that the shipping clerk needs to work overtime, depending on the amount of jobs to be processed. In the 3-month simulation, no overtime work was simulated. Therefore, as long as an order waited over night, the input time for that particular order would be more than 24 hours (i.e., a day). This kind of situations could overstate the statistics.

The two assumptions above is made in order to save time on overly detailed data collection. They are acceptable in this research because the research objective is to investigate the relationship between EDI and BPR, not to provide solid solutions to the current situation of the company. Substantial amount of work on data collection and more internal staff involvement will be needed if specific solutions are desired.

In fact, the average time actually spent on input (i.e., the duration at activity) is 1.26 minutes for an EDI order and 2.04 minutes for a fax order on average. These figures look more reasonable, but the difference is small. This is because the duration for the EDI orders input includes the time for downloading and translating the data, printing and editing the orders, and checking for errors. Furthermore, some data validation (e.g. verification of a product ID), which is embedded in the EDI application, is also part of the internal order administration system. This kind of mechanism helps to reduce time on checking errors. Therefore, the difference between the two input times is small.

All other average times look longer than expected. Again, this is because of the unavailability of the shipping clerk. There is only one shipping clerk responsible for the domestic market with the expected volume of purchase orders as shown above in the table. She is so busy because it takes around 39.26 hours, on average, for her to finish the daily supporting tasks[4]. As a matter of fact, an assistant comes to the office on every Monday and Tuesday to help the clerks (including the shipping clerk) in the shipping department. On the other hand, it is also found that the averages above have high standard deviations. That means some orders may take substantially less or more time to process.

In terms of cost, the fax orders cost less than EDI orders on average. This is due to the VAN charges for the EDI orders. However, the EDI orders should have lower error rate which is not measured in this research. Also, the VAN service would usually charge at a lower rate when the volume of transactions reach a certain point. (Currently, the company has around 485 EDI transactions per 3 months.)

Although the utilization rate of the shipping clerk is not 100% as shown above, she has other responsibilities which are not simulated in the current simulation. For example, she is also responsible for answering inquiries from customers or from other departments. Therefore, in the real situation, she is busier than 85.96%.

As it can be seen from the performance measures in Scenario 1, the introduction of EDI purchase orders to the order fulfillment process does not really shorten the cycle time nor reduce the cost on processing. This is because the clerk responsible still maintains a good amount of manual work which hinders the smoothness of the process. Some re-arrangements of the current process are needed in order to gain benefits from the EDI implementation.

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[4] The time is long because sometimes it may take several days to reconcile the inventory balances.

Scenario 2

Table 12 – Key performance measures on tasks for Scenario 2 (Case 1)

	Replication					Average
	1	2	3	4	5	
Number of EDI orders processed	1346	1354	1289	1259	1282	**1306**
Average time on main tasks (hours/order)						
Input EDI order	5.17	6.59	4.76	5.08	4.92	**5.30**
Call customers for errors	2.60	0.87	0.29	0.44	0.35	**0.91**
Wait until the day before shipping	68.45	72.31	76.96	75.24	77.67	**74.13**
Load shipment	9.27	11.83	9.54	11.16	9.92	**10.34**
Average time on supporting tasks (hours/daily task)						
Plan production	3.43	5.52	3.76	3.11	3.63	**3.89**
Balance inventory	16.59	17.69	6.43	9.25	13.03	**12.60**
Create daily shipping schedule	2.30	4.28	2.53	2.31	2.99	**2.88**
Generate information disk	2.20	4.64	2.70	2.49	2.42	**2.89**
Average cost on main tasks (dollars/order)						
Input EDI order	0.94	0.94	0.94	0.94	0.95	**0.94**
All sub-processes from calling customer to loading shipment	3.83	3.85	3.88	3.89	3.85	**3.86**
Average cost on supporting tasks (dollars/daily task)						
Plan production	19.47	19.23	18.97	19.33	19.66	**19.33**
Balance inventory	9.54	10.54	9.08	9.68	10.02	**9.77**
Create daily shipping schedule	4.88	5.19	5.08	5.10	5.15	**5.08**
Generate information disk	1.81	1.81	1.82	1.82	1.82	**1.82**

Table 13 – Utilization of the shipping clerk for Scenario 2 (Case 1)

	Replication					Average
	1	2	3	4	5	
Shipping clerk utilization (%/day)*	81.7%	83.8%	78.6%	78.6%	80.9%	**80.72%**

*Note: It is the percentage of working hours when the shipping clerk is occupied with the tasks. E.g., 88% means, on the average, the shipping clerk is 88% busy during her working hours (from 7a.m. to 12p.m., and from 1p.m. to 3p.m.)

Interpretation:

In this scenario, all the orders are received from EDI only. We can see that the overall time for input orders is reduced. Because the actual EDI order input time is shorter than the fax order. Other times are also shorter because the shipping clerk is not so occupied as in Scenario 1. But we cannot see sound improvement in the process in terms of time and cost even all the orders are received by EDI. This is mainly because the EDI process is too similar to the manual process. In fact, as explained in Scenario 1, a number of manual procedures are still inside the EDI process. On the other hand, the order administrative system helps to save some time in processing paper orders as comparing to a purely manual process. Therefore, there is no big difference between Scenario 1 and 2.

The utilization rate of the shipping clerk is lower in this scenario compared to the first one. That is why the times on various tasks are shorter than those in the first scenario – because it takes less time on waiting for the resources.

Scenario 3

In this scenario, some changes/re-arrangements are made to the current process in order to gain better advantages from the adoption of EDI. The changes made are:

- *No more printing of EDI purchase orders.* Because this is a non-value-added sub-process. Since all the data are entered into the OAS, it is not necessary to keep hard copies of the purchase orders.
- *No more checking on EDI transmission error.* In the current situation, the shipping clerk has to check the last serial number used and to see if any transaction missed between any two transmissions. This task is highly routine and should be performed by computer.

- *No more need to call carriers.* In the current situation, the shipping clerk or the foreman needs to call carriers on the day before shipment in order to make sure that they would come to pick up the shipments. If the filling of orders automatically triggers a bill of lading to the carriers, the clerks will not need to make such regular phone calls again. Yet it depends on the EDI ability of the carriers. After all, it is feasible because the North American road transport industry has become heavily involved in EDI since several years ago (Jones, 1993).
- *Shorter time on generating shipping documents.* If the bills of lading are sent by EDI, the number of pages for shipping documents will be less. Besides, not all the customers need invoices for payments. For example, one of the customers currently pay by purchase orders rather than by invoices. The company can eliminate the sending of invoices to that customer. This will also save postage costs.
- *No more input for shipment information.* In the current situation, the shipping clerk needs to input to the OAS to signal the shipment as "shipped" when the shipment has been picked by the carriers. At the same time, a bar-code system is currently used by the inventory system and a bar-code is generated for each pallet of goods. If the same bar-code system is used for the shipping department, no more input for the "shipped" shipments will be needed. Because the scanning of the bar-codes can be used to trigger signals to the OAS. This would also make the internal systems better integrated.
- *No more supporting tasks.* As it can be seen from the previous two scenarios, the supporting tasks are time-consuming and highly routine, and would hinder the smoothness of the main tasks. These should be carried out automatically by computer rather than by the shipping clerk, since all the information is already in the OAS. It is redundant to manually do the work on a regular basis.

After the modifications are made to the process model, the simulation results are shown in the following two scenarios. Scenario 3 shows what would happen if all the purchase orders are received by EDI. The next one, Scenario 4, shows what would happen if the proportion of fax and EDI purchase orders is as in the current situation.

Table 14 – Key performance measures on tasks for Scenario 3 (Case 1)

	Replication					
	1	2	3	4	5	Average
Number of EDI orders processed	1331	1401	1446	1402	1466	**1409.2**
Average time on main tasks (hours/order)						
Input EDI order	1.78	1.73	1.84	1.64	1.86	**1.77**
Call customers for errors	0.53	0.32	0.45	0.34	0.40	**0.41**
Wait until the day before shipping	76.40	77.46	81.54	77.53	79.59	**78.50**
Load shipment	11.02	9.80	9.22	10.06	10.34	**10.09**
Average time on supporting tasks (hours/daily task)						**0**
Average cost on main tasks (dollars/order)						
Input EDI order	0.88	0.88	0.88	0.89	0.89	**0.88**
All sub-processes from calling customer to loading shipment	2.83	2.77	2.78	2.81	2.79	**2.80**
Average cost on supporting tasks (dollars/daily task)						**0**

Table 15 – Utilization of the shipping clerk for Scenario 3 (Case 1)

	Replication					
	1	2	3	4	5	Average
Shipping clerk utilization (%/day)*	44.6%	46.2%	47.5%	46.0%	48.6%	**46.58%**

*Note: It is the percentage of working hours when the shipping clerk is occupied with the tasks. E.g., 88% means, on the average, the shipping clerk is 88% busy during her working hours (from 7a.m. to 12p.m., and from 1p.m. to 3p.m.)

Interpretation:

The tables above show that the cycle time and the processing costs drop to a great extent with the elimination of the supporting tasks. Since the shipping clerk no longer suffers from the supporting tasks, she can promptly respond to the purchase orders received. We can also see that the utilization rate of the shipping clerk reduces substantially. That means the stress factor for her should be lessened.

Scenario 4

Table 16 – Key performance measures on tasks for Scenario 4 (Case 1)

	Replication					Average
	1	2	3	4	5	
Number of fax orders processed	910	842	850	868	834	**860.8**
Number of EDI orders processed	531	424	514	462	493	**484.8**
Average time on main tasks (hours/order)						
Input fax order	1.84	1.42	1.46	1.63	1.55	**1.58**
Input EDI order	2.13	2.01	2.24	2.17	2.29	**2.17**
Call customers for errors	0.41	0.36	0.42	0.37	0.41	**0.39**
Wait until the day before shipping	76.54	78.15	78.43	83.33	83.48	**79.99**
Load shipment	9.68	9.50	9.41	9.12	9.20	**9.38**
Average time on supporting tasks (hours/daily task)						**0**
Average cost on main tasks (dollars/order)						
Input fax order	0.78	0.77	0.78	0.75	0.75	**0.77**
Input EDI order	0.89	0.89	0.88	0.88	0.89	**0.89**
All sub-processes from calling customer to loading shipment	2.80	2.83	2.82	2.79	2.77	**2.80**
Average cost on supporting tasks (dollars/daily task)						**0**

Table 17 – Utilization of the shipping clerk for Scenario 4 (Case 1)

	Replication					Average
	1	2	3	4	5	
Shipping clerk utilization (%/day)*	50.9%	45.3%	48.3%	46.2%	46.5%	**47.44%**

*Note: It is the percentage of working hours when the shipping clerk is occupied with the tasks. E.g., 88% means, on the average, the shipping clerk is 88% busy during her working hours (from 7a.m. to 12p.m., and from 1p.m. to 3p.m.)

Interpretation:

In Scenario 4, the fax orders are brought back. It is found that the performance measures are very similar to those in Scenario 3 even the fax orders remain in the process. They show that the process re-arrangements are really important in claiming benefits.

Discussion for all the scenarios

From the four scenarios above, it is obvious that the reengineering of process is very important in bringing the EDI benefits to the company. The EDI data received should be well-integrated into the current processes. Otherwise, limited and even negative benefits are gained from the adoption of EDI. In Scenario 3 and 4 (with changes in the process), we can see that the process performance has improved dramatically. In order to have a clear picture of the advantages gained. Table 18 gives a summary of the four scenarios. The units of the measures are adjusted so that comparisons among them are possible. For example, the unit for the time on daily supporting tasks (hours/daily task) are transformed into "the time per order" (i.e., hours/order) by dividing the daily time with the average number of orders per day.

Table 18 – Key performance measures for all the scenarios (Case 1)

Performance measures (on average)	Scenario			
	1	2	3	4
Total time (hours/order)				
On main tasks (excluding the task "Wait until the day before shipping")	18.32	16.55	12.27	11.56
On supporting tasks	1.88	1.11	0	0
On main and supporting tasks	20.2	17.66	12.27	11.56
Time savings compared to Scenario 1	-	**-12.6%**	**-39.3%**	**-42.8%**
Total cost (dollars/order)				
On main tasks	4.66	4.8	3.68	3.61
On supporting tasks	1.71	1.79	0	0
On main and supporting tasks	6.37	6.59	3.68	3.61
Cost savings compared to Scenario 1	-	**+3.5%**	**-42.2%**	**-43.3%**
Utilization rate of the shipping clerk	85.96%	80.72%	46.58%	47.44%

Although Scenario 4 (with fax and EDI received from customers) seems even better than Scenario 3 by simply comparing the simulation results, it does not necessarily mean that using fax and EDI together is better. Because the error rate in input is not considered in this case. Also, the VAN service charge rate will likely be lower if substantial volume of transactions are added. Yet these advantages are not reflected in the simulation model. Furthermore, intangible (strategic) benefits like better customer services are not shown in the model neither.

Concluding Remarks for Case 1

The company is an EDI follower (unmotivated adopter) rather than an initiator. The EDI implementation is not very well-integrated with the business processes. Therefore, the benefits gained are limited. Reengineering of the business processes is required in order to obtain the potential advantages of EDI, as shown in the different scenarios simulated.

(Note: After an analysis report had been sent to the company, the EDI coordinator informed the researcher that some modification had been made to the EDI system. Now, the "ship date" is generated by the system automatically rather than by the shipping clerk manually. Also, some new EDI-related projects are being developed. They include the testing of EFT with another customer, and the rewriting of the A/R system for the purpose of better integration with the OAS.)

CASE 2

Canadian National (CN, a.k.a. Canadian National Railway) operates Canada's largest railroad system. It is North America's sixth largest railroad based on 1996 revenue of C$4.2 billion. For 1997, the revenue is reported to be C$4.4 billion. Its revenue has risen about 15% from 1992 to 1997.

CN operates approximately 17,000 route miles of track across Canada and about 950 route miles of track in the United States. The network serves all five of Canada's major ports: Halifax, Montreal, Prince Rupert, Thunder Bay, and Vancouver, and includes strategic connections into the United States, including the Chicago gateway.

The railroad's revenues are derived from the movement of a diversified freight portfolio comprised of forest and industrial products, grain, coal, fertilizers, automobiles, and intermodal shipments. Almost 40% of the company's revenues are derived from transborder (U.S.) traffic, 25% from offshore traffic bound primarily to Asia and the Pacific Rim countries, and about 35% from traffic that remains within Canada.

Since its privatization in November 1995, CN has become a completely different company, undergoing a dramatic physical and cultural restructuring. The company was barely breaking even several years ago, but now is profitable and aiming at being the best railroad in North America.

Company Background

Industry	Transportation (railway)
Revenue	C$4.2 billion (1996); C$4.4 billion (1997)
Total employees	24,000 (Aug. 1996); 21,000 (Dec. 1997)
IT employees	470 (plus over 300 contractors and consultants)
EDI development and support employees	8 specialists, but not all dedicated to just EDI work
Competitors	Mainly from trucking industry, also from other railroads
Customers	Over 3,500 direct customers with over 10,000 physical locations
Suppliers	Over 13,000 suppliers
Mission statement	"... to meet our customer's transportation and distribution needs by being the best at moving their goods on time, safely and damage free."

EDI History

The history of EDI in the transportation industry has begun since the World War II, when the Berlin Airlift found the problem of keeping track of goods delivered to the beleaguered city because the paperwork was moving too slowly (Jones, 1993, pp. 10-13). In around mid 1960s, the Association of American Railroads started experimenting with exchanging information electronically and approached the U.S. Department of Transportation with the idea. Later, the Transportation Data Coordinating Committee (TDCC) was founded in 1966. It then gathered all the various parties to have a meeting concerning EDI message standards, which formed the basis of current North America EDI standards.

CN has been using electronic processes for more than 30 years to keep track of its complex operations (Clarke and Henderson, 1996). At that time it relied almost solely on proprietary standards. In the early 1990s, the transportation industry became more competitive and the railroads found their competitive challenge not only from each other but also from the trucking industry. They then began cooperative EDI-based scheduling processes in 1992. CN also realized that it needed an overall strategy to achieve its long-term goals of good service and started its new EDI strategy in 1993. As a result, an innovative system called Service Reliability Strategy (SRS) was acquired to integrate with EDI and to boost the customer service.

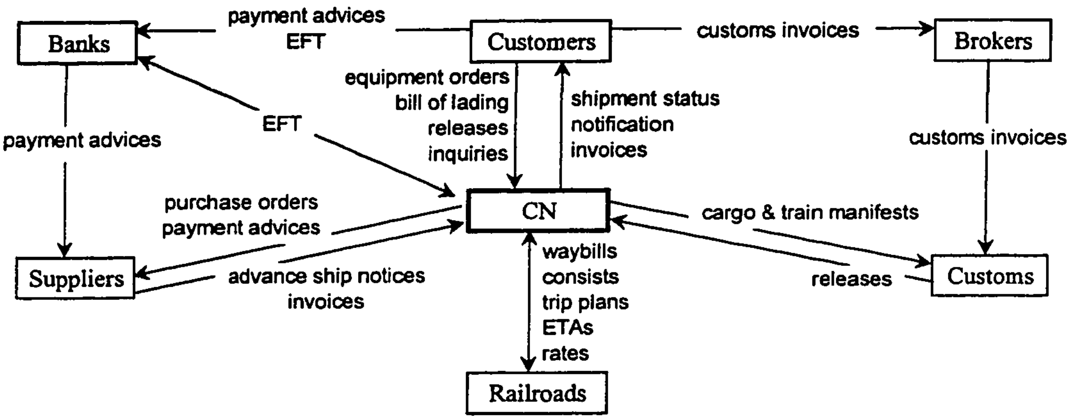
EDI is considered to be one of the most important technology in CN. The company is trying to go as quickly as it can for the EDI development. The number of different EDI transaction types has increased from less than 30 in 1993 to more than 60 today. Currently, more than 1 million transactions are transmitted between CN and its business partners every month.

EDI is considered to be a very important tool for CN to provide good services to its customers. For the time being, there are about half of the customers are sending EDI bills of lading to CN to order their transportation services. Since the EDI processes are linked with the internal system SRS, the receipts of EDI transactions will trigger various processes like moving of cars or sending of other EDI messages to other connecting railroads. The company is improving its EDI processes in order to make them eventually to be event-driven EDI which could provide fast and reliable services to its customers.

In addition, EDI is also playing a significant role in CN's team approach with its customers. For example, the EDI system is integrated with one of its customer's SAP[5] order entry system. In that case, both companies can be immediately and automatically notified when any shipment deviates from the agreed-upon estimated time of arrival.

EDI is emphasized to be mission critical in CN. The completeness, accuracy, and timeliness of EDI exchange is considered to be essential to the company's core business process. EDI can no longer be separated from the company's day-to-day business. It is being expanded and developed. The following diagram gives an idea about the electronic commerce processes in CN.

Figure 8 – CN's electronic commerce processes (Clarke and Henderson, 1996)



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[5] SAP (Systems, Applications and Products in Data Processing) is a provider of client/server business application solutions.

Classification of Case 2 By Frameworks

Iacovou et al. model

The variable classification and the corresponding reasons are given in the following table.

Factors	Classification	Reasons
Perceived benefits:		
Direct	H	Benefits like reduced labor costs, reduced errors, faster information exchange, and shorter business process cycle are perceived.
Indirect	H	EDI is emphasized to be mission critical in CN. It is also considered to be an overall industry effort to compete with the trucking industry. Other indirect benefits perceived include better relationship with customers/partners when integrating EDI with their business applications, improved responsiveness to changing business needs, and direct (dialogue) links to customers.
Org. readiness:		
Financial	H	IT budget: C$95million in 1998, C$89million in 1997 Development budget for electronic business services is about C$5million in 1998, i.e., about 5% of the IT budget.
Technological	H	Sophisticated hardware, software, and technically skilled staff. There are about 470 IT staff plus over 300 contractors and consultants in the company. Eight specialists are responsible for EDI development and support.
External pressure:		
Competitive	H	In addition to within industry competition, there are threats from trucking industry. The company tries hard to use technology to meet customer needs and to provide superior services, faster and more effectively than its competitors.
Imposition by partners	H	Sometimes the company are forced to react to some customers who change their electronic business processes without warning. For example, one of its customers declared that it will adopt the EDIFACT standards by mid 1999. That means CN has to prepare for that because most of the current transactions are in ANSI X12 standards.

All the independent variables in the model are classified as high for the company. According to Iacovou et al. (1995), it is a "ready adopter" which is well-prepared for EDI implementation and has the necessary resources to develop integrated EDI systems that will interface with its internal computer applications. In fact, EDI is emphasized to be mission critical in this company and is considered to be of most value when integrated with the applications, either originating the message or receiving and processing the message. It can be naturally expected that the EDI implementation is highly integrated and, in turn, that many benefits are gained in this company. The following table shows its internal and external integration.

Factors	Classification	Reasons
Integration:		
Internal	H	EDI is well-integrated internally in the company. Some examples are as follows: Integration with SRS (Service Reliability System, is the most important system to CN. It tracks the movement of shipments.), and CIS (Customer Information System, is the communication between the company and its customers.) Fleet Productivity System (handles the movement of empty equipment by exchanging EDI messages with other railroads.)
External	H	About 1,800 (53%) customers and 500 other partners are exchanging electronic messages with CN. The following examples describe how the company is linked with its business partners. With other railways: Rail-EDI (which links railway databases) allows customers to inquire freight rates, to trace their shipments on their trips across over 130 North America rail carriers, and to exchange electronic messages with other 9 participating railroads. ISM(Interline Service Management) makes trading of scheduling information with other railroads possible. With customers: The company obtains forecast information from some customers by EDI, so that advanced planning of car movements ensures the availability of cars for customers. The company links with its customer's SAP order entry system for quality measurement purpose. The integrated process monitors any deviation from the agreed-upon estimated time of arrival. The Fleet tracking service allows customers to trace their shipments in one query. It also supports FTP downloads so that customers can get the information and feed it into other systems for further uses.

The company is using EDI not only to streamline its own operations but also as part of a cooperative, overall industry effort to compete more effectively with the trucking industry (Clarke and Henderson, 1996). As pointed out by Mr. Carl Henderson, the manager of electronic business services in CN, the development of EDI in this company "is constrained not so much by available dollars but by the availability of knowledgeable and skilled people to define the business needs, process changes and translate these into effective systems and EDI requirements." This would mean that the integration of the EDI system has already reached the limit that the available financial resources can supply. Further integration would depend greatly on the peoples' knowledge within the company.

Massetti and Zmud's measurements

Facet	Measures of EDI usage
Volume	53% of bills of lading from customers; 100% of waybills from other railroads; 90% of shipment status inquiries; (The company measures its EDI volume by number of transactions rather than by percentage of total transactions. Therefore, detailed function's EDI document share is not available. There are more than 1 million EDI transactions per month in total.)
Breadth	53% of customers; 50% of top suppliers; about 450 other partners.
Diversity	15 business processes (which are advanced interchange consist, bill of lading, booking request, Canada customs, customer access, deprescription, financial EDI, industry reference files, interline settlement system, interline system management, intermodal ramp activity, rate EDI network, ship notice/manifest, U.S. customs, and waybill); more than 60 types of transactions, in ANSI and EDIFACT standards
Depth	Coupled work environment: part of marketing, rail scheduling; Application-to-application: most of marketing, finance, rail operations, and supply management.

The four facets above give an impression about in what extent EDI is used. It is found that the company has a rather high degree of usage in each of the four facets. This is probably the outcome of the company's aggressive approach in employing EDI.

Lummus' six-stage of EDI implementation

The EDI processes are pretty advanced in this company. According to the Lummus' six-stage model (1997), CN has reached Stage 5 (i.e. EDI is integrated with customers. Inquiry of a customer's database for information such as inventory status and shipments is obtainable.) For example, CN can get electronic forecasts of loading schedules at grain elevators throughout Canada from major grain companies. The information is very useful for the railroad to plan ahead so that it can allocate the right number of hopper cars in the right part of the country at the right time. Another good example would be the breakthrough achieved by integrating the EDI system with its customer's SAP order entry system. That particular customer demands that its rail carriers minimize variability in delivery and improve transit times. With the integration of the two systems, any shipment delivery deviation from the expected schedule would trigger an automatic notification to both of the companies.

Furthermore, CN is approaching to Stage 6 (i.e. EDI is integrated throughout the organization. EDI transactions could be found in all functions of the business organization such as quality control, engineering, manufacturing, marketing, and accounting.) As it has been shown in the Massetti and Zmud's measurements on page 62, there are already 15 business processes currently implemented with EDI. The company still keeps on expanding its EDI applications.

Venkatraman's five-level IT-enabled business transformation

According to Venkatraman's model (1994), CN is in Level 4 (Business Network Redesign). Because the relationship between the company and its business partners has changed since the advance of EDI development. For example, the Interline Service

Management (ISM) which is an EDI-based project will eventually enable railroads to trade scheduling information as goods move from one railway to another. Rail-EDI (which links railway databases) allows customers to inquire freight rates, to trace their shipments on their trips across over 130 North America rail carriers, and to exchange electronic messages with CN and the other nine participating railroads. This overall cooperative EDI strategy will allow CN to be more competitive with the trucking industry.

On the customer side, CN obtains forecast information from some of its major customers so that it is able to plan well for the allocation of empty equipment to ensure its prompt services to the customers. The company also integrates its EDI system with its customer's SAP order entry system so as to monitor the customer's shipment delivery status.

In this railroad, EDI is used as a means to redesign the business network rather than as an end in itself. With the well-integrated EDI systems, the company enables itself to create interdependent processes (as with the Interline Service Management), or enhance decision making (as with the availability of the electronic forecast information from its customers), or provide distinctive value-added services (as with the integration with its customer's SAP order entry system) that leads to effectiveness.

Analysis of the Order Fulfillment Process

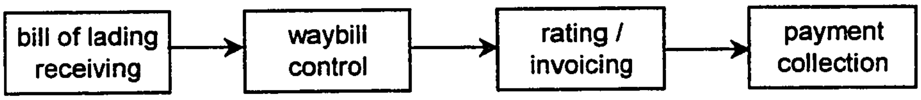
The company being studied is a railway company. Its "order fulfillment process" is to deliver services, i.e. the transportation services, rather than the physical goods. For the railroads, the orders received from customers who request transportation services are called "bills of lading." The document includes information on originating point, destination, weight and, if borders will be crossed, customs information. The information is necessary for the rail operations, and is crucial for customer invoicing and revenue collection. In this context, the "order fulfillment process" for the railroad starts from the receipt of bill of lading and ends at the collection of revenue. It is generally called the "revenue process" within the company.

Description of the process

As a very big railway company, CN's operations are really complex. For example, in the SRS waybill process system, there are around 800 programs handling the daily routine operations and the "specials" (e.g. Different customers may have different requirements in processing their transportation requests.) Some part of the process is highly automated. One good example is the Early Warning System (EWS) in the EDI receiving process. It can send warning messages directly from the system to the responsible personnel's alphanumeric pager for any unexpected delay in the pre-scheduled receiving of EDI messages from some big business partners.

Since the business processes are highly integrated with the internal computer systems, some data, which are usually confidential, are impossible to collect without time-consuming works by the participants. In order to make it manageable in this report, only the major and the higher-level parts of the process are shown. In the simplified revenue process, there are four main sub-processes: bill of lading receiving, waybill control, rating/invoicing, and payment collection.

Figure 9 – Major breakdowns of the revenue process in CN



Bill of lading receiving

This is actually the order-taking process for a railroad. A customer requiring freight services presents a document called bill of lading. This document, sent either physically (by mail or fax) or electronically, describes the commodity to be shipped, its destination and any special transportation or delivery instructions.

If the bill of lading is received in paper form (usually in fax), the information will be entered by the operators using WIP (Waybill Imaging Process) which can show the fax image on the WIP operator's screen. In case some data items are illegible, the bill of lading image is appended to a WIP queue which is handled by the WIP seniors who may call the customers when necessary. Then, the WIP seniors edit and pass the complete bill of lading to the next stage.

If the bill of lading is received in electronic form (i.e. EDI form), the information will be translated in batch of every 15 minutes. During translation, systematic errors are checked automatically by the programs within SRS. If errors are found in the bill of lading, it is sent to a queue called WBERR (waybill error) queue which is handled by the EDI support group who may call the customers when necessary. Then, the complete bill of lading is sent to the next stage.

Another similar document called waybill which is received from other railroads rather than from customers is also fed into the same revenue process. All the waybills from other railroads are received by EDI. These are for connecting freights originated in other partner railroads.

Both bills of lading and waybills are received by Customer Information Service (CIS, a system handling mailboxes, customer interfaces and some other applications like EDI translation.) They are then fed into SRS by a message router. The bill of lading process is time critical because any delay of the information entered into the system will affect the timely transportation service delivered to the customers. Once the bill of lading is completely entered into the system without errors, the delivery of the freight can start any time, for example, upon the receipt of the equipment at the gate for intermodal. The "receipt" activity indicates the readiness of the equipment to leave with the train and would activate the waybill control in the next step.

Waybill control

After the bill of lading is entered into the SRS completely (i.e. free of error), an SRS movement waybill is generated. The SRS movement waybill is used to get the goods shipped to their destination. The SRS then passes a full movement waybill to the Revenue Management System (RMS, part of the SRS, for managing freight related revenue reporting and support services), and an accounting waybill is created. The accounting waybill is used through the later stages to issue the customer an invoice and to collect the payment due.

The RMS process begins with Waybill Estimating. It mechanically analyzes the type of commodity shipped, the size of the car used, as well as the origin and destination points of the load in order to calculate the approximate freight charges. The system estimates the initial revenue (for market forecast purposes) on the waybill based on the statistics gathered from previous waybills over a period of approximately a year. The estimated accounting waybill is then sent to the RMS Waybill Control Edits.

The waybill control edits verify that the accounting waybill provided has all the necessary billing and shipping information to rate and invoice. If a problem is detected, the waybill is routed to the waybill control queue. In this sub-process, the waybill control analyst avoids potential invoicing problems by making sure that such items as scale weight, patron code and tax code have been correctly entered. Once the waybill control analyst has fine-tuned the details, the waybill is sent to the next sub-process – Rating.

Rating/invoicing

If the rate can be mechanically determined, the system generates an account receivable and issues an invoice to the customer if applicable. (Around 20% of customers do not need invoices. They just pay by bill of lading.) If no corresponding rates are found in the computer rating tables, or if the waybill requires specialized billing (e.g., the cargo is a co-load or a transit shipment,) the waybill is sent to a manual rating queue which is handled by the rate representatives whose job is to get the most competitive price for customers based on the rates established by Marketing.

Some waybills are rated before the freight services finish, while others cannot be rated until the freights reach their destinations because the weights of those shipments are taken in the yards along the way or at the destinations. (Not all the locations are with yards to take cargo weights.) About one-third of the waybills are rated at destination.

After the waybill is rated, an invoice (if applicable) is sent to the customer. Invoices (either in EDI or paper form) are sent daily.

Payment collection

Payments are collected electronically or manually. This sub-process is less time-critical because interest rate is counted on daily basis. Therefore, the receiving download schedule of EFT is also on a daily basis. However, only 5% of the freight related revenue is received by EFT.

Documents used in the process

From the process description above, we can see that documents (or information) play an important role in the transportation service delivery. As a matter of fact, EDI was initiated in the transportation industry because of the slow movement of the relevant documents. A closer look at the documents used along the process would give a better idea about how EDI is applied in this railway company. A summary of the relevant documents is shown in Table 19.

As it can be learnt from Table 19, most of the documents used along the process in the company are in electronic format. The company tries as much as it can to use high technology to increase efficiency in its daily business processes. For example, the fax bills of lading received from customers are captured by a system called Waybill Imaging Process which can get the fax images on screen rather than on paper. This would make the filing of bills of lading in better order and the retrievals of information easier in case reference to the originals is needed.

Table 19 – Analysis of the documents used from bill of lading to payment collection in CN

Document Type	Info. from	System	Human intervention / Personnel responsible	Format	Description
Bill of lading	Customer	CIS	Fax B/L is captured by WIP operators and is edited by WIP seniors. EDI B/L is handled by EDI support group in case of errors.	Mail, Fax or EDI(404)	Describing the commodity to be shipped, its destination and any special transportation or delivery instructions.
Waybill	Railroads	CIS	Handled by EDI support group in case of errors found.	EDI(417)	This is from other railroads for connecting freights. The content is similar to B/L.
SRS mvmt waybill	B/L or waybill	SRS	Customer Waybill Center (CWC) if manual work involved	Electronic (internal)	This is to get the cars moved to their destinations or to other railroads. This is also used to move empty cars to specific locations for later use.
RMS mvmt waybill	SRS mvmt waybill	RMS	Waybill control analysts if manual work needed.	Electronic (internal)	Once the freight starts to move, an RMS mvmt waybill is generated for later revenue collection.
Acctng waybill	RMS mvmt waybill	RMS	Waybill control analysts (for waybill control edits) Rate representatives (for manual rating)	Electronic (internal)	The information in this document is used to issue the customer an invoice. The accounting waybill should pass the waybill estimating, the waybill control edit, and the rating before a corresponding invoice is generated.
Invoice	Accounting waybill	RMS	A/R representatives	Paper or EDI(810)	This is generated by RMS from the accounting waybill. Then, it is sent to customer through EDI(810) or by mail.
Payment advice	Customer / Bank	RMS	A/R representatives	Paper or EDI(820, 823)	Customers can pay manually or electronically.

Preliminary data analysis for simulation

The main objective of this research is to see how integration of EDI with business processes can effect on the process performance. The collection of data in this case is done on a higher level without digging too deep into the details of lower levels. This is because the business processes in this company are highly complex and the collection of detailed data would require unreasonable amount of resources. More importantly, the data in lower levels are usually confidential and are impossible to collect without time-consuming works by the participants. Still, the higher level is good enough for evaluating the effect of EDI integration.

The higher level cycle times can be obtained from the reports which are used to constantly monitor the performance of the process by the company. For the lower level cycle times like data-entry time are obtained by interviewing the personnel concerned. They can give average cycle time figures by their perception and experience. Due to the unavailability of precise data set, some assumptions are made on the data in order to create the process model for simulation. For example, the data entry time for fax bill of lading is assumed to be normally distributed (Since the number of items in each bill to be input is similar, the input time should be more or less around a certain amount.), and the machine processing time is expected to be exponentially distributed according to the nature of the process.

Only the daily frequency of bill of lading is available. From the interviews, it is learnt that most of the bills are received in daytime. Therefore, 90% of the bills are assumed to be received evenly from 7:00 a.m. to 7:00 p.m. and 10% from 7:00 p.m. to 7:00 a.m. the next morning. It is also found that the number of bills of lading is much smaller in weekends. But since the bill of lading process is likely to be finished within a day, the simulation process is based on a typical day, with weekends ignored.

Simulation results

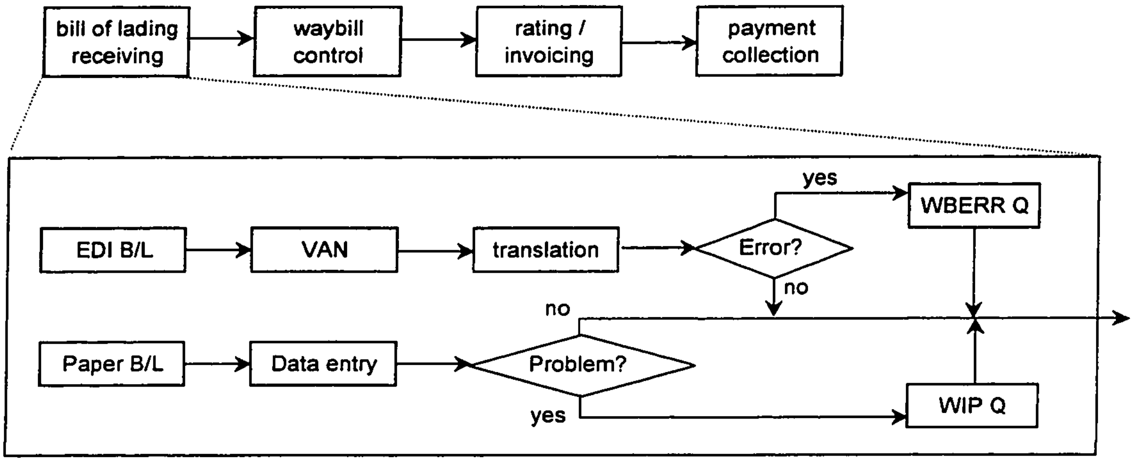
The company has already achieved a high level of internal integration of EDI. The search of further internal integration opportunities would require more involvement of the company staff. Still, external integration can be improved and investigated by using simulation. Two scenarios are then set up to evaluate the impact of the EDI implementation in the bill of lading process. A summary of scenarios is shown in Table 20. (Refer to Appendix 3 for process maps.) Similar to Case 1 in this research, the process models are developed and simulated to see the changes in the key performance measures (cycle time and processing cost) in different scenarios. In this case, the bill of lading process is likely to finish within one day. Therefore, the models are simulated for a period of one day with five replications.

Table 20 – Summary of the scenarios in Case 2

Scenario	Description
1	Current situation (with EDI and fax bills of lading)
2	Better external integration: the current EDI solution is extended to the remaining customers, i.e., the current total number of bills of lading is received by EDI only.

Since the bill of lading process is time critical for the whole revenue process, it is emphasized and described into lower levels in this study. The other three sub-processes (waybill control, rating/invoicing and payment collection) are not expanded further because their cycle times will based on a lot of factors other than those only related to EDI. For example, payment terms, price bases, origins, often make a difference in terms of rating time and the duration from invoice to cash. To make things worse, these factors are not unique even within a customer, meaning that one customer may have several payment terms. Therefore, the three sub-processes are shown on a higher level with average cycle times only. A simplified diagram in Figure 10 shows the sub-processes within the bill of lading process. (Refer to page 66 for the description of the process.)

Figure 10 – Sub-processes of the bill of lading process (Case 2)



Key performance measures

There are two key performance measures in this case: cycle time and processing cost. The cycle time measured here is only for the duration for the bill of lading process. The overall figures for EDI bill of lading and paper bill of lading are available from the weekly reports generated by the relevant departments. Yet it is beneficial to look into the sub-processes to calculate the rough processing cost. Processing cost is calculated by using activity-based costing. For example, if a certain amount of time of an operator is spent on entering the data for paper bill of lading, that portion of the operator's salary should be allocated to be the processing cost for the bill of lading process.

Scenario 1

Table 21 – Key performance measures for Scenario 1 (Case 2)

	Replication					Average
	1	2	3	4	5	
Paper bill of lading						
Number received	3,186	3,161	3,171	3,201	3,258	**3,195**
Cycle time (hours/bill)	2.23	2.15	2.24	2.25	2.30	**2.23**
Processing cost (dollars/bill)	3.23	3.18	3.19	3.17	3.14	**3.18**
EDI bill of lading						
Number received	3,358	3,242	3,241	3,296	3,207	**3,269**
Cycle time (hours/bill)	0.26	0.26	0.26	0.27	0.26	**0.26**
Processing cost (dollars/bill)	0.24	0.25	0.25	0.25	0.24	**0.25**

Interpretation:

From the table above, we can see that the performance of EDI bill of lading is a lot better than paper bill of lading. The EDI bills need 88% less cycle time and 92% less cost to process. Based on the available data, the big difference between EDI and non-EDI bills of lading is mainly because of the difference in time and cost spent on the data input for the two kinds of bills. The EDI bills are transmitted in a standard format so that the internal applications can process the bills without human intervention under normal circumstances. The EDI representatives deal with the "exceptions" only. On the other hand, the paper bills are sometimes sent in various formats (Some customers use their own forms rather than the railroad's standard form.) and the data-entry operators has to search through the "free" forms for the required information. Sometimes the paper bills are not complete or illegible and the seniors have to call the customers in order to complete the bills. In the worst cases, the customers cannot provide the necessary information right away and the process may last several days.

The paper bills of lading may cost even more in the real situation. This is because the customers can send their faxes by using a toll-free phone number (1-800). There is no detailed breakdowns of the toll-free telephone charges for the railroad. Therefore, the figure is not available for this simulation. There are also some other costs, like the computer running costs, are not shown in the simulation. Readers are reminded that these are rough estimations only. More accurate analysis would require detailed data collection which is currently very difficult to do.

In this case, the EDI implementation is well-integrated into the business processes. Minimum human intervention is needed during the EDI process. The Early Warning System (EWS) is a good example of high-level integration. Since the EDI integration level is very high, the difference in performance between the EDI and non-EDI transactions are very big. That means the benefits claimed are impressive.

Scenario 2

Table 22 – Key performance measures for Scenario 2 (Case 2)

	Replication					
	1	2	3	4	5	Average
EDI bill of lading						
Number received	6,471	6,671	6,536	6,494	6,405	**6,515**
Cycle time (hours/bill)	0.27	0.27	0.26	0.26	0.26	**0.26**
Processing cost (dollars/bill)	0.26	0.24	0.24	0.24	0.25	**0.25**

Interpretation:

In this scenario, we can see that even all the paper bills are fed into the EDI process, the results are similar to those for the EDI bill of lading in Scenario 1. This means that the current EDI work force can manage the extra amount of bills of lading. Actually most of the work is done by computer automatically. The workload of relevant personnel is not increased very much because of the extra bills. However, it should be noted that the available time for the EDI representatives to answer customers' inquiries will be less if more bills are sent by EDI, since they have to spend more time on editing. And, there are no data for us to judge if the computer systems would be able to process the extra bills with the same processing speed. Again, all of these would require more detailed data collection.

Discussion for the two scenarios

High level integration of EDI with the business process is proposed to gain substantial benefits. In this company, the EDI system has been being developed for many years and is already well-integrated internally. The Early Warning System (EWS) is a good example. The search of further internal integration will definitely require more involvement of the process owners and workers. In view of that, the focus of the simulation analysis is put on external integration only. The two scenarios show how better EDI external integration can help to reduce cycle time and processing cost in the bill of lading process.

DISCUSSION

The main idea behind this research is that doing EDI alone is not enough because an independent implementation would not provide significant benefits to the adopter organizations, but an integrated approach would. From the two cases studied, the integration of EDI with business process has effect on the performance of the processes involved. The two heterogeneous cases give significant demonstration about how EDI works within the organizations and support the main idea of this research.

Although the two cases are different in several factors (i.e., size, industry, and years of experience in EDI), the four proposed frameworks provide a means for comparisons. According to the Iacovou et al. (1995) framework, the company in Case 1 is classified as an "unmotivated adopter" while that in Case 2 is classified as a "ready adopter." They do not have the same attitude towards EDI. The degree of perceived benefits in Case 1 is lower than that in Case 2. The analysis of the cases shows that both internal and external integration are low in Case 1 but are high in Case 2. This result agrees with previous research such as what Iacovou et al. (1995) suggested that both organizational readiness and perceived benefits are required for highly integrated systems.

The Massetti and Zmud (1996) framework provides a portrait about how EDI is used within the organizations. The framework, together with the other two (i.e., the Lummus' (1997) and the Venkatraman's (1994)), gives more details about the level of the EDI integration and how EDI is used for process reengineering. Again, it is found that the EDI system in Case 2 is much more sophisticated than that in Case 1, in other words, Case 2 has a higher level of integration.

The benefits of EDI in the two companies are investigated by using simulation to compare the performance of the EDI and the paper orders (i.e., cycle time and processing cost) in each company. It is found that no advantage is gained in Case 1 before any re-arrangement of the business processes. However, a significant difference in performance between EDI and non-EDI bills of lading is obtained by Case 2. This supports that EDI integration is necessary for realizing substantial benefits from EDI implementation, as Case 1 and 2 have different levels of EDI integration. Moreover, the simulation results show that even more benefits can be gained from EDI by redesigning the current processes. The research findings clarify the relationship between EDI implementation and BPR. It is obvious that the EDI implementation together with BPR provides dramatic advantages to the adopter organizations.

In this research, the combination of qualitative case analysis methods with process modeling techniques contributes to the attainment of the research objectives. On one hand, case analysis methods help in examining the EDI implementation (e.g. the environmental factors and the level of integration) and its performance. This is done by using frameworks from previous research to provide a basis for comparisons between the two cases. On the other hand, process modeling techniques help to study the potential EDI impact. This is done by using process mapping and simulation. Process mapping assists in displaying a clear and comprehensive picture of the current business processes so that the non-value-added sub-processes stand out. Simulation allows the researcher to do experiments on various scenarios to evaluate the potential impact quantitatively.

In practical situations, process modeling could supply the decision makers with the quantitative information they need in order to make informed decisions. This research gives a good example showing how process modeling is used to evaluate the potential impact of the different scenarios and to improve the EDI implementation. Without investing in the real implementation, the decision makers can plan ahead with the simulation results.

LIMITATIONS

Multiple cases are used to enhance the external validity of this research. However, only theoretical replication (heterogeneous cases) is made due to the limitation of the sample population. Although several replications are made in the simulation runs, it is still preferable, if possible, to have literal replication (homogeneous cases) in order to provide more evidence about the findings.

A complete simulation study requires verification (a determination of whether the model is built right) and validation (a determination of whether the right model is built) of the simulation process models. Verification was carried out by following the principles of structured programming, self-documenting the models, checking whether the input data are used appropriately, and ensuring the output is within reasonable range. But, validation cannot be carried out completely because of the limited resources. Face validation was done with the knowledgeable experts within the organizations, and so were some sensitivity analyses. (For example, if only one variable is changed, the output should be within expectation.) However, if possible, it will be better to compare statistically the simulation output with the output from the real system. Yet, this would require the participants to spend a lot more time on that. Still, the models are validated to some extent. But if the participants would really like to make re-arrangements on the process based on the simulation output, it is suggested to have a complete validation.

The researcher has made some re-arrangements on the current processes in Case 1 in order to show how EDI integration effects on the benefits gained. The integration is a form of reengineering effort. However, as suggested by Hammer and Champy (1993), the reengineering would require a team (especially with the process owners and experts involved in) to accomplish. The real reengineering effort would likely be different from what is shown in this research. Yet, the research is conceptually good enough to show how the reengineering will affect the EDI implementation.

FUTURE RESEARCH

This research shows conceptually how EDI integration would affect the performance of the EDI process with the aid of a process modeling tool. No actual reengineering effort was really made to the current processes in this research study. Future researchers could take this way ahead. They may take a longer time and may involve a reengineering team to work out the reengineering effort to see whether the re-arrangements would really give the same results as the simulation suggests.

CONCLUSION

From the two cases in this research, it can be learnt that EDI alone does not provide significant benefits to the adopters. However, if EDI is used as an enabler for business process reengineering (here, in the form of integration with the business process), dramatic improvement could be obtained. It is also found that process modeling techniques can help on the way to reengineering. Adopter organizations may take this as a guideline to implement their EDI development.

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APPENDIX 1 – STRUCTURED QUESTIONS

The following structured questions were sent to the relevant employees in the participant companies by e-mails. (Questions were slightly modified according to the company situation.) The information collected are mainly for the classification of the companies by the frameworks.

1) How much is the revenue for the year of 1997 (or 1996)?
2) What is the number of employees in the organization, in IT dept., and in EDI support?
3) Who are the major competitors to your company? About how many competitors does the company have?
4) How many customers does the company have?
5) What kinds of suppliers does the company have? How many suppliers does the company have?
6) What do you think the major direct (immediate) benefits from the current EDI processes are?
7) What do you think the major indirect (long-term) benefits from the current EDI processes are?
8) What is the budget for IT development for the year of 1997 and 1998?
9) What is the budget for EDI development for the year of 1997 and 1998?
10) Do you think the company has enough financial resources for IT and EDI development? If no, how much more is needed? And for what specific purpose?
11) Do you think the company has enough technological resources (hardware, software, and technical personnel) for IT and EDI development? If no, how much more is needed? And for what specific purpose?
12) Do you agree that the market is highly competitive for your company? If yes, do you think the competitive market puts pressure on your EDI development?
13) Do you think your business partners (customers, suppliers, etc.) put pressure on your EDI development? If yes, who are they and why?

14) Do you have the following measurements for the extent of EDI usage in your organization?

% of function's documents exchanged via EDI: For example, % of marketing document, % of supply management document, % of rail operations document, % of finance document

% of organization's documents exchanged via EDI

% of business partners connected with EDI (by function): For example, % of customers, % of suppliers, % of other railroads, % of other partners

% of organization's total business partners connected with EDI

Number of business functions using EDI

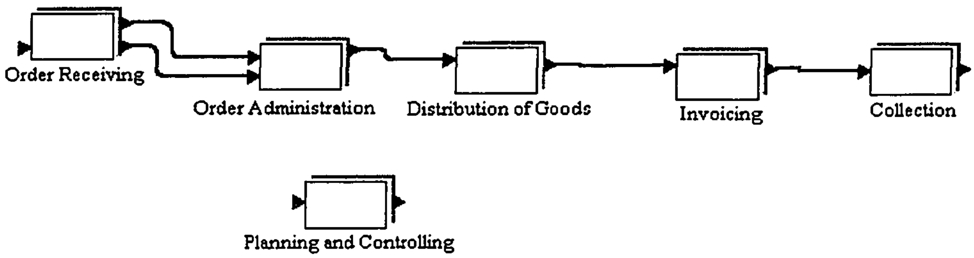
Number of document types exchanged via EDI

APPENDIX 2 – PROCESS MAPS FOR CASE 1

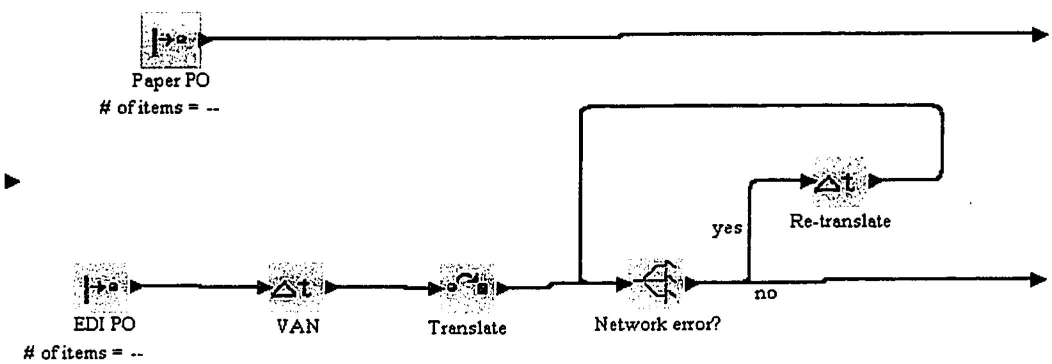
SCENARIO 1

Level 0 (top level)

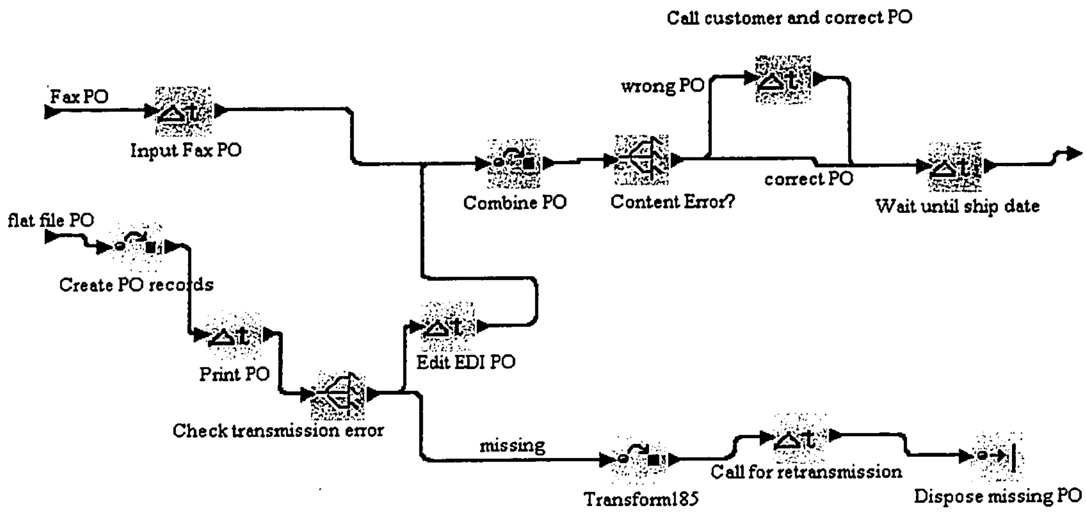
Order Fulfillment Process



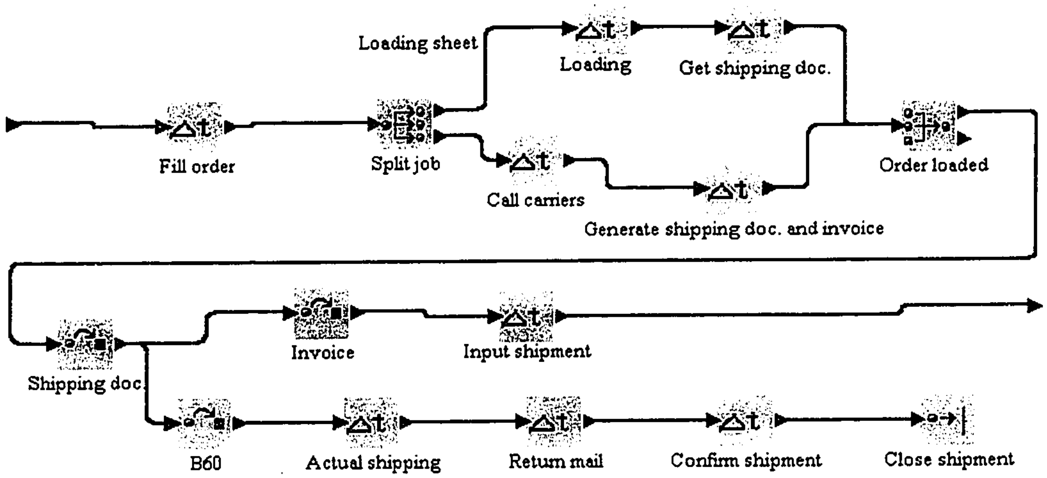
Level 1 – Order Receiving



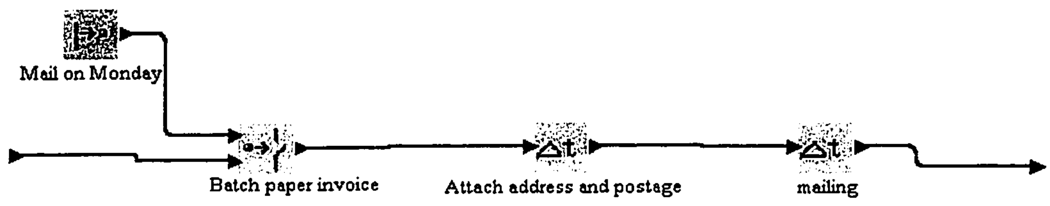
Level 1 – Order Administration



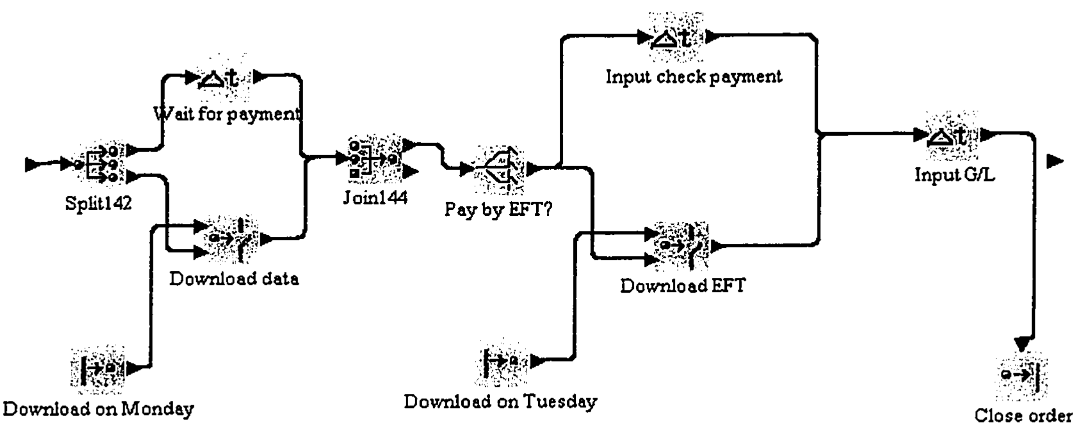
Level 1 – Distribution of Goods



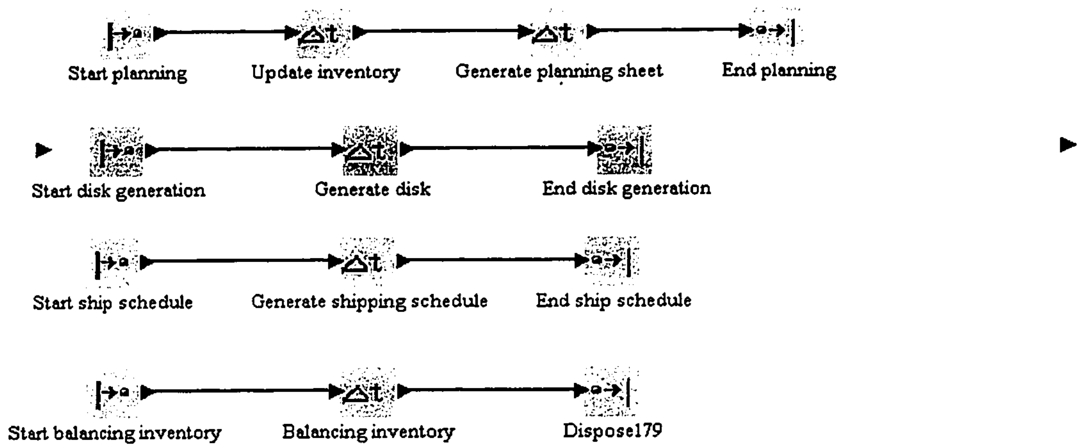
Level 1 – Invoicing



Level 1 – Collection



Level 1 – Planning and Controlling

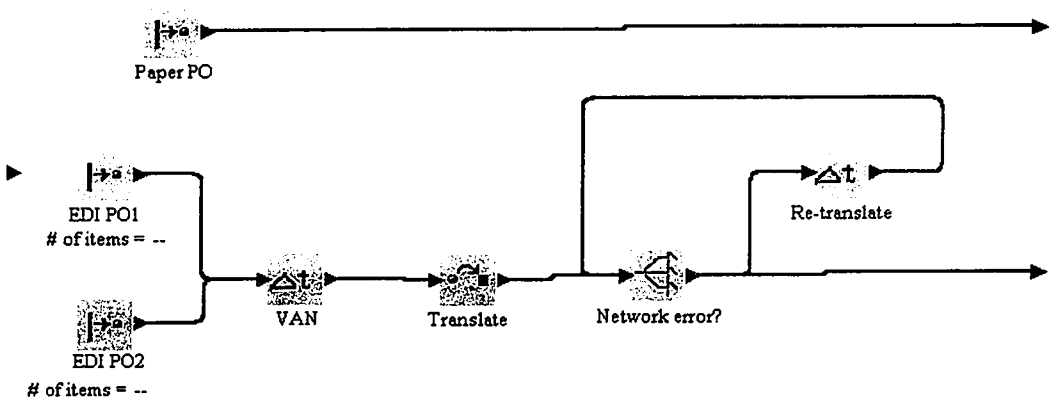


<u>SCENARIO 2</u>

All the maps in Scenario 2 are the same as those in Scenario 1, except the diagram for "Order Receiving" in Level 1.

Level 1 – Order Receiving

(Note: In this scenario, no "Paper PO" will be received in the simulation.)

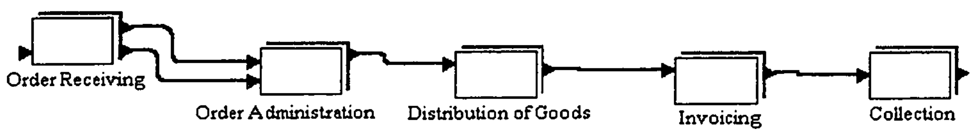


SCENARIO 3

All the maps in Scenario 3 will be the same as those in Scenario 2, except the diagram in Level 0. No "Paper PO" will be received in the simulation. In addition, no diagram will be for "Planning and Controlling" in Level 1.

Level 0

Order Fulfillment Process



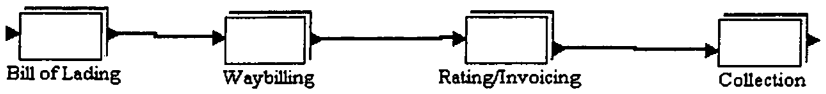
SCENARIO 4

All the process maps in Scenario 4 will be the same as those in Scenario 3, except the diagram for "Order Receiving" in Level 1, which will be same as that in Scenario 1. "Paper PO" will be received in the simulation.

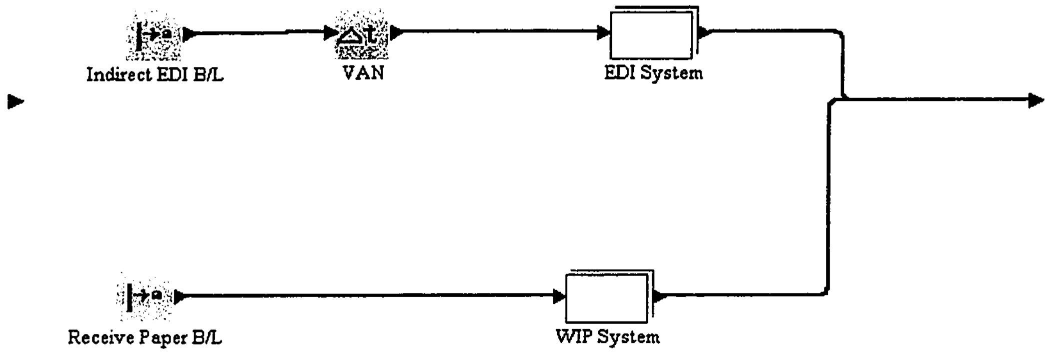
APPENDIX 3 – PROCESS MAPS FOR CASE 2

SCENARIO 1

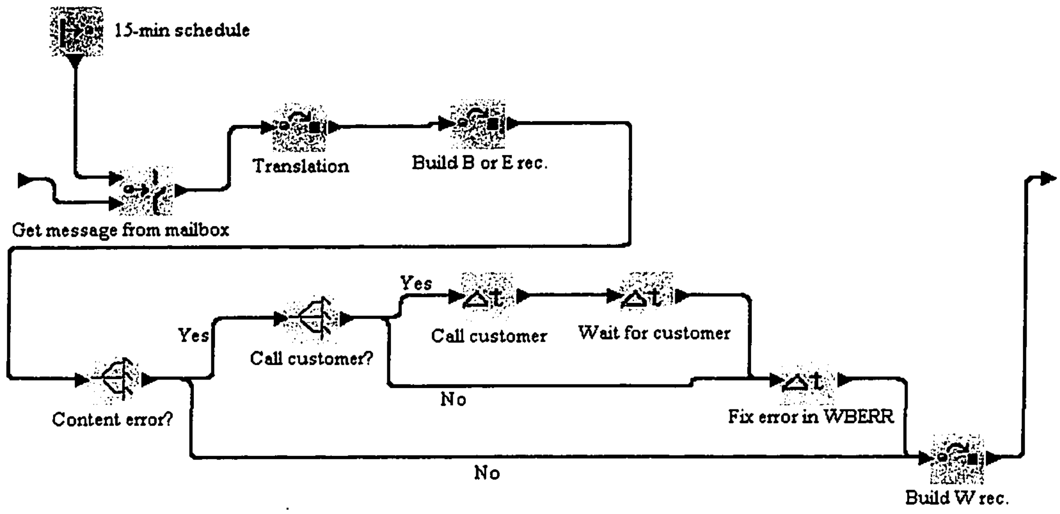
Level 0 (top level)



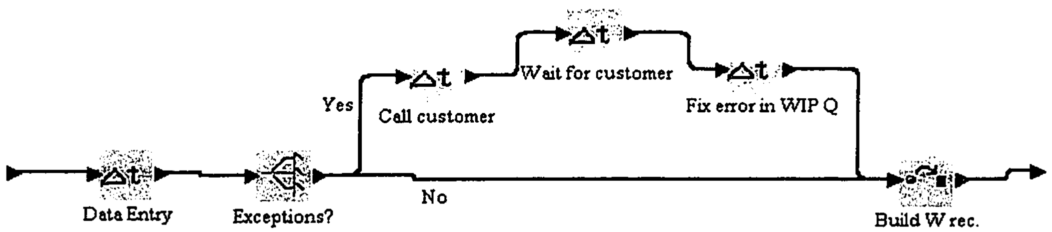
Level 1 – Bill of Lading



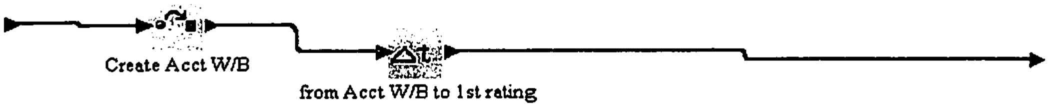
Level 2 – EDI System



Level 2 – WIP System

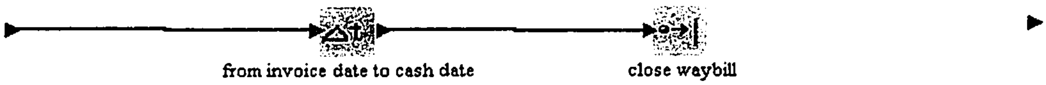


Level 1 – Waybilling



Level 1 – Rating/Invoicing

Level 1 – Collection

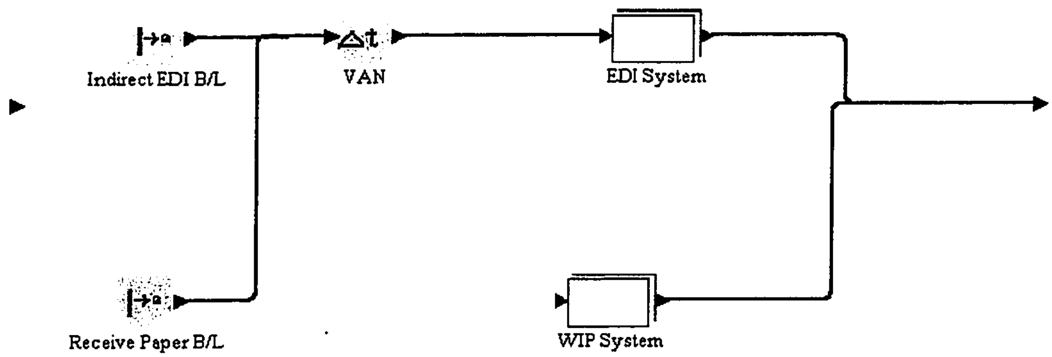


SCENARIO 2

All the process maps in Scenario 2 will be the same as those in Scenario 1, except the diagram for "Bill of Lading" in Level 1.

Level 1 – Bill of Lading

(Note: No bill of lading will be sent through the WIP System.)



APPENDIX 4 – SAMPLE SIMULATION RESULTS (SIMPROCESS REPORT)

SIMPROCESS Standard Report
Extracted from output file: C:\Program Files\SIMPROCESS\SPUSER\Thesis\Scen1.mon
Simulation Concluded at : Mon Mar 23 17:11:50 1998

Entity : Total Count - Observation Based : Replication 1

Entity Names	Total Generated	Remaining In System	Total Processed
Fax PO	918	2	916
PO flat file	499	0	499
PO EDI rec.	499	0	499
Invoice	1347	665	682
EDI PO	504	5	499
Loading sheet	1347	0	1347
weekly schedule	39	0	39
PO rec.	1410	63	1347
Payment term	1232	476	756
B60	1347	110	1237
PlanRoutine	65	0	65
GenDiskRoutine	65	0	65
ShipSchdlRoutin	65	0	65
BalRoutine	65	0	65
missing EDI rec	5	0	5
Shipping doc.	2694	0	2694

Entity : In System Count - Time Weighted : Replication 1

Entity Names	Average	Maximum
Fax PO	3.098	33
PO flat file	0.003	28
PO EDI rec.	2.090	40
Invoice	456.936	674
EDI PO	3.061	31
Loading sheet	1.174	37
weekly schedule	0.000	2
PO rec.	58.074	94
Payment term	326.251	539
B60	94.719	231
PlanRoutine	0.132	2
GenDiskRoutine	0.110	2
ShipSchdlRoutin	0.099	2
BalRoutine	0.831	8
missing EDI rec	0.000	1
Shipping doc.	0.000	1

Entity : Cycle Time (in Hours) By State - Observation Based : Replication 1

		Total In Process----		Duration At Activity		Wait For Resources--		Hold For Conditions-	
Entity Names	#Observed	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Fax PO	916	5.069	49.755	0.034	0.092	5.035	49.734	0.000	0.000
PO EDI rec.	499	9.149	51.501	0.021	0.035	9.128	51.483	0.000	0.000
EDI PO	499	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Entity : Cycle Time (in Hours) - Observation Based : Replication 1

Entity Names	#Observed	Average	Maximum
PO flat file	499	0.012	2.050
Invoice	682	953.645	1099.137
Loading sheet	1347	1.903	64.505
weekly schedule	39	0.000	0.000
PO rec.	1347	82.177	1154.005
Payment term	756	720.000	720.000
B60	1237	156.997	525.767
PlanRoutine	65	4.443	26.732
GenDiskRoutine	65	3.686	24.582
ShipSchdlRoutin	65	3.316	24.207
BalRoutine	65	27.918	234.976
missing EDI rec	5	0.124	0.196
Shipping doc.	2694	0.000	0.000

Resource : Units Busy - Time Weighted : Replication 1

Resource Names	Capacity	Average	Maximum	Percent
Telephone	1.000	0.001	1.000	0.066%
Foreman	1.000	0.020	1.000	2.034%
A/R Clerk	1.000	0.010	1.000	1.017%
VAN	1.000	0.000	1.000	0.000%
Mail clerk	1.000	0.006	1.000	0.614%
Paper	7365.844	0.210	3.000	0.003%
Postage	9438.347	0.006	1.000	0.000%
EDI coordinator	1.000	0.000	1.000	0.028%
Printer	1.000	0.065	1.000	6.532%

Resource : Number of Units By State - Time Weighted : Replication 1

		------Idle------		------Busy------		-----Planned---- Downtime		----Unplanned--- Downtime		----Reserved----	
Resource Names	Capacity	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Shipping Clerk	1.000	0.026	1.000	0.189	1.000	0.786	1.000	0.000	0.000	0.000	0.000

Resource : Percent Utilization By State : Replication 1

Resource Names	Idle	Busy	Planned	Unplanned	Reserved
Shipping Clerk	2.555%	18.860%	78.585%	0.000%	0.000%

Activity : Entity Cycle Time (in Hours) By State at Selected Activity - Observation Based : Replication 1

Activity Names	-------Total In Process--------			-----Duration At Activity------			-------Wait For Resource-------		
.Entity Names	Average	Maximum	#Observed	Average	Maximum	#Observed	Average	Maximum	#Observed
Fill order	8.347	64.733	1347	0.069	0.174	1347	8.278	64.664	1347

Time Stamp : Time Elapsed (in Hours) - Observation Based : Replication 1

Stamp Keys	Average	Std. Dev.	Minimum	Maximum	#Observed
StFaxPO to EdFa	5.069	8.744	0.021	49.755	916
StEdiPO to EdEd	9.161	11.940	0.066	51.501	494
StPOrec to EdPO	82.177	115.002	0.686	1154.005	1347
StWait to EdWai	70.812	113.311	0.000	1152.000	1354
StPOrec1 to EdP	0.947	2.961	0.000	22.487	1410
StPOrec2 to EdP	10.333	16.426	0.576	66.994	1347

Attributes : Replication 1

Attribute Names	Stat Type	Average	Std. Dev.	Minimum	Maximum	#Observed	Current
Model							
.F15	observatn	309.000	178.112	1.000	617.000	617	0
.F30	observatn	150.000	86.313	1.000	299.000	299	0
.E16	observatn	242.000	139.430	1.000	483.000	483	0
.E30	observatn	6.000	3.162	1.000	11.000	11	0

Entity : Cost Of Processing in Dollars : Replication 1

	----- Capacity ------		----- Absorption ----	
Entity Name	Total Cost	Avg. Cost per Entity	Total Cost	Avg. Cost per Entity
Fax PO	682.66	0.75	774.16	0.85
PO flat file	N/A	N/A	N/A	N/A
PO EDI rec.	219.46	0.44	248.65	0.50
Invoice	1849.69	2.71	12864.23	18.86
EDI PO	235.88	0.47	235.88	0.47
Loading sheet	N/A	N/A	N/A	N/A
weekly schedule	N/A	N/A	N/A	N/A
PO rec.	5192.04	3.85	5888.36	4.37
Payment term	N/A	N/A	N/A	N/A
B60	448.89	0.36	509.71	0.41
PlanRoutine	1266.92	19.49	1438.57	22.13
GenDiskRoutine	117.94	1.81	133.92	2.06
ShipSchdlRoutin	317.32	4.88	360.31	5.54
BalRoutine	575.56	8.85	653.54	10.05
missing EDI rec	12.41	2.48	12.41	2.48
Shipping doc.	N/A	N/A	N/A	N/A

Resource : Cost Of Use in Dollars : Replication 1

	----- Capacity ------		----- Absorption ----	
Resource Name	Total Cost	Avg. Cost per Unit	Total Cost	Avg. Cost per Unit
Shipping Clerk	8968.45	8968.45	10183.56	10183.56
Telephone	32.69	32.69	32.69	32.69
Foreman	N/A	N/A	N/A	N/A
A/R Clerk	652.48	652.48	11638.36	11638.36
VAN	235.88	235.88	235.88	235.88
Mail clerk	N/A	N/A	N/A	N/A
Paper	43.65	0.01	43.65	0.01
Postage	985.60	0.10	985.60	0.10
EDI coordinator	N/A	N/A	N/A	N/A
Printer	N/A	N/A	N/A	N/A