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TABLE CONTENTS

THE EFFECT OF EMERGENCY WAITING TIME ON PATIENT SATISFACTION

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ABSTRACT

The federal law requires hospitals to offer emergency care to everyone that come through the doors, despite their ability to pay. The use of emergency care doctors as primary physicians along with other factors have contributed to emergency waiting time. The purpose of this paper is to examine waiting times at hospitals in Jefferson and Orleans parishes' in respect to the average national waiting times and patient satisfaction. A data driven model and a survey method included face-to-face interviews and on-line survey tool were applied. 200 respondents were surveyed to distinguish the coalition of actual waiting time and patient expected waiting time. Data was gathered from six hospitals. The result of the analysis of data shows that overall 33% patients were satisfied with the emergency departments' service. Furthermore, the data revealed that 45% of the patients are very satisfied with the service provided by the doctors. However, only 27% of the patients are very satisfied with care from the emergency room administration. Additionally, the examination of the data show that national waiting time of 4 hours 5 minutes is higher than the actual waiting time of the hospitals surveyed. This research could be helpful to hospital emergency room management in reducing the waiting time and increasing patient satisfaction.

Keywords: Actual and Expected Emergency room waiting times, patient satisfaction

INTRODUCTION

Healthcare issues have been a problem for many Americans for years. A number of presidents have tried to reform the Healthcare system. Today more people than ever are financially and medically are at risk because they might not be able to effort health insurance and to be treated at the earlier stage of their sickness (Glied, 2010). Perhaps, this is one of the many reasons that on March 23, 2010, president Obama signed the Affordable Care Act which allows for a complete health insurance reforms (The White House, 2010). The promise of this reform is that the poor and those who cannot afford medical expenses can get proper health care. However, these law changes do not affect the problem that Hospital emergency departments as they are faced today.

Without a doubt, when looking at Healthcare reform, we cannot overlook the problem of overcrowding and lengthy waiting times in most emergency rooms (Horwitz, 2009). In 2008, a study was conducted by Ontario researchers where they stated, long waiting time not only affects patient satisfaction, and they increase the risk of death and hospital readmission for patients who have been discharged from the emergency department (Laupacis, 2011). According to the

American College of Emergency Physicians, emergency room visits will continue to rise, regardless of the Healthcare ruling (Cheung-Larivee, 2012). Many Americans today are living without healthcare insurance, so they are using the emergency room doctors as their primary physician (The White House, 2010).

Statement of the Problem

In 2007, a nationwide Emergency Room Pulse Report was done to examine more than 1.5 million patients treated at 1656 emergency rooms. The experiment findings concluded that:

- The average waiting time in emergency rooms was 4 hours, 5 minutes, which has increased by 5 minutes from the previous year.
- Unpredictability, the state by state average waiting times were between 2 hours to 6 hours.
- Another important point was that geographic location showed a distinguishing difference in overall satisfaction. In the top 10 patient satisfaction report, the highest levels were from the emergency room in Milwaukee, WI, with New Orleans, LA coming in 5th.
- The study showed that a shift in waiting times was the main overall issue when dealing with patient satisfaction. It was revealed that the Emergency Department could alleviate patient satisfaction even when waiting times were high, by updating patient with information while they were waiting (Emergency Department Resources, 2008).

These facts and observation support the idea that the quality of care and waiting times patients are receiving, should be taken into consideration when looking at patient satisfaction. Indeed, long waiting times have increased the risk of mortalities. Today we must consider the idea that some people may not mind waiting for care if the quality of care is satisfactory.

Many hospitals measure waiting times as the average time from arrival and check-in, to the time when the patient is placed in a room and care is started (Shelton, 2013). Nevertheless, there is not a set rule when it comes to how hospitals actually handle emergency room waiting times. According to a new report from 2010 Emergency Department Pulse Report, from the moment patients walk into a hospital emergency room until the time they are discharged from the emergency department, the average time spent 4 hours and 5 minutes (Emergency Department Resources, 2009). Many researchers have found that waiting times are different depending on the number of patients to be seen, triage procedures, staffing, and availability of beds (Shaikh, 2012). The Press Ganey Association states that to improve the patient experience, health care providers must first be able to see and understand "the complex relationships between satisfaction, clinical, safety and financial measures" (Emergency Department Resources, 2010).

Statement of the Objective

According to the Board of Health Care Services, one out of every three Americans is visiting the hospital emergency department a year, which account for more than 114 million people (HCS, 2007). Studies have shown that the rise in waiting times and overcrowding in emergency departments has had an unfavorable effect on the acute sick in the emergency rooms (Horwitz, 2009). As a result, most Americans are not willing to wait no more than 2 hours for emergency care (Shaikh, 2012). It is evident that we attempt to look at all aspects of the emergency room care given today, in respect to waiting times and patient satisfaction. The main objective of this research project is to:

- Compare the actual waiting times and expected waiting times of the several local hospitals in respect to the national average waiting times.
- Show that patient satisfaction has an overwhelming coalition to actual waiting times.

BACKGROUND

The Emergency Departments of the United States started with the railroad companies'. They were the first to use accidental services in the nineteenth century. In 1911, the first trauma care specialized center opened at the University of Louisville Hospital in Louisville, Kentucky. In the 1930s, Arnold Griswold, a surgeon, was credited for Louisville hospital development (The American Heritage Medical Dictionary, 2007). The structures of emergency departments in most hospital are the same. They are location on the bottom floor, with its own entrance and exit. Patients are able to come in "round-the-clock, 24 hours per day, 7 days per week, and 365 days per year" with no restrictions on who gets care. Patient can come in with any type of complaint, and go thought the triage process. The emergency department triage is "the sorting of injured or sick people according to their need for emergency medical attention" (Torrey, 2012). This system of check-in is used to determine priority, to see who gets care first; triage can be performed by any emergency medical technician.

The emergency department is responsible for the first line of care in urgent medical matters. In fact, Healthcare professional are trained to deal with all types of health problems, such as trauma, major injuries, serious and life-threatening illnesses. In most emergency departments, patients are cared for with no regard to age, race, gender or insurance status (Nelnet Company, 2012).

According to Researchers from the International Journal of Emergency Medicine, the emergency department is characterized in four ways: "Physical location of ED", "Physical layout of ED", "Time period open to patients of ED" and "Patient type served by ED".

The physical location of the emergency department can be placed into two groups: "hospital-based EDs" and "freestanding EDs." Hospital-based emergency departments are found in acute and specialty hospitals, which accounts for the more than 4600 emergency department today. Freestanding ED offers the same type service as the acute emergency department, but they are mostly located in rural areas where there are no nearby hospitals (Steptoe, 2011).

In addition, there are two types of physical layouts of emergency departments; contiguous and noncontiguous. In a contiguous environment, medical and surgery treatment are in "one or adjacent areas" of the hospital. However, some patients sought emergency care in noncontiguous emergency departments. These service locations offer care from several different departments depending on the type of care needed by the patient (Steptoe, 2011). For example, a patient with brain injuries might receive care in the Neurology Department, but in the same hospital, a patient with a heart attack would be seen in the Cardiology Department.

The authors described "time period open to patients of ED" as the time emergency departments are open. In the United States most emergency department are open "round-the-clock" 24 hours per day, 7 days per week, and 365 days per year, Nonetheless, the article brings out the point that there are some emergency department that are part-time, but in the United States these care units are called urgent care facilities.

The last characteristic the authors ended with is “Patient type served.” The authors let us know that there are three main groups of patients served: “general population EDs,” “adult EDs” and “pediatric ED.” The general population emergency department was defined as “service given to all patients regardless of age, sex, race/ethnicity or other major socio-demographic factors” which is a combination of adult and children cared for in one location. On the other hand, there are some faculties that separate adults and children in two different areas. In spite of all this, the authors concluded “Viewing emergency care on the ED level allows researchers to track the development of an emergency care system while embracing the fact that systems of emergency care must adapt to local circumstances to succeed.” These views let us know that all emergency department cultures are not the same (Steptoe, 2011).

Emergency Room Waiting Times

According to an article published by Health Affairs the author defines emergency department wait times as “the time a person arrives in the ED, to when they first see the doctor” (Hospitals & Health Networks, 2008). He also bring attention to the fact that although waiting times were longer for all demographic groups, indisputably, he found waiting times for Blacks were 13 percent longer and 14.5 percent longer for Hispanic than for Whites. Furthermore, he found that waiting times for women were 5.6 percent longer than for men (Hospitals & Health Networks, 2008).

An investigation by the American College of Emergency Physicians (2006) revealed that out of 4,917 hospitals surveyed, 4,862 (99%) reported 101.6 million visits per year. Yet, only 1 out of 3 emergency departments "received less than 8,760 visits per year; the national median was 15,711 visits per year" (Sullivan, 2006). “Among all ED per-capita visits varied by state, with the highest ED visit rates in Washington, DC; West Virginia; and Mississippi” (Sullivan, 2006)..

Finally, in a report done by The Institute of Health, researcher stated that only a minority of emergency department actually achieved suggested waiting times for all of their emergency departments and less than half hospitals consistently admitted patients within 6 hours. These findings indicate that emergency waiting times and the length of a patient care are the main determinant of “timeliness,” “efficiency,” “safety” and “patient-centeredness” of emergency care (Horwitz, 2009, Hing, 2012).

The Risks of Emergency Department Overcrowding

In an article on “Frequent overcrowding in U.S. emergency departments” the authors defined overcrowding as patients waiting in hallways, all the emergency room beds are occupied, full waiting rooms with patients waiting more than 6 hours and acutely ill patients waiting more than 60 minutes (Derlet, 2001).

In like matter, The American College of Emergency Physician defines overcrowding as a healthcare problem that is caused by an increase in patient volumes, staff shortages, insufficient beds and poor triage flow (Laupacis, 2011). Without a doubt, evidence show that overcrowding cause doctors not to have adequate time to spend with patients and, as a result, they may miss something important to save someone' life.

Patient Satisfaction

According to an article published by the American College of Emergency Physician (2006), the authors state that lengthy waiting times are a very significant driver of patient satisfaction. The Press Ganey report stated "For patients, the most frustrating thing about hospital emergency departments is not only that they are waiting longer to get attention but that too often nobody on the ED staff will tell them how long they can expect to wait" (Emergency Department Resources, 2008). It has been made evident that most patients waiting prefer to be provided with updated information regarding their progress during the emergency department visit.

In response, many emergency departments have begun communicating their estimated hospital wait times to the general public. Some emergency departments have been said to use waiting time advertising as a tool to manage patient arrivals within a given geographic area, with the idea that they can boost patient satisfaction. The methods most hospitals use today are billboards, websites and smart phone applications (ACEP Emergency Medicine Practice Committee, 2006).

Nonetheless, there is some debate that advertising waiting times can be become life-threatening. Some researchers believe that the idea of advertising waiting times can cause patients with emergent conditions to delay care as a result of viewing hospital wait times (ACEP Emergency Medicine Practice Committee, 2006).

Improving patient satisfaction in the emergency department is particularly critical for health care leaders because patients are the most important public face of the hospital. In fact, most hospitals recognized that patient satisfaction is a key matter when dealing with the emergency department. Therefore, they have successfully started programs such as "fast tracks" and have hired dedicated staff trained to communicate about wait times delays (Hospital & Health Network, 2008). Indeed, it should go without saying that evidences support the overwhelming coalition between waiting times and patient satisfaction. For that reason, the objective of this research is to explore the patient's satisfaction in terms of emergency waiting times.

METHODOLOGY

For years, there has been an absence of a concrete measurement tools that completely investigate waiting times in respect to patient satisfaction (Bleich, 2009). In the paper, we explored the factors that affect hospital emergency departments in relationship to waiting times, the quality of care received, and patient satisfaction.

Data collected in response to waiting times provides distinctive opportunities to understand how patient's satisfaction is influenced. This paper focuses on the comparison of waiting times and how relevant it is to the quality of emergency care in Jefferson and Orleans parishes' hospitals. The objective of this project is formulated in terms of the following issues:

- Issue 1: examine patient's expected waiting times
- Issue 2: examine patient's actual waiting times
- Issue 3: compare expected and actual waiting times in respect national waiting times
- Issue 4: examine patient's overall satisfaction in respect to administration, nurse and doctors
- Issue 5: examine patient overall satisfaction with respect to the emergency room

❖ Issue 6: demographics

The answers to these significant questions will be subject of the next discussion.

Developing the Survey

To construct the survey design, review of the literature generated basic information focused on the targeted audiences. The study was conducted using qualitative methods and survey-based techniques. The open-ended, multiple choice and Likert scale style surveys were developed. The design of the survey was created from general information to specific questions to support the research study.

There were two survey-based target audiences: The emergency department administrators and past and present emergency room patients. As Figure 1 shows, the first set of survey questions focused on the staff and expectations of the hospital emergency room department. The second set of questions focused on demographics, expected waiting times, actual waiting times and overall patient satisfaction.

Figure 1: Survey Questionnaire 1 Layout

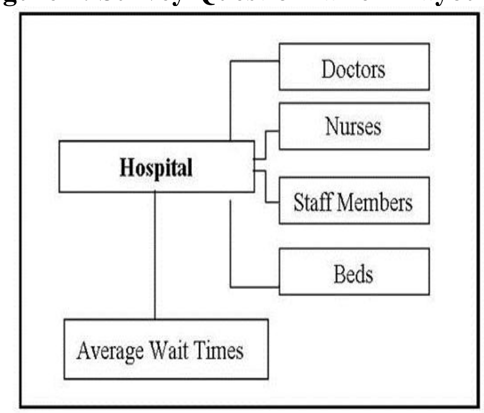
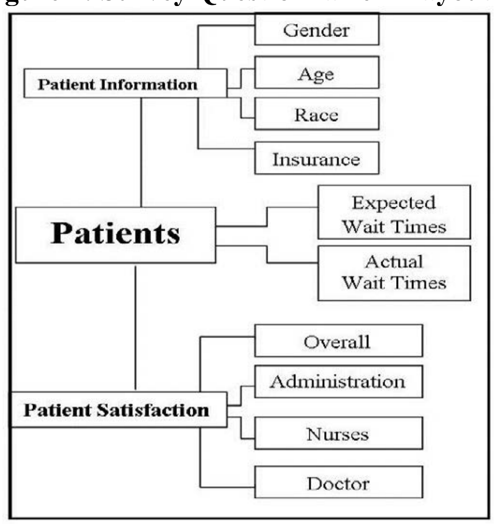


Figure 2: Survey Questionnaire 2 Layout



Distributing the Surveys

The data was distributed to from 2 parishes Jefferson and Orleans during a 12 week period. Six different hospitals were selected where patients and administrators were involved in face-to-face interviews. These hospital are identified as Hospital-1 through Hospital-6 as indicated in founding section.

Open-ended survey questions were given to the administrators at each hospital, to obtain the emergency departments average waiting times and staffing. Further investigation was done to discover if emergency department had adequate facilities. Additionally, www.fluidsurvey.com was used to ascertain past emergency visits by random patients via; Facebook and email. As patients exited the emergency room, they were given a multiple-choice questionnaire intended to determine expected and actual waiting times, how satisfied were they with the service and would they prefer urgent care facilities.

Collecting Data

The survey was conducted during a 6 week period. There were 6 surveys collected from Management of all the Emergency departments in each hospital using survey questionnaire 1. 50 people responded to the online survey provide though www.fluidsurvey.com sent out using www.facebook.com and www.yahoo.com. Fluidsurvey provided summary report that included detail analyzes.

There were 150 patients from 6 hospitals in the Orleans and Jefferson parishes, who were asked questions face-to-face, during the day and night. For all of the face-to-face and online surveys, questionnaire 2 was used. However, after review of the 200 responds 50 of them were incomplete which are excluded from collected data. The overall data collection procedure was continued during the research time period.

Tabulating Data

The data was collected and tabulated from 150 respondents. The questionnaires were done face-to-face, and it was inputted in Excel Spreadsheet and analyzed. Data was also collected and tabulated from 50 respondents. The questionnaires were answered online and tabulated by www. FluidSurvey.com. All 150 of the data analyzed using standard statistical procedures to interpret the finding.

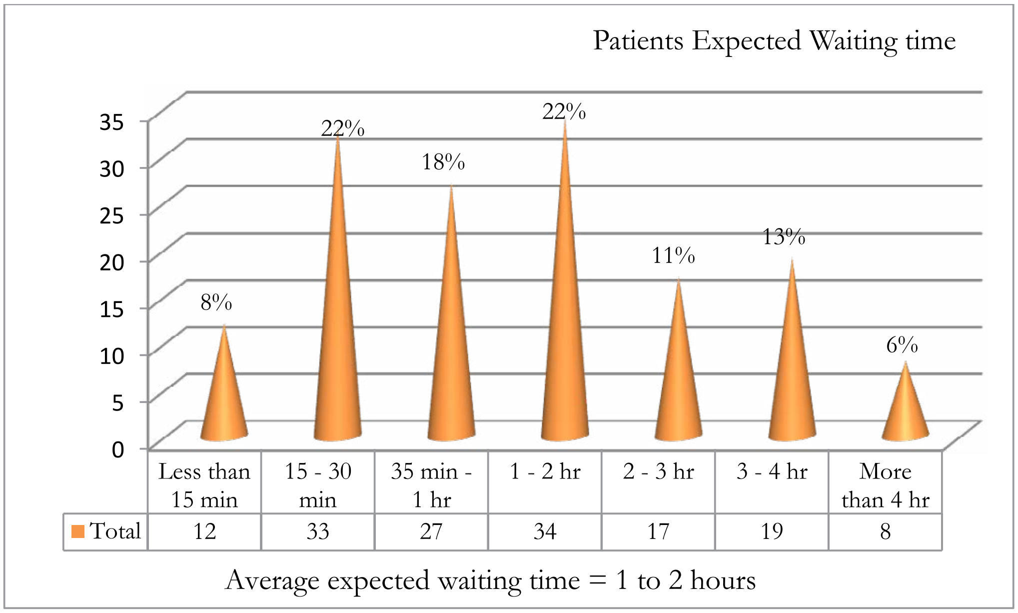
FINDING

Hospital management understands today that the emergency room departments are a vital part of the US health care system. Research must explore all aspects of hospital emergency departments, however this research focuses on how long the wait is and how satisfied patients are with their ER visit.

Issue 1: Examine patient's expected waiting times

In relationship to wait times patients are willing to wait for service, yet according to research patients' expectations are far from the actual time they have to wait when coming to the emergency department. Figure 3 reveals that 22% of patients' expect to wait 15 minutes – 30 minutes. In reality, patients know that wait times are usually higher so as a result, the findings show that 23% of patients' expect to wait 1 hour to 2 hours.

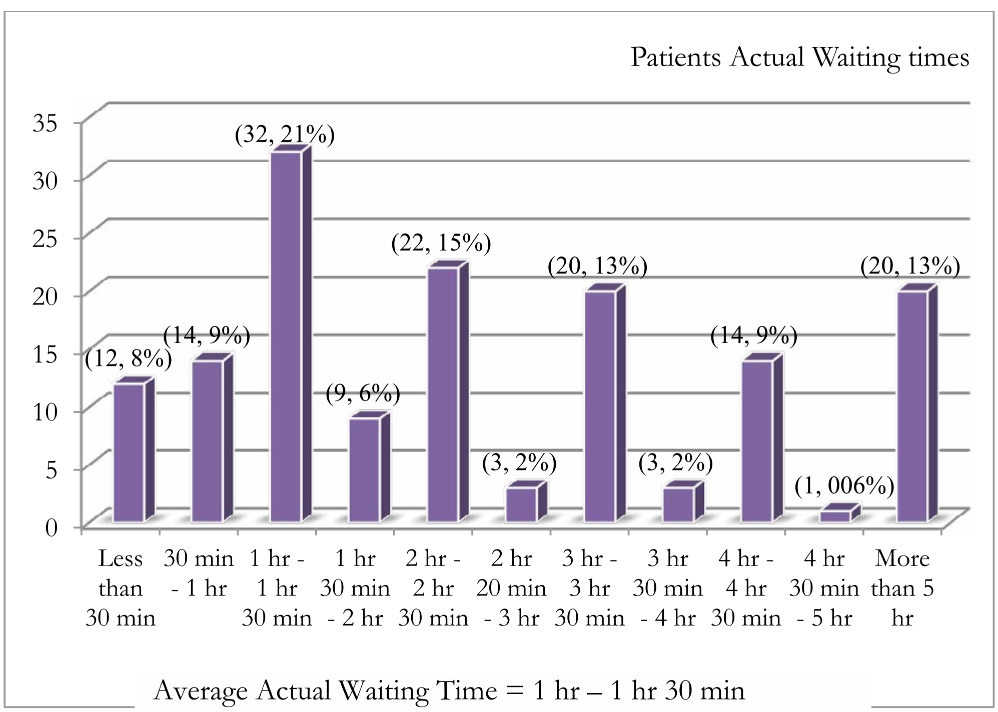
Figure 3: Overall Expected Waiting Times for Service



Issue 2: Examine patient's actual waiting times.

Unlike, expected waiting times patients are faced with the reality that most hospitals have high wait times. Figure 4 below shows that 21% of patients actually wait between 1 hour and 1 hour and 30 minutes in respect to the 6 hospital studied. It should be stated that in some cases hospital waiting times were more than 5 hours 13%, more than the national average of 4 hours 5 minutes.

Figure 4: Overall Actual Waiting Times for Service



Issue 3: Compare expected and actual waiting times in respect to national waiting times.

Figure 5: Side-by-side comparison of expected waiting times and actual waiting times

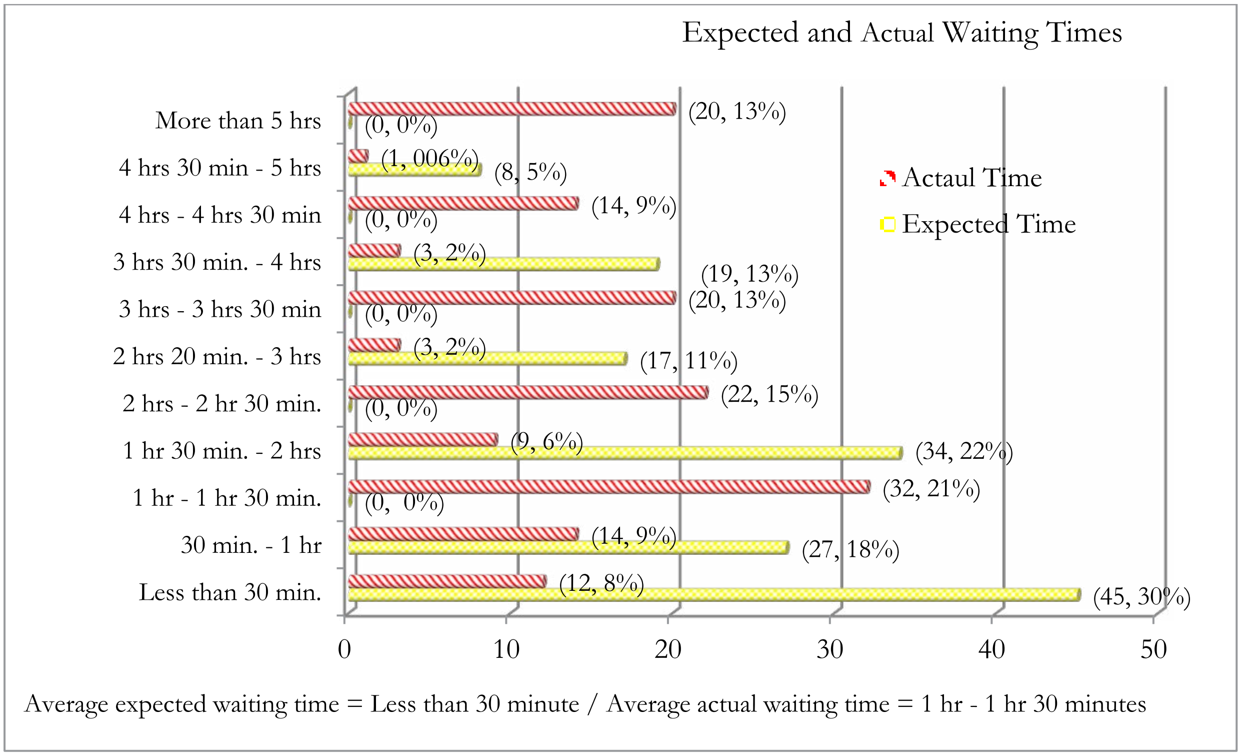
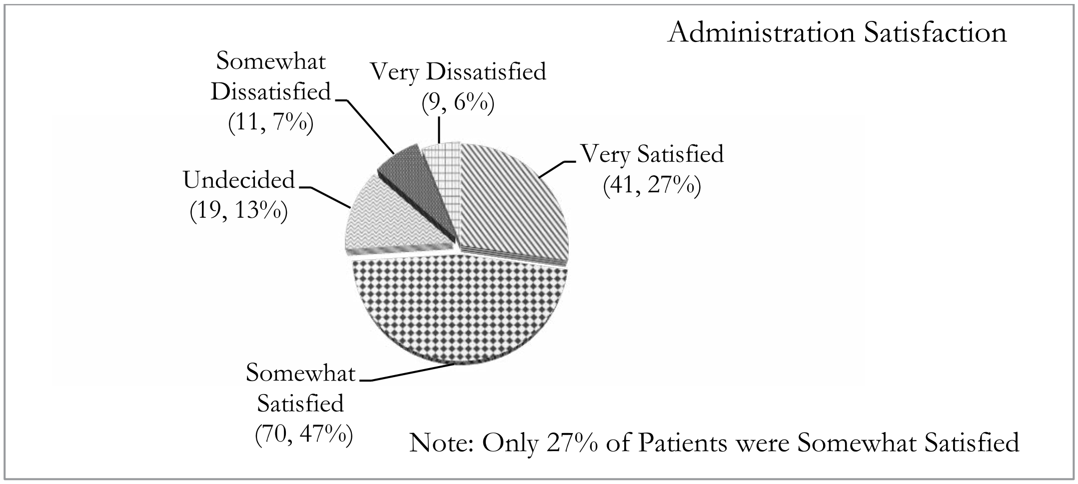


Figure 5 above compares expected waiting times to actual waiting times of the 6 hospital examined. The expected wait times are 1 hour – 2 hours, yet the actual waiting times was 1 hour – 1 hour 30 which is lower than the national average. As mentioned in the previous issue, when investigating waiting times we must look at waiting times on the national level in respect to local hospitals waiting times. Data shows that the national waiting time is 4 hours and 5 minutes.

Issue 4: Examine patient's overall satisfaction in respect to administration, nurse and doctors.

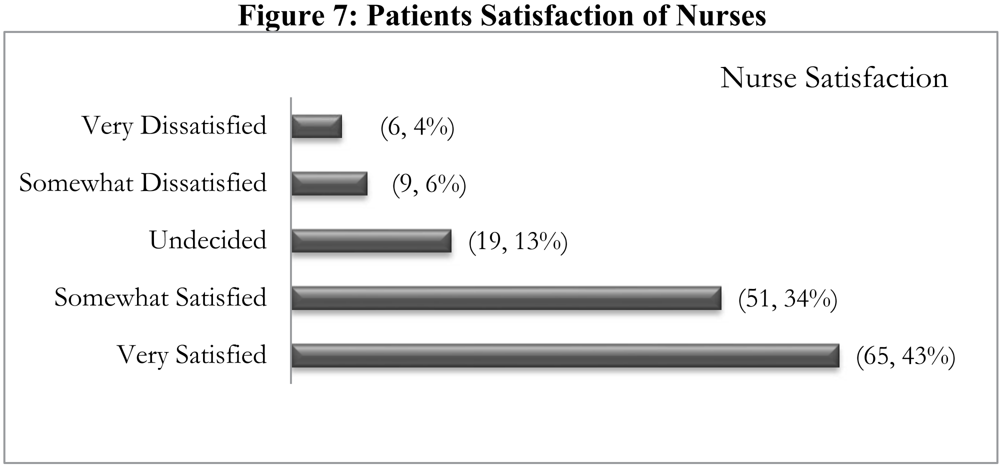
The Hospital emergency staff primary goal should be to care for the patient in a professional and dignified matter. This can especially be seen in review of the next three issues; by examining how satisfied were the patients with the individual care of the emergency room administrators, nurses and doctors. The Figure 6 below shows that only 27% of patients were very satisfied with the care they received, yet the highest marks reveals that 47% of patients were somewhat satisfied.

Figure 6: Patients Satisfaction of Administrations



The nurses are sometimes the first people to administer care in the emergency room, so the way they handle patients' needs are just as important as the doctors. Indeed, the research Figure 7 below reveals that 43% of the patients were very satisfied with the care nurses provides.

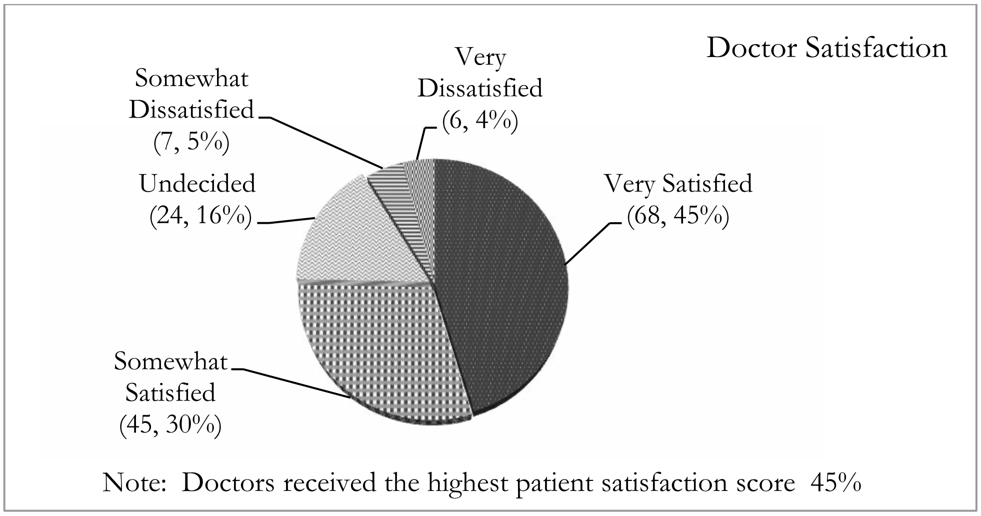
Figure 7: Patients Satisfaction of Nurses



Note: Almost 50% of Patients were very satisfied with

The data also reveals that 45% of the patients were very satisfied with the doctors that provided service as seen in Figure 8. The findings expose that patients were overall very satisfied with the care they received by the doctors from all 6 hospitals.

Figure 8: Patients Satisfaction of Doctors

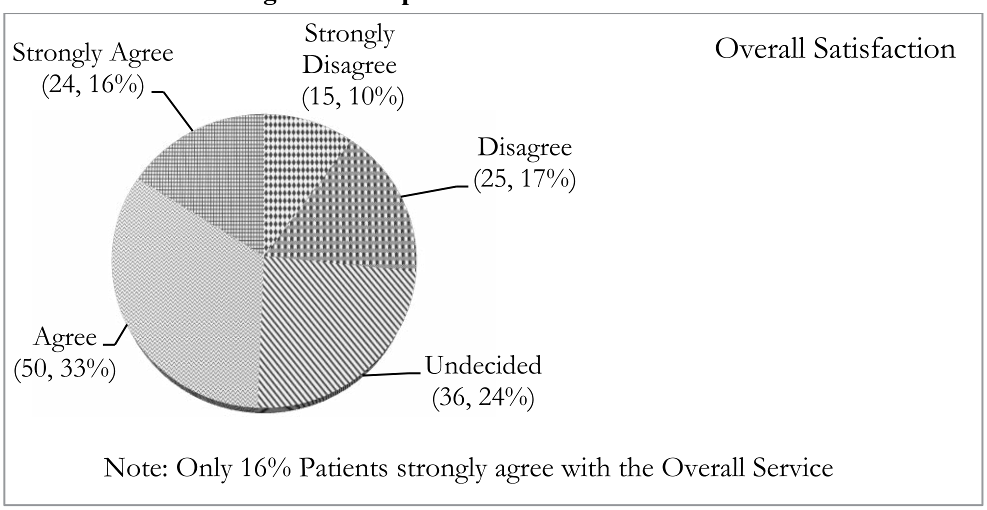


The findings show that patients were very satisfied with the care from the doctors.

Issue 5: Examine patient overall satisfaction with respect to the emergency room.

The first issue examines how satisfied were the patients with their visit to the emergency room. As shown in Figure 9, the patients agreed by 33% that they were satisfied with the overall service that was provided by the emergency departments in all 6 hospitals, yet only 16% strongly agree that their visit was satisfactory.

Figure 9: Hospitals Overall Satisfaction



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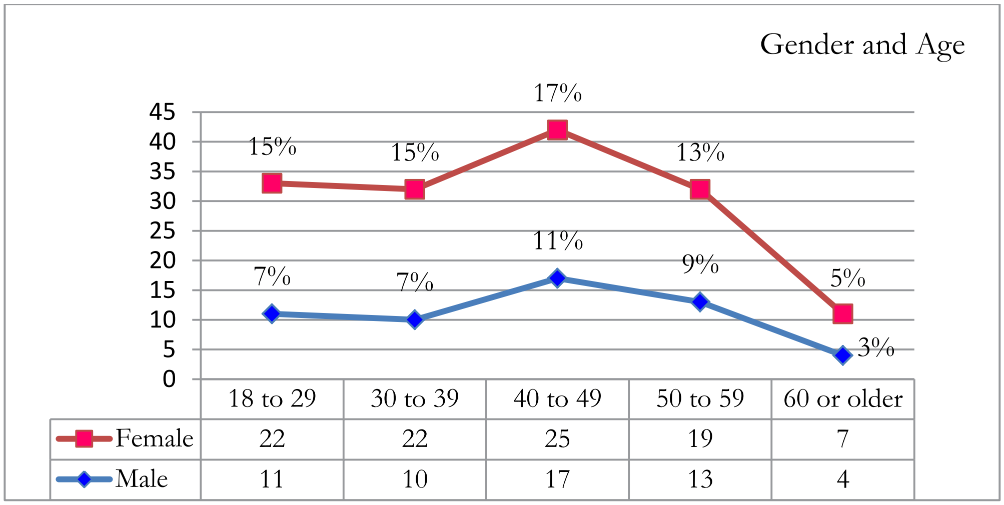
Issue 6: Demographics of target audience

During the survey, sex and age was asked of each individual. The demographics of this research reveal 95 female patients completed this survey with 17% belonging to the 40 to 49 age group. In addition, out of the 150 respondents 55 was male and 11% were in the 40 to 49 age group. These results can be viewed in Figure 10 below.

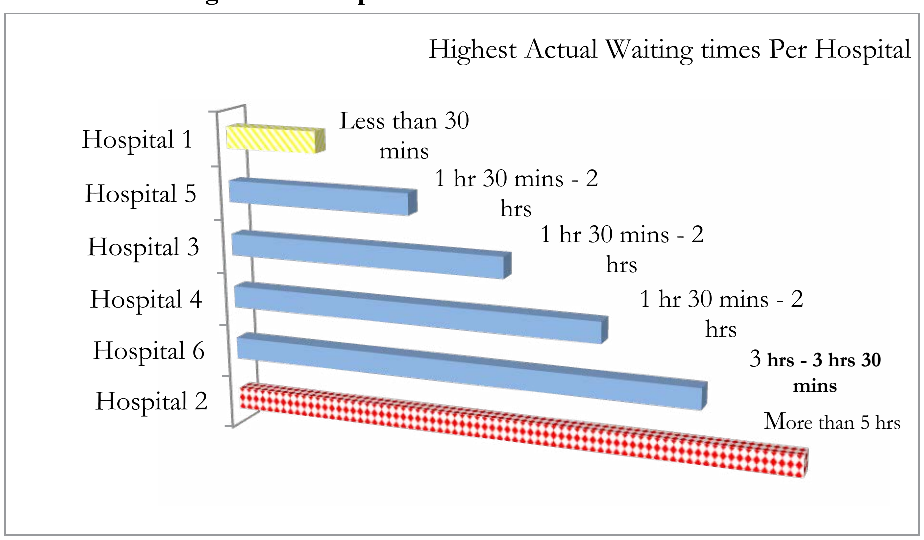
Figure 10: Demographics



Further Outcome

Another important point worth noting came from questionnaire 2 which was given to the management of each hospital. The survey asked the management specific questions as: how many patients seen and how many doctors in the hospital emergency room daily. Nonetheless, the only data focused on in this research study was the highest waiting times by hospital 2 and the lowest wait times by hospital 1 as shown in Figure 11.

Figure 11: Hospital Performance Measurement



The research looks at the performance measurement in one day for both hospitals' emergency room. To examine the data a formula was devised:

Let:

R_1 is the patient to doctor ratio for hospital 1
R_2 is the patient to doctor ratio for hospital 2
P_1 is the number of patient served by hospital 1
P_2 is the number of patient served by hospital 2
D_1 is the number of Doctors in hospital 1

D_2 is the number of Doctors in hospital 2

As a result,

$R_1 = P_1/D_1 = 150/4 = 38$ ratio

$R_2 = P_2/D_2 = 220/9 = 24$ ratio

We can see that although hospital 2 sees 70 more patients with 5 more doctors, Hospital 1 is performing better in respect to waiting times. Hospital 2 on a daily bases see more patients, as a result the waiting times are 4 hours and 30 minutes more than hospital 1 as shown in Figure 21 above. It follows that, the data shows that overall; the hospitals in Orleans and Jefferson parishes are doing better than the national ratings by 3 hours and 25 minutes with a ratio of 38.

These finding from the research done in this paper shows that hospitals are considering waiting times and patient satisfaction, hence why most hospitals are finding ways to increase patient satisfaction by advertising emergency waiting times via online and smart phone. Tools such as these are just one avenue to help with the emergency room issues, as result hospital have also started updating their patients on their progress and waiting times to satisfy the patients.

CONCLUSION

Hospital emergency departments' facilities have played a key role in our nation's healthcare system. Patients' visit emergency rooms in great numbers on a daily bases, which is one of the factors that cause waiting times to increase. Yet, the evidence presented in the previous chapters showed that patients were willing to waiting for care if the care was done in a timely and professional matter.

Although it is hard to measure, one of the most important goals of any healthcare system should be patient satisfaction. Studies on patient satisfaction gained popularity and usefulness as it provides the chance for healthcare providers and mangers to improve the services in the public health facilities. Today, we cannot ignore the fact that hospital management can and has used patient satisfaction ratings as a tool for improving the quality of care given to patients. Research showed that another factor that affected patient satisfaction was when emergency departments' staff updated patients with information while they waited.

The goal of this research study was to examine 6 key issues and suggest measures that hospital administrators can use to increase patient satisfaction and reduce emergency room wait times. These issues include examine patient's expected wait times, examine patient's actual wait times, examine patient's overall satisfaction in respect to administration, nurse and doctors, overall satisfaction, comparison of expected and actual waiting times, and demographics of target audience.

Patient satisfaction is a critical aspects of the hospital emergency department and it is has to be addressed by healthcare providers and more research must be done in order to develop an effective solution to improving it.

Based on the data investigated the results reveal that patients overall satisfaction involves several factors. With this in mind, the first line of patient satisfaction comes into play when the patient is triaged by the hospital staff. If this encounter is not pleasant is sets the tone for the entire visit. It has been proven by the data which showed that only 16% of the patients were very satisfied with the administration when arriving to the emergency room. The data revealed that 45% of the patients were extremely satisfied with the service provided by their doctor. Yet, only

27% of the patients were extremely satisfied with the care from the emergency room administration.

Although patients were ill when arriving to the emergency room, patients as shown from the research, expect to wait for service. More importantly, it was proven that patient's expected wait times were higher than the time patients actually had to wait for service. Altogether, these finding also indicated that when patients waiting times were higher than expected, patient satisfaction decreased.

Another notable point was made in comparison with hospital performance in respect to the patient, doctor ratio measurement. Indeed, these findings showed in comparison the performance of two hospitals, yet in reality there are many factors that come into consideration when measuring hospitals overall performance.

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BIG DATA ANALYTICS THE NEXT BIG LEARNING OPPORTUNITY

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ABSTRACT

The relentless collection of data from user interactions in websites have introduced both a high level of complexity, as well as a great opportunity for businesses. In addition, the trend of connecting not just people, but also machines to the Internet, and then collecting data from these machines via sensors would soon result in an unimaginable repository of data. This ever increasing collection of data, also known as Big Data, will only be useful if it can be analyzed to give useful insights into business problems, and perhaps even to make suggestions as to when and where future problems will occur (predictive analytics) so that the problems can be avoided or at least mitigated.

Students must be prepared take advantage for future opportunities in the field of big data analytics. In most business programs, specifically information system as the major, core course like database design, office applications, and basic programming are taught to learners. A critical component missing from many undergraduate business programs are core courses focusing on data analytics. The US Department of Labor predicts 4.4 million opportunities will exist by 2018, working with data analytics. The imperative to include such courses in business information systems programs exist.

Universities are beginning to notice the great interest in data analysis by organizations, which want data driven solutions to their problems. A few major business schools such as Arizona State University, University of Southern California, and Michigan State University have recently embarked on specialized Business-Analytics graduate Programs, while others such as Northwestern University has no such specialized Programs, but requires all business students to take them. In any case, many employers such as Taco Bell (Yum Brands), General Electric (GE), Boeing, and Walt Disney (Gellman, 2014) are asking for more employees with analytics skills to gain insights from the enormous volumes of data that they collect.

The purpose of this article is to examine the rapidly growing field of Big Data Analytics and to study why and how big data analytics needs to be integrated into business skill sets and curriculum designs. The research will provide a practical framework to design and teach the skills sets needed to solve organizational problems by analyzing the vast amounts of data that are being generated and stored.

This paper will be prove very beneficial to IT educators and academic researchers, as they will gain a solid understanding of why Big Data needs to be an important curriculum component, and the benefits to students and potential employers. Business managers will also benefit from the research as it shows them how new Big Data tools can be deployed to solve *complex business problems, and coax them to encourage universities to incorporate Big Data in their curriculums so that their future employees can compete successfully in an increasing complex, global, inter-connected, data-driven world.*

Keywords: big data, technology, analytics, program design, curriculum design, student learning

INTRODUCTION

It is astounding that about 90% of the world's data has been generated in just the last 2 years (SINTEF, 2013). Companies like Facebook, Google, Twitter, and Amazon collect data from interactions and activities by its users. Added to that is yet another new phenomenon known as IoT (Internet of Things), that generates a deluge of data from sensors on equipment and appliances that is even much bigger than what humans create. This ever-increasing collection of data, known often as Big Data, will however, only be useful if it can be analyzed. Analysis will provide useful insights into business problems, and perhaps even make suggestions as to when and where future problems will occur (predictive analytics) so that the problems can be avoided or at least mitigated. Most of the world's big organizations such as Apple, GE, Walmart, Exxon and Samsung have global operations (factories, warehouses, transporters, and customers) and serve several customers with a wide variety of products and services. The complexity of such vast and highly connected networks is hard to unravel, and makes it very difficult for humans to find where and why problems occur.

Data analytics allows businesses to examine large data sets to respond to existing needs in the respective industry of operation. With data being produced continuously by humans and machines, the sheer amount of data available is much more massive than at any time in the past (Hardgrave, 2013). Business analytics is useful for a business to examine patterns and trends in large data sets. Examining the data helps a business generate models for future predictions of patterns and trends. Thus, businesses seek to recruit and hire individuals who understand how to handle large data sets to drive business decision making. This is evident by the increasing demand in the job market for people who have data analytic skills.

Smigala (2014) reports by 2015, 4.4 million jobs will be offered globally to address the needs for big data analysis. Business Schools across the world recognize the need to infuse big data education in the curriculum; however, understanding how to integrate data analysis appropriately in the curriculum presents a challenge. Business Management Information systems courses encourages students to learn how to create and enter data, access data, and generate business reports that can support business decision-making; however, courses offering a specific focus on using data analytics at the undergraduate level seems to be a course educational institutions must examine and integrate in teaching and learning practices.

The purpose of this paper is to briefly describe the nature of big data, highlight its importance in the business world, and make the case for incorporating big data analytics as an essential tool in business and incorporate these tools in university curricula. eCampus News (Barmer, 2014) demonstrates a lack of implementation of data analytic programs in undergraduate curriculums. This research focuses on how undergraduate business schools may help students in higher education gain the big data and data analytics skills and experience necessary to fill the current employment gap of trained professionals in the field.

The Nature of Big Data

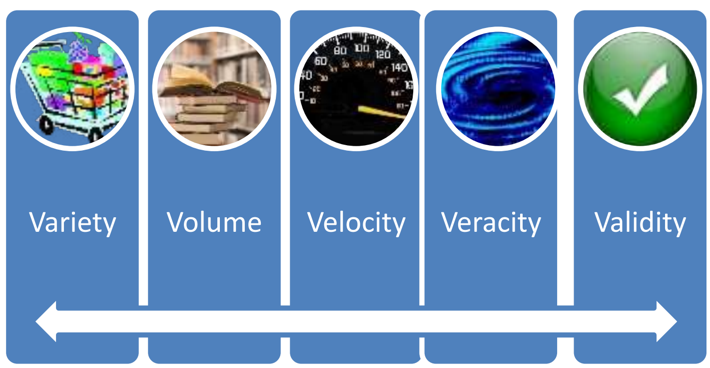
Big data is not just a massive database. Traditional databases store structured data in a table format as shown in Figure 1. In this example, all Employee data records are stored as rows in a table with 6 columns for each Employee, hence, the data is referred to as "structured". Structured data can be easily processed by modern database management systems such Oracle, DB2 and SQL Server and using languages such as SQL.

Figure 1: Example of Structured Employee Data

Employee Name	Id	DOB	Department	Email	Tel#
Bean L	1234	11/22/1960	Accounting	Bean@xyz.com	111-222-3333
Peas G.	2234	4/5/1970	IT	Peas@xyz.com	111-333-2222
…					

Big data, however, is often unstructured. The data source can be generated by humans or by machines. Examples of human generated unstructured data include Microsoft Word

Figure 2 Big Data Dimensions



documents, "text" messages from cellphones, posts in Facebook and Twitter, or web pages of companies or individuals. Examples of machine-generated data could be "location" information from mobile phones, sensor information from automobile engines, satellite images, and video clips from surveillance cameras. It is just not that big data is unstructured, but the rate of data generation is fast, and the volume of data that is generated is massive – the business challenge is to rapidly analyze these mountains of data in order to generate actionable insights. The fact that big data is generated with little direct control at the source also brings into question the very veracity (quality, accuracy etc.) of the data, and hence making the results of data analysis questionable at times. Another aspect of big data is validity - how valid is the data for analyzing a problem, and if there is an expiration data after which the data is not that valuable. In summary, the five important dimensions of big data are shown in Figure 2.

The proliferation of big data, by itself, is not useful. The real benefits lie in analyzing the data and using the patterns they reveal in making decisions – the discovery of actionable insights. Big data infrastructure comprises of a big data repository, data analytics software, and the data scientists. Data scientists use their domain knowledge and expertise in the growing field of data sciences, which need strong mathematical, statistical, and information technology. As stated before, the whole idea is to sift through the mountains of data, and get actionable insights.

Tools for Big Data

Traditional relational database management systems are not efficient, nor effective in handling big data due to its unstructured nature and high volume. A new class of systems such as Apache Hadoop and NoSQL data stores are far more suited to big data. Hadoop is an open source platform for storing and processing big data on a cluster of inexpensive servers. Hadoop is highly scalable as demand varies, and is very resilient from failures due to its built-in redundancy. It is also very efficient in processing big data over parallel processors using the Map/Reduce technique pioneered by Google. The cost savings of a Hadoop system versus the traditional systems are staggering - instead of costing tens of thousands of dollars per terabyte, Hadoop based computing and storage capabilities costs just hundreds of dollars per terabyte (Nemschoff, 2013).

NoSQL (Not only SQL) data stores are popular methods to store data on Hadoop servers because certain types of queries are much faster to compute, and are easier to formulate than using traditional SQL on Relational databases. Unlike SQL, however, there is no standard NoSQL database, and several types are available – each having advantages depending on the type of big data problem being solved. Some popular NoSQL databases are Cassandra, Hbase, Apache CouchDB, MongoDB, Dynamo and Neo4J.

Hadoop and NoSQL databases make up the infrastructure to maintain and process big data. A plethora of new big data analytics software vendors are now emerging to take make sense of all this big data and gain some deep insights in order to make rapid, effective decisions. Some of the major Analytics software vendors include SAS, Palantir, Qlik, Splunk, Jaspersoft, Platfora, and Sumo Logic. Some other vendors such as Tableau and Zoomdata specialize on building dashboards and data visualization tools to visually appealing graphics for easier and more effective understanding of large volumes of data, and hence leading to better decision making.

Many of the traditional large IT vendors such as SAP, Microsoft, HP, IBM also have their own built in tools for big data Analytics. Given the rapid growth of big data and the need to manage and analyze it, it is clear that Information Systems curriculums need to be quickly updated in order to impart these vital technology skills.

The Big Data Advantage in Decision Making

A big part of managers' duties is to make decisions. In traditional decision making (see Figure 3) managers' knowledge about the situation (via reports from traditional IT systems and business intelligence), skills, past experiences, biases, innate intelligence, and intuitions are some important factors in making effective decisions in a timely manner. A good dose of luck also plays an important part, as there is much uncertainty about external factors. Organization's hire the best managers possible based on their past successes, and hope that they can use their history of good decisions to make excellent future decisions as well. As we can see, there is a lot of

Figure 3 Traditional Decision Making

subjectivity in this kind of decision-making process, and it is largely based on past experiences of decision makers.

With the advent of real time big data from sources such as web data, customer data, operational data, machine data and so forth, managers suddenly have a data-driven tool to help make smarter decisions (Lo, 2014) that are based on more objective, actual events (represented by real-time big data streams) and deep insights into them (analytics software and data scientists). There is less reliance on subjective managerial inputs and past experiences due to the availability of real time deep insights from big data to make decisions more data-driven. The overall "luck factor" and "external uncertainty" is also diminished, thus leading to potentially better decisions. Figure 4 depicts "smarter and data driven," managerial decision-making in the big data World.

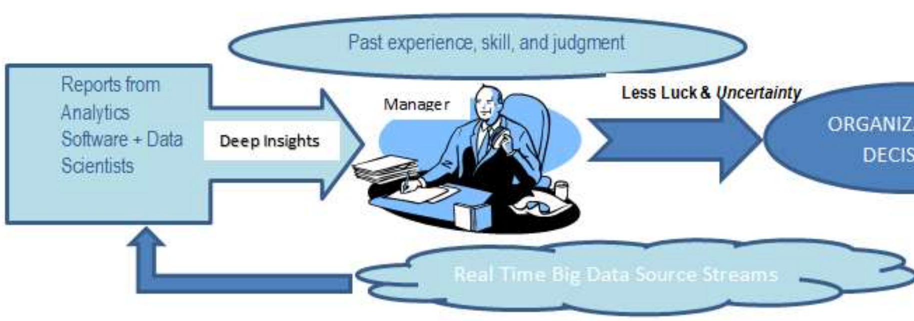


Figure 4 Smart and Data-Driven Decision Making Using Big Data

As we have seen, big data analytics is potentially a new, powerful decision making tool that can be leveraged by managers. We shall now look at some practical applications of big data. Cyber security is increasingly becoming a major problem for many organizations, and the traditional method was generally to keep the "bad guys" out of the systems. Many of the current security breaches reveal that it is almost impossible to keep hackers out of a network, so it has become essential to do real time monitoring and analysis of all the network event data generated by customers, employees, business partners, public actors, and even other machines. The volume of data generated by event logs is huge – for example, the automobile portal website Edmunds.com experiences 50,000 events per minute and produces 60 to 70 gigabytes of data per day (Splunk, 2014). In order to analyze and make sense of all this big data, Edmunds uses a Splunk based software solution. Spulnk Analytics software not only look for security breaches, but also analyzes consumer behavior on Edmund.com's web site, and also looks for issues that could damage company image (say, via social media posts). In summary, Splunk big data analytics generates real-time alerts for real-time decision-making. It also provides hourly, daily, weekly, and data for historical analysis.

With regards to cyber security, a smarter technique using big data is currently being developed - a "risk-based" approach that lends itself to cost/benefit analysis, manage risks, and expected outcomes. Big data is used for risk assessment of IT Assets, and investment decisions to secure IT systems are made accordingly. Hence, it is important to find of probability of breach and the severity of the loss as well. Behavioral Analytics of big data of network events makes this possible. It is, therefore, critical that IT and business students get familiar with the newer managerial techniques using big data analytics.

Demand for Trained Big Data and Data Analytics Professionals

The advent of data from multiple streams require trained professionals to analyze, describe, and predict the current or future consumers' needs for a business based on the data collected and stored in an organization. Preparing for opportunities to work with big data is increasing. In 2014, the top ten big data employers (see Figure 5) created 10,318 jobs (Columbus, 2014).

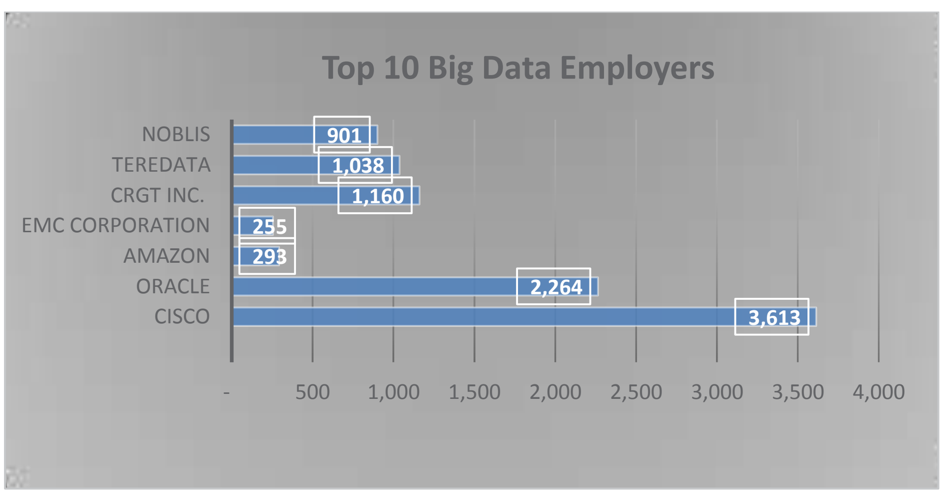


Figure 5 Big Data Positions Created in 2014

Based on current predictions, job growth potential in the big data field is very positive. Projections for 2015 suggest the creation of about 1.4 million jobs data analytics field in the

United Stated. A gap in qualified candidates to fill those positions will likely range from 140,000 to 190,000 by 2018 (Figure 6). It is imperative that undergraduate schools examine their curriculums to understand what the institution can do to prepare students for careers in the industry. (Lazar, 2012)

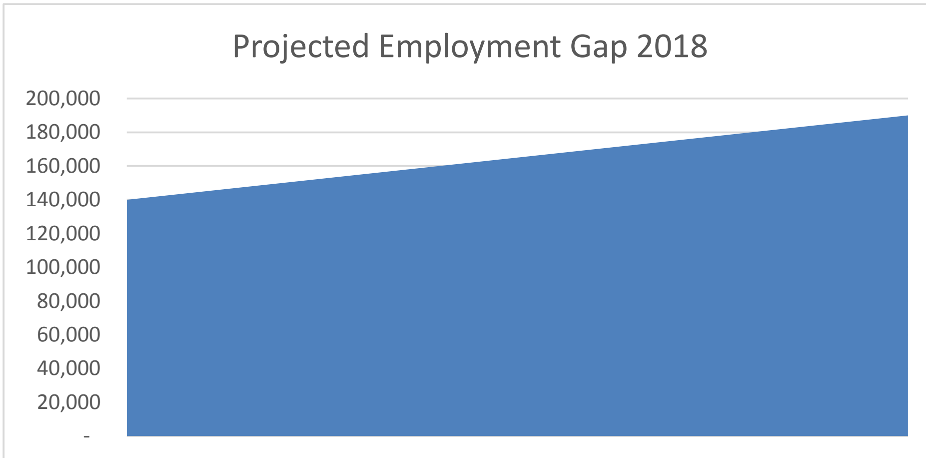


Figure 6 Gap in qualified Big Data Analytics applicants in 2018

Big Data Integration in Business Education Curriculum

To integrate big data in the curriculum, information systems curriculum designers should be familiar with what students need to know. Many business school programs offer an introduction to big data within existing database courses; however, a greater need exists to develop courses to addresses the current gaps in educating students to meet big data skill demand in industry. These new courses will incorporate core big data concepts and analytics techniques in the IT curriculum.

Universities are beginning to notice the great interest in data analysis by organizations, which want data driven solutions to their problems. A few major business schools such as Arizona State University, University of Southern California, and Michigan State University have recently embarked on specialized Business-Analytics graduate Programs, while others such as Northwestern University has no such specialized Programs, but requires all business students to take them. In any case, many employers such as Taco Bell (Yum Brands), General Electric (GE), Boeing, and Walt Disney (Gellman, 2014) are asking for more employees with analytics skills to gain insights from the enormous volumes of data that they collect.

The current projection by (Lazar, 2013) is that by 2018, the United State will have a shortage of 140,000 to 190,000 skilled personnel to perform data analytics jobs. Educators can prepare to address this gap by designing a curriculum to address the demands of the current marketplace (Ferguson, 2014). Knowing how to manage, analyze, and report results from analysis of large data sets will support an organization in making decisions on products to market, coupons to offer, or services to be rendered fulfilling an exceptional need for businesses trying to compete in a global economy. In addition, Integrating appropriate learning objectives in the curriculum helps keep the learning relevant and students prepare for challenges they will face in their careers working with data (Ferguson, 2014).

Graduate school is where big data programs are appearing most often to prepare excessive demand for data scientist. In fact, the first domestic master's program in analytics offered was at North Carolina State University in 2007 (Bengfort, 2013). Arguably, as the demand increased new programs were developed to fill the gaps. The list of the top 10 graduate programs were identified by eCampus News (Sharnoff, 2013). Most of the top graduate big data programs were developed in business schools such as Bentley University-Waltham, Drexel University, Louisiana State University, Massachusetts Institute of Technology, and New York University. Each program shared a common theme in most of the curriculums, teaching students real-world application of big data and analytics to help businesses make effective business decisions (Sharnoff, 2013).

Few undergraduate business programs offer a major in big data programs. These include Drexel University, Southern New Hampshire University, and Arizona State University. A recent undergraduate data analytics program in the United States was launched at Ohio State University (Barmer, 2014), which seems determined to meet the demands of businesses. The program at OSU recognizes the impact big data can have across the curriculum. To address the dynamic need for the business industry, Ohio State will be offering the program as an interdisciplinary degree from medicine to the arts (Barmer, 2014). The program is nestled in their Discovery Themes Department, whose focus is on answering global questions surrounding the environment, technology, and social issues. This program is the first of its' kind and the long-term goal is to recruit 500 teaching and tenured/tenure track professionals. (Box-Steffensmeir, Riffe, Hoy, et al, 2014)

Educators Preparation for Big Data Instruction

To facilitate learning of data analytics in educational settings course instructors should investigate the tools and resources needed to implement big data in the curriculum. Educators have to make the learning real and relevant to learners to address the current gap in industry with a need for trained professionals to mash-up and analyze data to respond to the demands of the market. Industry communicates an extensive need to make intelligent decisions based on volumes of data available (Hardgrave, 2013, Ferguson, 2014). Institutions of learning must adapt teaching and learning in information science and systems programs to respond to address the predicted need. The exact strategy to refine teaching and learning experiences for students will likely emerge from examining existing models and by evaluating the programs that are currently being implemented.

Teaching big data in the classroom can be a daunting task if the teaching tools are missing from the learning experience. An essential tool needed to teach data analytics is having access to big data sets. To address this issue Tacit a technology news leader suggest building partnerships with businesses (Admin, 2013). Another approach to getting access to data would be to invest in purchasing vendor software that includes data sets or to search for universities' that provide access to data sets (Flood, 2013, Watson, 2013).

Identifying businesses, universities, or vendors to provide datasets to facilitate learning in the course will support students with gaining hands on experiences working with data and analyzing data sets (Admin, 2013). Having access to data sets will help students analyze small or large data sets (Topi, 2013, Watson, 2013). Students will likely have classroom opportunities to explore scenarios and to conduct analytics of data sets when institutions collaborate with businesses, universities, or vendors willing to share data to facilitate student learning (Topi, 2013). The University of Arkansas is one such institution of learning who willingly shares data sets (Watson, 2013)

Getting access to data sets is a foundation for preparation to teach students how to work with big data to understand its impact on commerce; however, software must be identified to hone analytic skills. Watson (2013) offered several powerful tools instructors could explore to support analytics of data. Tableau is data analytics software (Topi, 2013, Watson, 2013). This tool can be used to analyze to data sets and to develop awareness of data visualization. Hyperion, SAS Enterprise Miner, and Cognos are vendor software tools available at no cost or an affordable rate. Each tool offers case studies and research reports to support student development of big data analytics (Watson, 2013).

Teredata University Network offers free online learning. (Watson, 2013). Faculty can use the repository of resources on the site to teach student data analytics skills. Data sets are included for student use to make the learning experiences rich and practical to what student would likely anticipate experiencing in the real world. This online training tool offers certification courses. Organizations look favorably on the opportunity hire students who enter the workforce with certifications.

Big Data Curriculum

Database skills are a skillset that instructors in business information technology instructional programs believe are important to career readiness. The use and teaching of big data traditionally aligned with teaching students how to use Excel and Access to enter, access, and pull data. With the emergence of big data and analytics, some believe that educators need to do a better job of teaching students how to deal with data (Ferguson, 2014). Revamping the curriculum is a necessity to teaching big data. This initiative is supported by President Obama's administration who announced a push for a Big Data Research and Development Initiative (Lazar, 2012). The announcement of this initiative has evoked conversations about how to teach and leverage big data and analytics in the business world. For the purpose of this research, the researcher will focus on how to develop the curriculum to teach data analytics. This section will answer the question of what the curriculum should include.

Big data Professor Fouladkar purports the existing curriculum dealing with data instruction should be redesigned to move from a focus on an extensive list of data collection, entry, and reporting (e.g. sales numbers for a reporting period), to a visual tool that will provide peaks and low points of sales during a reporting period (Ferguson, 2014). This new design approach demonstrates how big data can provide opportunities for further analysis beyond knowing the numbers and crunching the data to create more opportunities for data analysis.

Hardgrave (2013) offers three areas should be studied "big data, analyzing data, and making decisions using data. Analytics professor Watson (2013) offers the notion that three kinds of analytics exist and that academic studies developed should produce students for careers in industry when learners have an understanding of descriptive, predictive, and prescriptive analytics. These three kinds of analytics necessitate skill development and readiness to manage, analyze, and interpret large and small data sets to make business decisions (Hardgrave, 2013, Topi, 2013, Watson, 2013).

A program that focuses on descriptive analytics will challenge students' critical assessment what has occurred. Students will have the opportunity to explore scorecards, dashboards, reporting, and online analytical processing (OLAP) and data visualization. This learning strategy will teach students to critical assess business and performance management strategically (Watson, 2013).

Another program area a student may consider educational training is in predictive analytics. Predictive analytics sets forth a critical assessment of what will happen in the future. The student will engage in factor and regression analysis. Effective implementation of this process the learner will need training in demand forecasting, customer segmentation analysis and fraud detection (Watson, 2013).

In addition to the other programs of, instructors should consider is designing the curriculum to teach prescriptive analytics skills. Learning prescriptive analytics will train the learner to focus on what should occur. The learner who develops in this area of analytics will engage in advocating revenue management. Industries that need analytics in this focused area of learning are airlines, hotels, and businesses who sell perishable goods (Watson, 2013).

The question remains as to how to introduce business education students to big data concepts in a business education program. Mathematics and Statistics programs will lead the way in the development of programs and tools used to analyze data (Frydenberg, 2014). However, business education schools have the opportunity to teach students how to analyze and use the most appropriate data analytic tools garnered to support a business working with big data. An early introduction to big data the curriculum is most practical (Frydenberg, 2014).

Business education programs engagement with big data offers opportunities to prepare students for the demands of industry through training on “analyzing and interpreting complex organizational data (Topi, 2013 pp. 12, p5).” Exposure to “storage space, processing power, Internet connectivity, security, and ways to access or update information online” becomes the foundation to preparation for a big data curriculum (Frydenberg, 2014, p. 2, p7, Topi, 2013). Students’ learning includes the use of standard MS Office software such as Excel or Access depending on the size of the data set the instructor uses with students (Frydenberg, 2014). Tableau Software is available free to higher education institutions (Flood, 2013). Other highly recommended tools are Hadoop, Python, R, or RSuite. Keep in mind the professors’ instructional time will likely increase when introducing command driven tools like R or R Studio when learners are inexperienced with programming and command driven learning tools (Columbus, 2014, Hill & Kline, 2014).

Established prerequisite courses students complete prior to entry into a big data course should include statistics, calculus, and programming. Each will reduce apprehension and anxiety students may experience when learning to work with big data (Hill & Kline, 2014).

Offering courses in big data will likely support students in gaining the insights into the volume, velocity, veracity, and validity of big data by working with real data sets (Admin, 2013, Frydenberg, 2014) Unstructured data sets are available accessible for use for educational purposes at no cost. Salient data collected from students confirms students will gain practical real-world experience, increasing readiness to meet the needs of a potential employer (Frydenberg, 2014).

Ethics, Privacy, and Legal Issues

Curriculum development includes development of hard skill sets and soft skill sets. Developing students’ ability to analyze data is a hard skill. Instruction is incomplete without inclusion of lessons that support development of soft skills too. One such soft skill as it relates to working with big data is ethics. Including ethics in the curriculum supports awareness of how to avoid being overly intrusive when gaining access to data sets from sources such as Twitter, Facebook, or other social media feeds. Additionally, it helps students learning ethical implications for misuse of private information.

Addressing the ethical issues associated with data analytics curriculum is a necessary component to teaching data analytics. Ethics touches every facet of a business organization. Privacy, too, is an important aspect of ethical use of data. Access to big data allows the analyst to be very intrusive and predictive of consumer behaviors. The data collected will provide descriptive information from a variety of data sets. Data sets can come from a variety of sources such as text, social media, and the internet (Chessell, 2014).

Consumers provide access to this information by agreeing to allow businesses to track them through following them through text, social media outlets, and tracking on the internet. Agreeing to share information does on give the business permission to market products or services based on personal discoveries. One such example given by Sterrey (2014) is releasing a marketing campaign based on gathering data that predicts a "health care concern or pregnancy." Figure 7 is an ethical awareness framework that helps an organization analyze and develop policies on how to analyze and use data collected (Chessell, 2014).

The chief concern of instructors teaching big data courses is to embed in the course the legal and ethical standards employees must follow by understanding what a business can legally do with data collected versus what the company may desire to do with the data. Data can be used legally, but it still may not be an ethical use of that data. Students, therefore, need exposure to real case studies dealing with ethics, privacy, and legality. Students also need to be aware that there is such a thing as "too much information privacy" when manipulating and analyzing data as well. There is often a tradeoff between profits and ethical use of data.

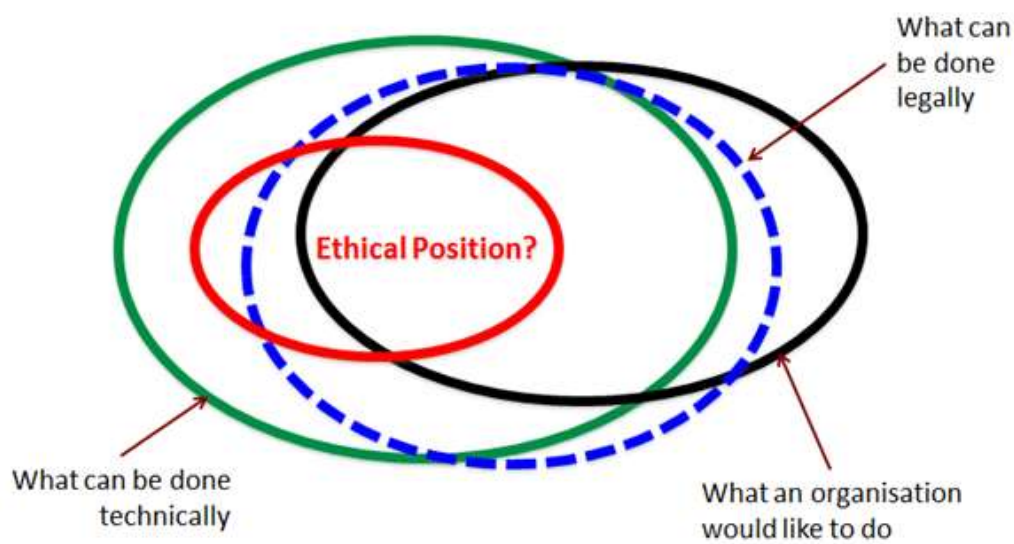


Figure 7 Ethical dimensions of Data

Summary and Conclusion

It is clear that big data is a powerful tool in the corporate arsenal, and that students need to be well versed in its effective use. Businesses need data scientists who have received expert training to shift through the data and find the untold stories embedded in the data. What is understood is that businesses need to understand that multiple streams of data contribute positively to the businesses bottom line.

A big data gap exists in undergraduate education, and institutions of learning must respond to the needs of businesses to help students gain the requisite skills to meet the unmet needs of businesses. This research provides a practical framework to design and teach the skills sets needed to solve organizational problems by analyzing the vast amounts of data that are being generated and stored. The end goal for this research is to explore and develop appropriate educational tools and curriculum designs needed to prepare students to manage, manipulate, and analyze massive data sets to help business make intelligent decisions purely on data analytics.

Preparing undergraduate students to manage the data flows and to use applications to create visualizations of what the data is saying from a business sense translates into a student prepared to help organizations anticipate and respond to consumer needs. Educators seeking online resources to understand the latest developments with designing big data courses will increase familiarity and preparation to design appropriate learning curriculums for students. Interaction on educational socially networked sites can support the development of creative instructional strategies for teaching students how to leverage social media for use in the business world. Further research is needed to understand whether the course design prepares students for the demands of business at an undergraduate level.

In summary, big data is here to stay as the volume and velocity of the data is going to increase. It is imperative that educational programs are developed to teach students what big data is, why it is needed, and the real world applications of how big data and analytics transform business decision making. The legal and ethical elements of how data is used and shared are extremely important to prevent students from mishandling the data and putting an organization at risk for public embarrassment or experiencing legal ramifications. This research presents a strong case for development of curriculum content to help students learn how to prepare for careers requiring big data and data analytic skills.

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ONTOROGICAL LEVEL BUSINESS PROCESS CHANGE FOR GROWTH STRATEGY EXECUTION

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ABSTRACT

Strategy Execution is an essential matter for company to keep sustainable growth. Ability to transform strategic plans into action is also a universal concern. This paper conducted two case studies of strategy execution in two Japanese companies in order to discuss business process change with growth strategy execution from the ontological perspectives. The results suggested that (1) it was not always necessary to change construction level of business processes and action rule in case of market penetration and market development, and (2) it was necessary to change construction level of business processes and action rule in case of product development and diversification.

INTRODUCTION

Strategy Execution is an essential matter for company to keep sustainable growth. Even companies which once succeeded in current business could often lose their competitive advantages in environment change. Some of them are doubted continuation of their businesses, some challenge to realize new growth strategy. When they succeed in strategy execution, they may sustain competitive advantages.

Business organizations' interest in strategy execution has grown in recent years and will continue to do so (Bear, Dennis, Lee et al., 2006). The survey of CEOs in Conference Board (2008) revealed that chief executives were so concerned about strategy execution that they rated it as a top challenging issue. Overall, consistent execution of strategy by top management was one of the crucial challenges (The Conference Board, 2006).

Neilson, Martin and Powers (2008) mention that brilliant strategy, blockbuster product, or breakthrough technology can put company on competitive map, but only solid execution can keep them there. They have to be able to deliver on their intent. Unfortunately, many companies are not very good at it, by their own admission.

Traditionally, organizational change and transformation mainly focused on change in organizations' structures and practices. However, Neilson, Martin, and Powers (2008) show that enterprises fail at strategy execution because they go straight to structural reorganization and neglect the most powerful drivers of effectiveness such as decision rights and information flow, although key for success in enterprise transformation seem to be different from initiative to initiative.

In this paper, author focused on exploring relationship between type of growth strategy and type of implementation. In detail, author explored how company trying to execute growth strategy implemented their business process from the point of ontological perspective (Deitz, 2006).

What is strategy execution? Bossidy and Charan (2002) define it as a systematic way of exposing reality and acting on it, and explain that "heart of execution lies in three core processes: people, strategy and operations (Kaplan and Norton, 2008)." Kaplan and Norton (2008) define six sequential stages intended to help organizations capture what they call an "execution premium." Bear, Dennis, Lee, Overholt, Vickers, and Williams (2006) define strategy as "a major plan that an organization makes to attain a defined and positive business goal," and they also define strategy execution as "a process of implementing plans and achieving goals." Author employed the last definition in this paper.

The remainder of this paper is organized as follows: First, related studies are reviewed in chapter 2. Research method is described in chapter 3. Hypotheses are described in chapter 4. Next, two case studies are introduced in chapter 5. Thus, the cases are analyzed in chapter 6 and discussed in chapter 7. Finally, limitations of this study and implications for future research are described in chapter 8.

RELATED STUDY

Growth Strategy

Growth strategy is one of the most important enterprise strategies, which is featured by Product-Market Growth Grid (Ansoff, 1965), because quite a few companies are straggling to grow in the competitive environment.

Product-Market Growth Grid (Ansoff, 1965) is a widely adopted framework that conceptualizes market diversification, which is also a kind of marketing strategy and growth strategy. It includes market penetration, market development, product development, and diversification.

The framework is intuitive, and some longitudinal descriptive studies, such as Miller and Friesen (1984) and Greiner (1972), provides some qualitative evidence for aspects of the framework.

Although strategy has been discussed from various points of view, "how" and "why" enterprises execute strategy is still critical research topics. Accordingly, this paper explored the relationship between growth strategy as "why" organizations transform and business process change as "how" organizations execute strategy.

Strategy Execution

Strategy execution relates "how" enterprises execute strategy because strategy execution is defined as "a process of implementing plans and achieving goals" (Bear, Dennis, Lee et al., 2006." That is how strategies and the way they are implemented adapt to internal and external feedback, sparking other decisions and new strategic initiatives in response (Bear, Dennis, Lee et al., 2006).

But Neilson, Martin, and Powers (2008) show most of companies aren't very good at strategy execution. When a company fails to execute strategy, the first thing managers often think to do is restructure. But fundamentals of good execution start with clarifying decision rights and making sure information flows where it needs to go. Clarifying decision rights means, for instance, “Everyone has a good idea of the decisions and actions for which he or she is responsible,” “Once made, decisions are rarely second-guessed,” “Managers up the line get involved in operating decisions.” Making sure information flows means, for instance, “Important information about competitive environment gets to headquarters quickly,” “Field and line employees usually have information they need to understand bottom-line impact of their day-to-day choices,” “Line managers have access to the metrics they need to measure the key drivers of their business,” “Conflicting messages are rarely sent to the market.”

These studies suggest that it is necessary to create better strategy execution method and that clarifying decision rights and making sure information flows are ones of the keys for successful strategy execution.

Business Rule and Business Process Changes

Clarifying decision rights and making sure information flows have a close relationship with defining business rule and business process.

Business rule is defined as ‘‘a statement that defines or constrains some aspect of business. This must be a term or fact (described as a structural assertion), a constraint (described as an action assertion), or a derivation. It is ‘atomic’ in that it cannot be broken down or decomposed further into more detailed business rules (Nelson, Peterson, Rariden and Sen, 2009).

Enterprise transformation is enabled by “work process change” to approach value deficiency, which requires “allocating of attention and resource” to make enterprise anticipate and adapt to change with resources to yield further enterprise state (Rouse, 2005). Enterprise transformation is, however, more innovative and strategy related change that it influences multiple aspects of an organization, for instance: routine, organization structure, human capital, marketing strategy and so on. (Op’t Land, Dietz, Waage and et al, 2009, Op’t Land and Dietz, 2012).

Author concluded from these studies that company should change decision rights and information flow according to business process change in order to succeed in strategy execution, when they executes strategy.

Process with Strategy

Miles, Snow, Meyer and Coleman (1978) propose theoretical framework which deals with alternative ways in which organizations define their product-market domains (strategy) and construct mechanisms (structures and processes) to pursue these strategies. Similarly, Miles and Snow (1978) develop a typology of organizational strategies that contain four ‘ideal types’: defender, prospector, analyzer, and reactor. Then they argue that strategy is a way of adjusting relationship between an organization and its environment, and that internal structure and processes in turn must fit strategy if this adjustment is to be successful.

Author concluded that company should examine their business process when they have an intention to execute new strategy.

RESEARCH METHOD

Author created a hypothetical relationship between type of growth strategy and necessity of business process change. And then the hypothetical relationship was examined by applying two case studies.

In this study, author employed Product-Market Growth Grid (Ansoff, 1965) for classifying growth strategy and DEMO (Design and Engineering Methodology for Organization) (Dietz, 2006) for describing and analyzing business process.

Product - Market Growth Grid

Product-Market Growth Grid (Ansoff, 1965) is a widely adopted framework that conceptualizes growth strategy, which is a kind of marketing strategy. It includes market penetration, market development, product development, and diversification (Figure1).

As Figure1 shows, there are four strategies, one for each of the quadrants in Product-Market Growth Grid.

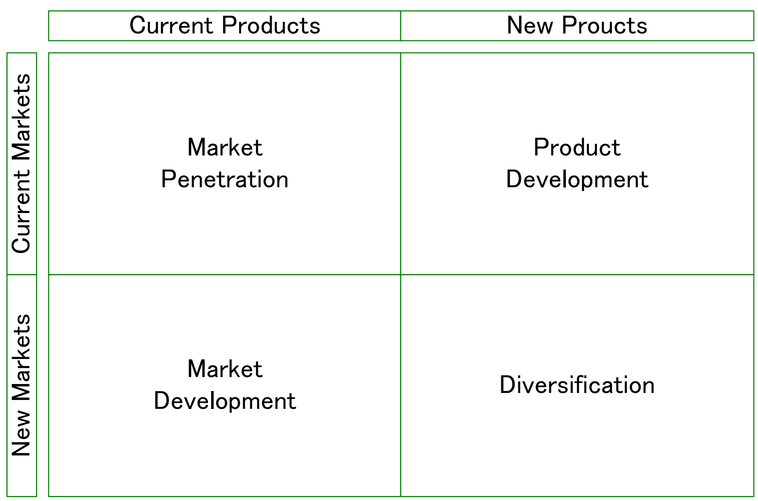

Figure 1 Product-Market Growth Grid

Market Penetration strategy is suitable for a case in which a product is in a current but still growing market. There are three major approaches to increase current product's market share: 1) encourage current customers to buy more, 2) attract competitor’s customers, and 3) convince non-users to use the product.

Market Development strategy is suitable for a case in which a current product is launched in a new market. There are three approaches to develop the market: 1) expand distribution channels, 2) sell in new locations, and 3) identify the potential users.

Product Development strategy is suitable for a case in which a new product is launched in a current market. Intensive growth strategies could be to: 1) develop new features, 2) develop different quality levels and 3) improve the technology.

Diversification makes good sense as better opportunities are found outside a present business. When a new product is launched in a new market, the diversification strategies are of three types such as 1) concentric diversification strategy - develop new products with an earlier technology for new segments, 2) conglomerate diversification strategy - develop new product for new market and 3) horizontal diversification strategy - develop new product with new technology for existing customer.

Author employed Product-Market Growth Grid for classifying type of strategy in this paper.

DEMO (Design and Engineering Methodology for Organization)

Given complexity of change, several researchers have argued that business process should be considered from a modular and system's perspective instead of from a workflow perspective. When business is conceptualized and modularized, similar businesses can be managed using dominant logic (Bettis and Prahalad, 1995), thus the complexity of change can be simplified and become analyzable. Op't Land and Dietz (2012) suggest that DEMO (Design and Engineering Methodology for Organization can be used for modeling enterprise transformation with a high return on modeling effect (ROME).

DEMO is an enterprise ontology used to describe the essential structure of an enterprise without getting into implementation details. It includes four aspect models: Construction Model, Process Model, Action Model, and State Model.

Actor Transaction Diagram (ATD) and Transaction Result Table (TRT)

The Construction Model is featured by Actor Transaction Diagram (ATD). As shown in Figure 2, Actor Transaction Diagram (ATD) aims to describe construction of an enterprise by defining transaction and actors.

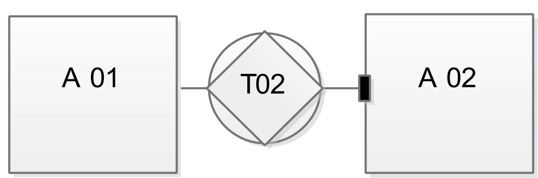

Figure 2 ATD (Actor Transaction Diagram)

a) Transaction: Transaction is a sequence of acts between two actor roles, including communication loop acts (request, promise, state, and accept) and production acts.

b) Actor Role: Actor Role is defined in terms of responsibility, authority, and capability. As shown in Figure 2, the actor role A01 is an actor role which initiates the transaction T02, and the actor role A02 is the actor role that executes the transaction T02.

By using Actor Transaction Diagram (ATD), we can show a main structure of an organization as well as how its main business is conducted, who is involved, and what responsibilities they take can be clarified without getting into implementation details.

Transaction generates result. The transaction T02 and its result R02 are described in Transaction Result Table (TRT), as shown in Table 1.

Table 1 TRT (Transaction Result Table)	
Transaction	**Result**
T02 Prepare	R02 Pizza P is prepared

Action Model

Action Model specifies action rules that serve as guidelines for actors in dealing with their agenda. It contains one or more action rules for every agendum type. Action Model is the most detailed and comprehensive aspect model, hence it is in a very literal sense. When there are any changes in ATD, Action model also changes accordingly. Even when there are, however, no changes in ATD, Action Model may change in some cases.

In this paper, author employed Actor Transaction Diagram (ATD) in order to analyze cases from the point of business process perspective. Author described an ATD of business process before growth strategy execution and an ATD of business process after growth strategy execution. Thus the two ATDs were compared. When there were any differences between the two ATDs, there were also any differences in action rule because action rule was subject to ATD. There could be, however, some differences between the two action rules (action rules before and after growth strategy), even when there were not any differences between the two ATDs. Hence the two action rules were compared even when there were not any differences between the two ATDs.

HYPOTHESES

Based on the pre-research and amount of case investigations, author created four main hypotheses for relationship between type of growth strategy and business process change.

Market Penetration

When Market Penetration strategy is executed, it is assumed that there are no essential business changes in construction, but there could be some changes in its implementation like human behavior and information systems. Thus;

Hypothesis 1-1: There are not any differences between Actor Transaction Diagrams before and after Market Penetration Strategy is executed.

Hypothesis 1-2: There could be difference between action rules before and after Market Penetration Strategy is executed.

Market Development

When Market Development strategy is executed, it is assumed that there are no changes in product, but there are changes in activity field. It could generate implementation level changes such as in human behavior change and information systems change. Thus;

Hypothesis 2-1: There are not any differences between Actor Transaction Diagrams before and after Market Development Strategy is executed.

Hypothesis 2-2: There could be differences between action rules before and after Market Development Strategy is executed.

Product Development

When Product Development strategy is executed, it is assumed that new product and service need new production systems, which lead construction level changes and their subordinating implementation level changes such as human behavior change and information systems change. Thus;

Hypothesis 3-1: There are differences between Actor Transaction Diagrams before and after Product Development Strategy is executed.

Hypothesis 3-2: There are differences between action rules before and after Product Development Strategy is executed.

Diversification

When the Diversification strategy is executed, it is assumed that there is product change including service change which needs a new production system. And activity area also changes. These changes lead construction level changes and subordinating implementation level change such as human behavior change and information systems change. Thus;

Hypothesis 4-1: There are differences between Actor Transaction Diagrams before and after Diversification Strategy is executed.

Hypothesis 4-2: There are differences between action rules before and after Diversification Strategy is executed.

CASE

Author employed two case studies in this paper.

The first one was Baby Product Store Company. This case was described based on five-time interview for the President of "Company A," which was conducted from April 2012 to March 2013. The interview was analyzed and the results were described in the following chapters. To ensure accuracy of interpretations, the description was reviewed by the President of Company A.

The second one is IT Service Provider. This case was described based on four interviews with several managers of "Company B," which was conducted from April to June 2012. The interviews were analyzed and the results were described in the following chapters. To ensure accuracy of interpretations, the description was reviewed by a senior manager of Company B. Although author employed in part Nagayoshi (2013), it was analyzed from additional point of view in this paper.

Baby Product Store Company – Company A

"Company A" was established in 2005, and the headquarters were located in Shibuya, Tokyo, Japan. The company had six baby products stores including one online store, and not only deals with direct consumers but also sold to other retailers. Goods sold included cribs, strollers and various kinds of toys not only to consumers but also business customers.

The stores' total number of product vendors was fifty, and most of them were overseas product makers dealing in baby goods. The main products they dealt in were baby strollers, baby carriers, toys and so on, with a total product line-up of roughly one thousand items.

The company succeeded in growing its business. After establishing the company in 2005, they started their online business. When they began, the headquarters in Tokyo were used as an office and warehouse, as they did not have any physical stores. The President of Company- A and two part-time employees operated the business in those days.

The roles of the headquarters' staff were receiving and shipping orders from their website, dealing with retail companies such as department stores, managing shops, finance, human resource, purchasing and inventory, and searching out new vendors. The number of employees including part-time employees at the headquarters was four.

Store relocation and Area Expansion

The company succeeded in growth. In 2007, they had a chance to open their first physical store in Shibuya, Tokyo near the headquarters. To do so, they increased their staff numbers to five, because they now had to take care of customers visiting their store. Fortunately the company continued to increase revenue, and became well known to customers in a market. So the President decided to move the first store to a bigger site next to the current site in order to have a chance to expand their sales revenue.

New Physical Stores Open

They became more well-known to customers in the market. It led them to open their second store in Yokohama in the spring of 2011. They were invited to open the store. The Yokohama store was approximately 20 kilometers from Tokyo. At the Yokohama store. One salesperson worked on weekdays, and two salespersons worked on weekends there.

In addition to the Yokohama store, third physical store was also opened in Fukuoka in the autumn of 2011. At the Fukuoka store, the staff system was similar to the one in the Yokohama store, with one salesperson working on weekdays, and two salespersons working on weekends. In total, five salespersons worked in shifts at the Fukuoka store.

Moreover, they succeeded in the market and were invited to open more stores. They opened one more store in Yokohama as the fourth store on February 2013, and the fifth store in Toshima, Tokyo on March 2013.

Business to Business

The shop floor at the first store in Shibuya was similar to a "boutique shop," where ladies who had good taste in fashion often patronized. Inside the store, the baby goods were displayed in a manner that suggested a good quality lifestyle for both babies and their parents. The buyers in many famous department stores in Japan found the first store and the dealing products so sophisticated that they were invited to special events in several department stores. Company- A started to sell to business customers like department store, and the headquarters were in charge of such wholesale business.

English Learning Material

Many parents in Japan wanted their children to learn English well. Company A started to deal in English learning materials these days. The materials were imported from overseas companies. Then the English learning materials were mailed to the domestic customers monthly. The headquarters were also in charge of this business.

Business Consulting and Translation Service

Company A also provided business consulting service and translation service, although only the President had ability to provide these services.

The President of Company A had a couple of working experience at major business consulting firms in Japan as a business consultant. Since the President had good relationships with the business consulting firms, they sometimes asked the President to help when they did not have enough consultants' availability. In this case, a business consulting firm contracts with Company A, and then the President of Company A worked for the final client as a member of the business consulting firm.

And the President of Company A studied in United States and had an excellent skill of translation between Japanese and English. Moreover the President had knowledge in information technology and project management. The President of Company A also provides technical translation service with skill and the knowledge.

IT Service Provider – Company B

Company B was a Japanese IT service provider founded in 1969 as a software provider. Company B expanded its businesses into system integration from the late 1980's. Since primary contractors created solutions by identifying and analyzing customer requirements, Company B took a role of sub-contractor and dispatched workers to end user companies based on primary contractors' request. With evolution of new technology and keen competition in information technology, Company B identified new business opportunities to enhance their competitiveness, and they decided to transform the company. The transformation inside Company B includes the following five transformations.

First Division

The First Division made business change, which was to transform from a software package provider to an application service provider (software as a service type of business).

Second Division

The Second Division made two business changes. They were (1) delivery change from a passive-type business to an active-type business, and (2) organizational structure change to conduct the active-type business.

Third Division

Company B acquired a business for application software package, which is for managing IT security, from the company. The package had various functions such as single sign-on, authentication with IC card and secure printing. Company B reorganized an organizational structure change in the third division, in order to achieve the new software package business. The division made two business challenges: (1) When the Third Division started the new business, the software package was modified to serve their own existing customers, and (2) Based on the new software package, the division found new market opportunities and new customers in other industries.

CASE ANALYSIS

The cases were analyzed from the point of two analytical frameworks; 1) type of strategy in Product-Market Growth Grid, and 2) business process change in ATD and action rule.

Type of strategy in Product- Market Growth Grid

Baby Product Store Company (Company A)

a) Store Relocation and Area Expansion: The purpose of the store relocation and area expansion was to get more sales opportunity. They aimed at encouraging current customers to buy more, attracting competitor's customers and convincing non-customers to buy goods by upgrading the store. Hence the store relocation and area expansion was classified into the market penetration strategy.

b) New Physical Stores Open: They opened the four new physical stores- two stores in Yokohama, one store in Fukuoka and one store in Toshima, aiming at getting new customers in these areas. They started to sell in the new locations by opening the new stores. The new physical stores open was classified into the market development strategy.

c) Business to Business: They started to sell their baby goods through department stores, aiming at getting new customers. By selling through the department stores channel, they were assumed to be able to access new customers because the department stores had other type of customers who were different from ones Company A already had. And it was also good for Company A because the department stores had better ability to pull in more customer than

Company A. Selling through the department stores' channel was classified into the market development strategy.

d) English Learning Material: They started to deal in the English learning material in order to meet market need. Many parents in Japan wanted their children to acquire English ability, so Company A contracted with an overseas partner to deal in the English leaning material. By dealing in the English learning material, they were assumed to satisfy the need of existing customers as well as potential customers. Hence dealing in the English learning material was classified into the product development strategy, and could be the diversification strategy: the conglomerate diversifications because the English learning material was a new product and the potential customers were also in the new market.

e) Business Consulting and Translation Service: They started business consulting and translation service for business customers. This was the conglomerate diversification because both of the market and product were new for them.

IT Service Provider (Company B)

a) Transformation from a software package provider to an application service provider in the First Division: This was the product development strategy, because Company B developed a new application service to serve the local governments in Japan.

b) Change from a passive-type business to an active-type business in the Second Division: This was the diversification strategy. For product aspect, Company B transformed their position from a sub-contractor providing workers to a primary contractor providing systems integration services. For market aspect, customer of Company B was changed from existing customer such as system integrator to end user of system in distribution industry.

c) Organizational structure change to conduct an active-type business in the Second Division: This was the market penetration strategy and/or the market development strategy, because they provided an existing system integration service as a primary contractor not only to current customers in distribution industry but also to new customers in other new industries.

d) Software package modification to start a new software package business in the Third Division: This was the product development strategy, because Company B acquired an application package from another company and modified it in order to provide IT security services to existing customer.

e) Applying the software package to a new market in the Third Division: This was the market penetration strategy and/or the market development strategy, because they provided an existing (acquired and modified) application software for IT security not only to existing customer but also new customer in other industries.

Business Process Change in ATD and Action Rule

Baby Product Store Company (Company A)

The ATD before the growth strategy execution in Company A is shown in Figure 3.

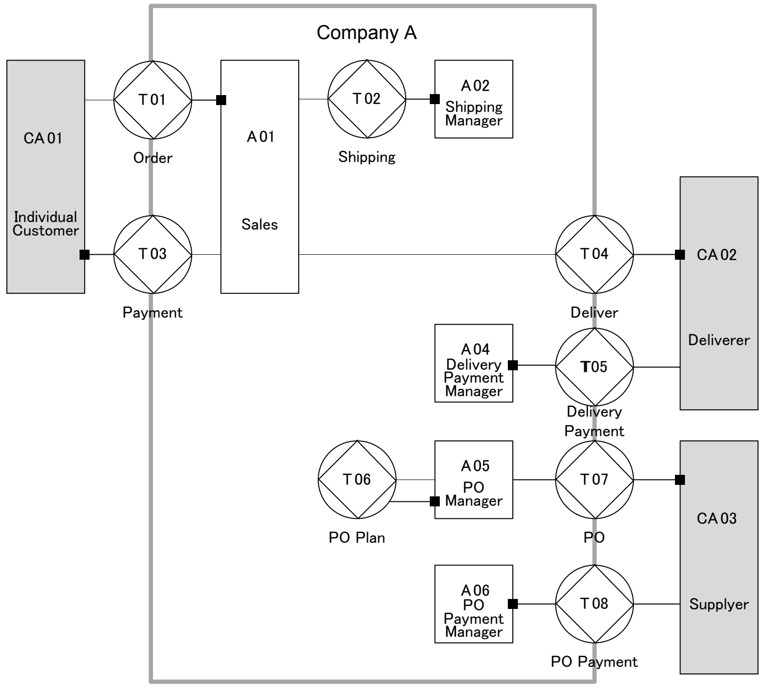

Figure 3 ATD before the growth strategy

a) Store Relocation and Area Expansion: The ATD after the store relocation and the area expansion of the Shibuya store was same as Figure 3. The action rule after the movement and expansion was also same as the one before the execution.

b) New Physical Stores Open: The ATD after opening the stores was the same ATD as Figure 3, but the action rules were different. For example, the purchasing order was issued only from the headquarters before opening the new stores, but it was issued based upon the purchasing request from stores after opening the new stores.

c) Business to Business: The ATD for selling to business customer is shown in Figure 4.

Comparing the ATDs in Figure 3 and in Figure 4, the two ATDs had same number of actor roles and transactions, but different names in the two actor roles; "CA01 Consumer" in Figure 3 was changed to "CA01 Business Customer" in Figure 4, and "A01 Sales" in Figure 4 was changed to "A01 B2B Sales Manager." The action rules were also changed accordingly.

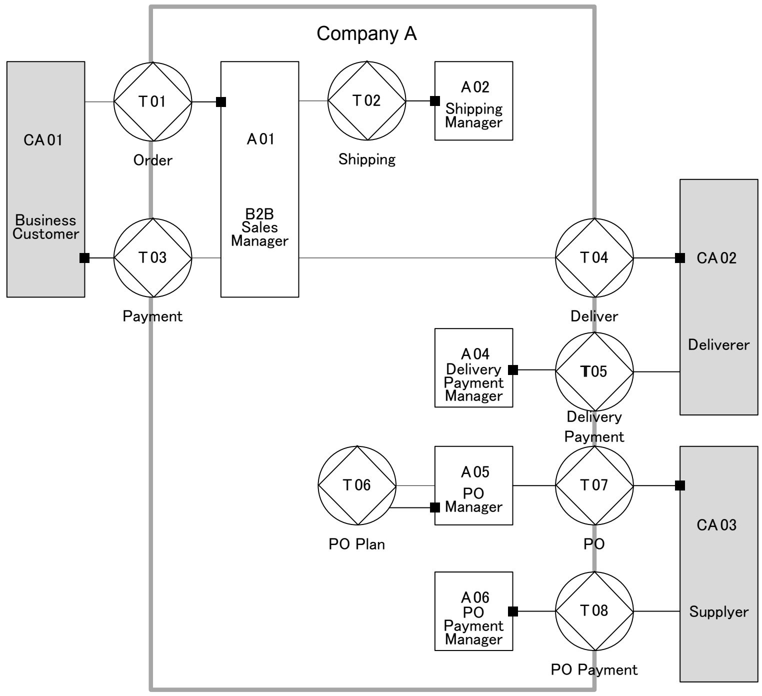

Figure 4 ATD for selling business customer

d) English Learning Material: The ATD for dealing in the English learning material in Company A is shown in Figure 5.

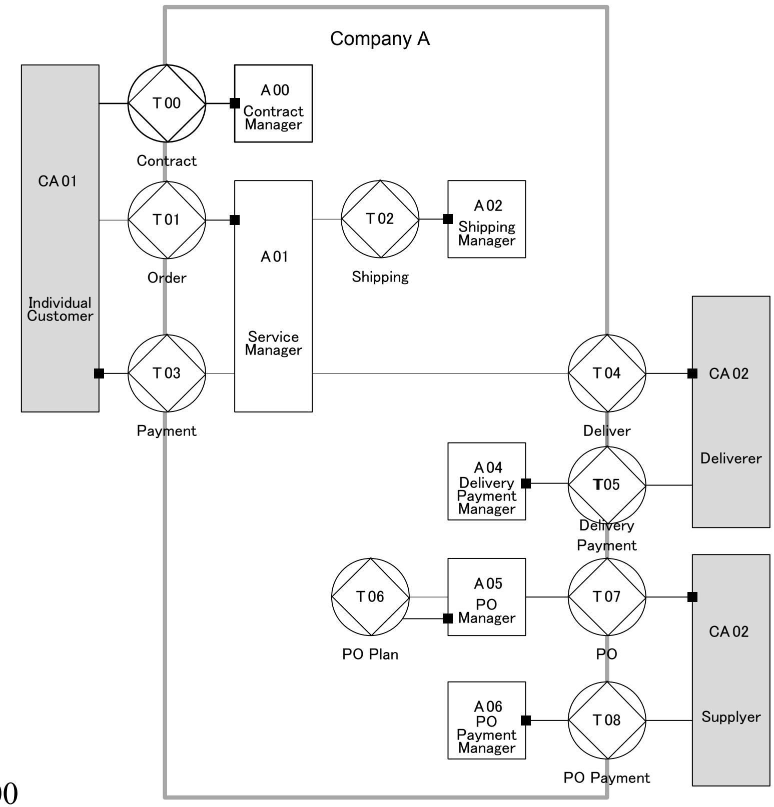

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Figure 5 ATD for English learning materials

Comparing the ATDs in Figure 3 and in Figure 5, the actor roles and transactions in Figure 5 were more than in Figure 3. The actor role "A00 Contract Manager" connecting with "CA01Individual Consumer" and the transaction "T00 Contract" were added in Figure 5. And the actor role "A01 Sales" in Figure 4 was changed to "A01 Service Manager" in Figure 5. The action rules were also changed accordingly.

e) Business Consulting and Translation Service: The ATD for the business consulting and the translation service was shown in Figure 6.

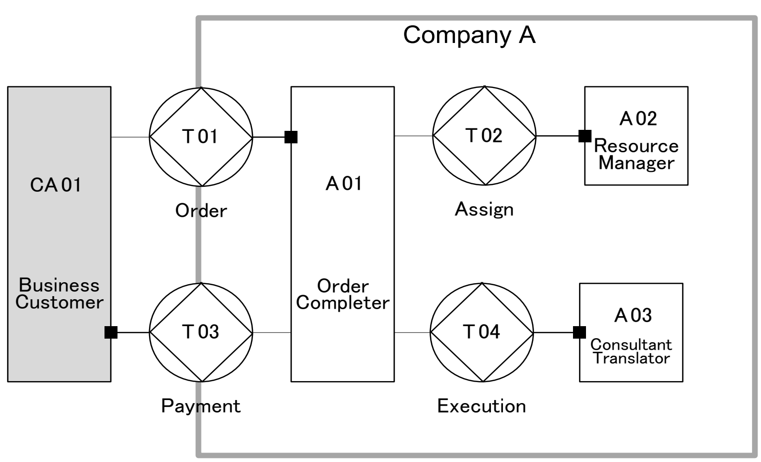

Figure 6 ATD for business consulting and translation service

The ATD before the growth strategy execution in Figure 3 was different from the ATD for the business consulting business and the translation service business in Figure 6. The action rules were also different from each other.

IT Service Provider (Company B)

The ATDs and the action rules before and after the growth strategy execution in Company B were compared.

a) Transformation from a software package provider to an application service provider in the First Division: There were changes at the transaction "plan work." The transaction was no longer initiated by order completer. Instead, it was initiated by product manager, so that a "work plan" could be made before an order was received. Company B supplied a service to customers instead of shipping a software package to customers. Accordingly, the rule of "payment" changed from being based on price of a software package to charging customers for services. This change caused ATD changes which are described in Figure 7 and Figure 8, and action rule change.

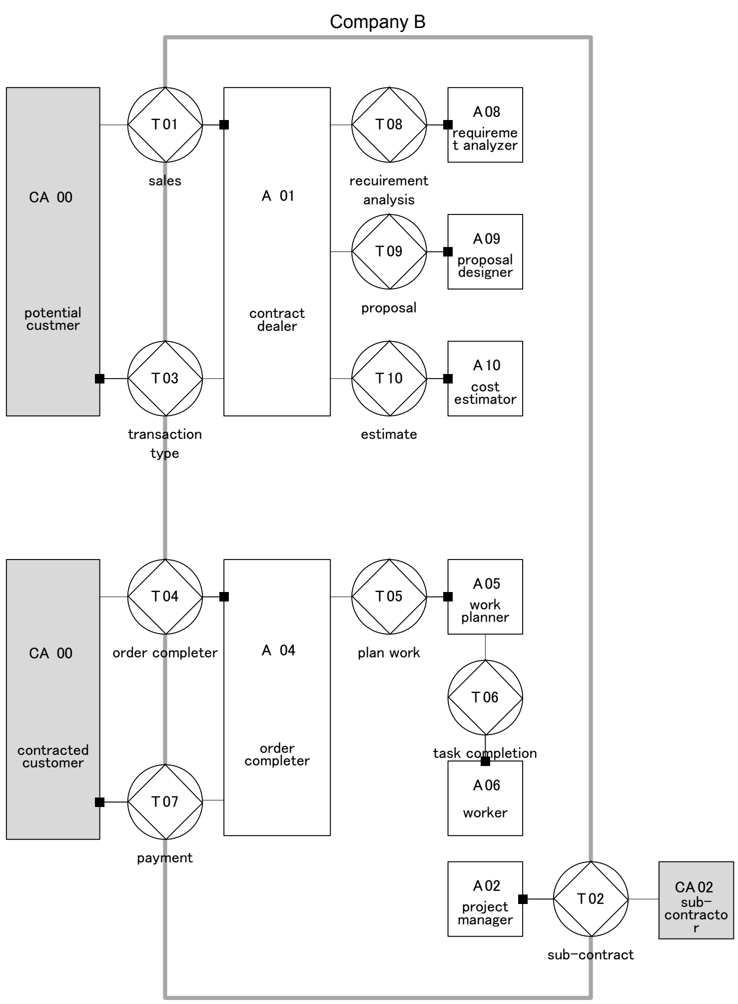

Figure 7 Before the strategy execution in 1st Division

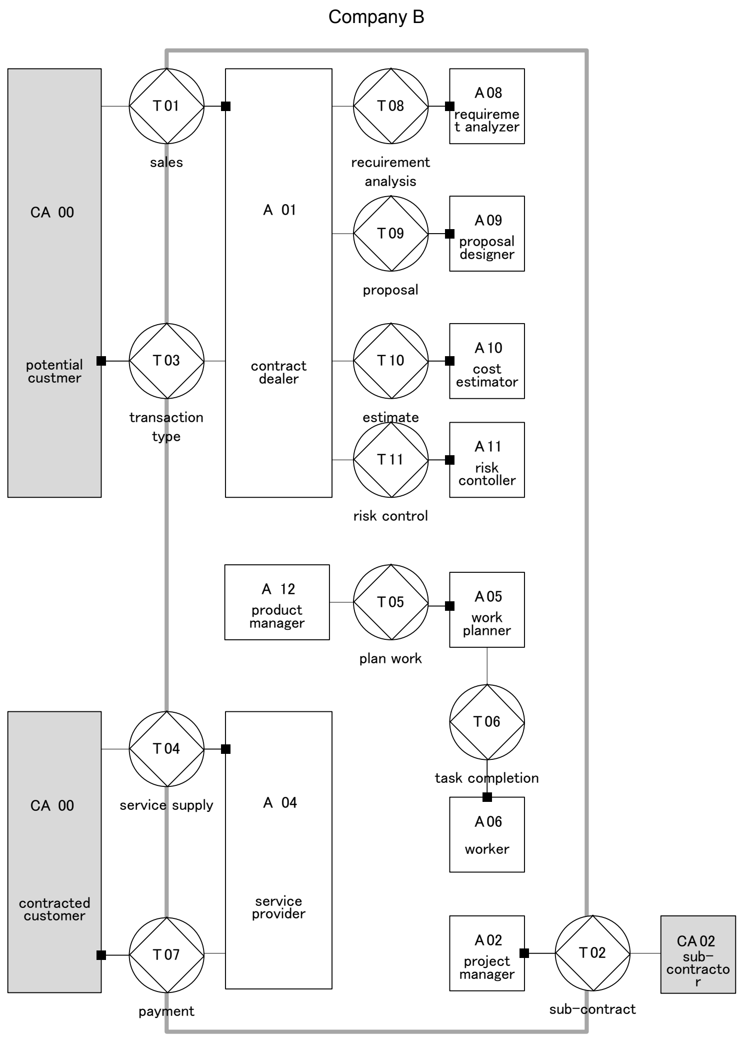

Figure 8 After the strategy execution in 1st Division

b) Change from a passive-type business to an active-type business in the Second Division: Before the growth strategy execution, primary contractor or customer had to control cost, quality, and schedule of project. However, in the new business, all these responsibilities lied with Company B. This change caused ATD changes which are described in Figure 7 and Figure 8, and action rule change accordingly.

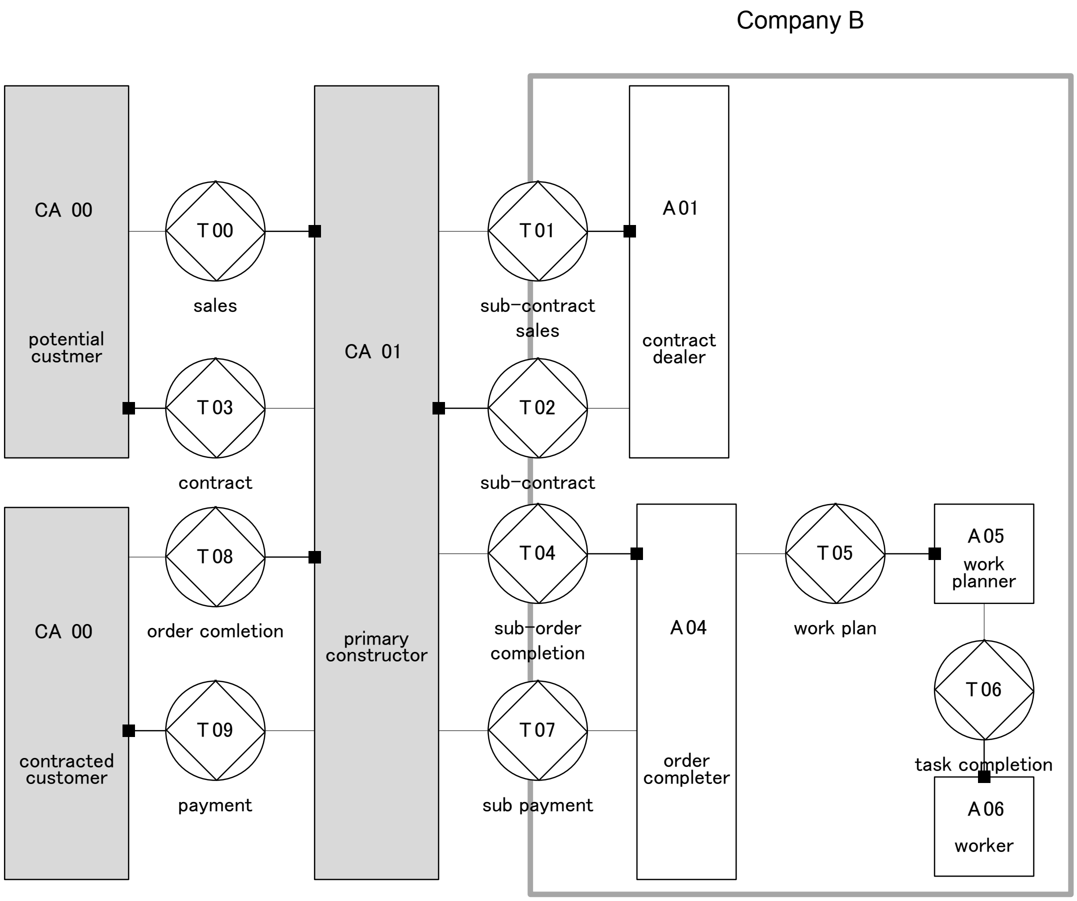

Figure 9 Before the strategy execution in 2nd division

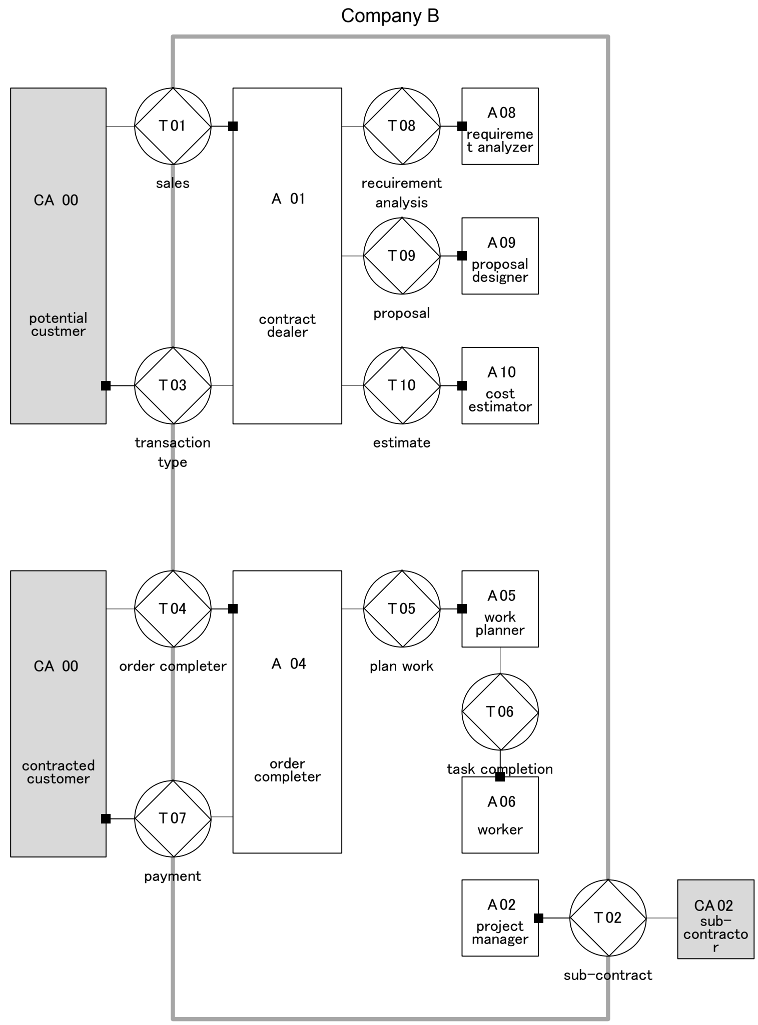

Figure 10 After the strategy execution in 2nd division

c) Organizational structure change to conduct an active-type business in the Second Division: The ATD for primary-contractor-type business was the same ATD after the growth strategy execution (the ATDs are same as the Figure 10), but the action rule after is different from the one before the growth strategy execution. For example, a sales person and an engineer made proposal for proposal request before the growth strategy execution, but the "proposal group" was responsible for making proposal after the growth strategy execution.

d) Software package modification to start a new software package business in the Third Division: It was necessary, in the ATD after the growth strategy execution, to add some important activities such as market investigation, market requirement analysis, cost estimation, risk assessment, decision making for investment, and modification to the ATD before the growth strategy execution (see Figure 11), in order to sell the new application software. These additional transactions and actor roles were shown in Figure 12, and the action rules were changed accordingly.

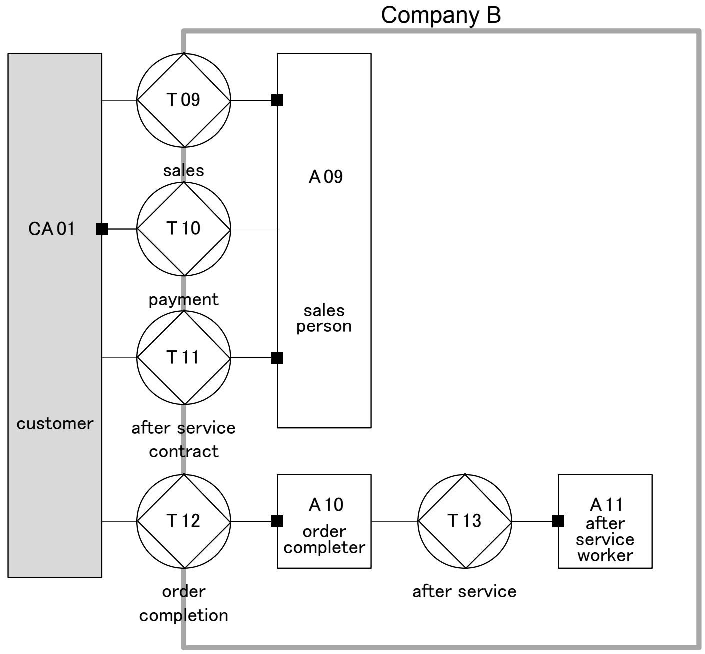

Figure 11 Before the strategy execution in 3rd division

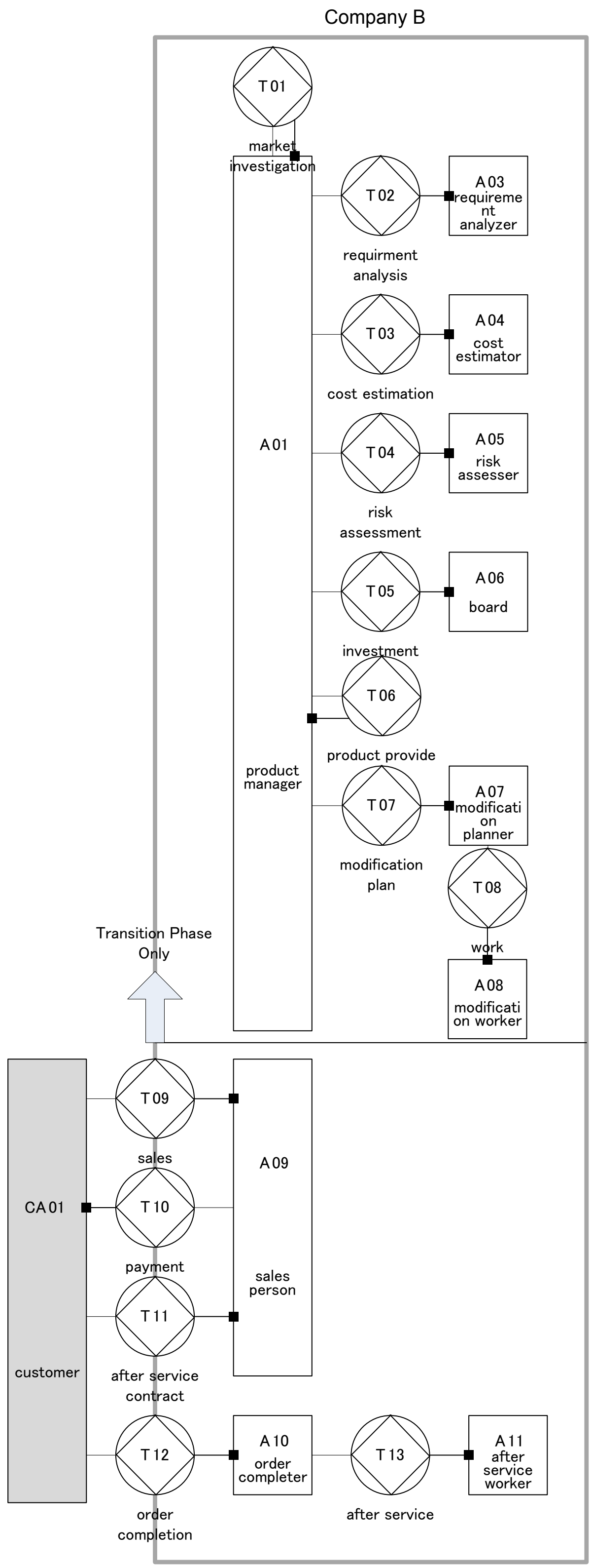

Figure 12 After the strategy execution in 3rd division

e) Applying the software package to a new market in the Third Division: The ATD for selling the new software package to a new customer in a new industry market was same as the ATD (the ATDs are same as Figure 12), and the action rule was also same as the action rules before the growth strategy execution.

DISCUSSION

Table 2 shows the result of the case studies in terms of growth strategy type, and business process changes in ATD and action rule.

According to Table 2, the result of the cases in the market penetration strategy corresponded to "Hypothesis 1-1: There are not any differences between ATDs" and "Hypothesis 1-2: There could be difference between the action rules" before and after the market penetration strategy is executed.

Table 2 Growth Strategy and Business Process Change

Case		Growth Strategy	Business Process Change	
			ATD	Action Rule
Baby Products Store Company	Store Area Expansion	Market Penetration	No Change	No Change
	Open New Stores	Market Development	No Change	Change
	Business to Business	Market Development	Change	Change
	English Learning Material	Product Development	Change	Change
	Business Consulting / Translation Service	Diversification	Change	Change
IT Service Provider	Application Service Providers	Product Development	Change	Change
	Active-type Business	Diversification	Change	Change
	Organization Change for Active-type Business	Market Penetration / Market Development	No Change	Change
	Software Package Modification	Product Development	Change	Change
	Software for New Market	Market Penetration / Market Development	No Change	No Change

The result of the cases in the market development strategy did not correspond to "Hypothesis 2-1: There are not any differences between ATDs before and after the market development strategy is executed" because the ATD of "Business to Business" is different from the ATD before the market development strategy execution. The constructs in the ATDs were similar but just the names of the two actor roles were different, thereby the degree of the deference was assumed to be small. However it corresponded to "Hypothesis 2-2: There could be difference between action rules before and after the market development strategy is executed."

The result of the cases in the product development strategy corresponded to "Hypothesis 3-1: There are differences between ATDs" and "Hypothesis 3-2: There are differences between action rules" before and after the product development strategy execution.

The result of the cases in the diversification corresponded to "Hypothesis 4-1: There are differences between ATDs" and "Hypothesis 4-2: There are differences between action rules" before and after the diversification strategy execution.

CONCLUSION

In this paper, the growth strategy executions in Company A and Company B were analyzed from the point of the ontological business process changes. This study demonstrated real-world examples of applying DEMO to study growth strategy execution. The key findings were: (1) It was not always necessary to change the construction level of business processes and the action rule in the case of market penetration and market development, and (2) It was necessary to change the construction level of business processes and the action rule in the case of product development and diversification.

There are however, limitations. Author studied just two cases in Japan. Author does not have any intention to claim these findings are universal. There may have different results in case of other company, other industry or different country.

Hence these findings just show new viewpoints for further research on strategy execution and enterprise ontology for now. They might be helpful for those companies which try business transformation to execute growth strategy efficiently. But it is needed to study it in further research.

It is also necessary to collect more quantitative evidence to further support the findings because this study is mainly qualitative. To this end, it is also necessary to develop quantitative indicators. Moreover it is necessary to discuss the necessity to study growth strategy execution from the point of business process change with enterprise ontology. More studies are needed to generalize the findings beyond this study.

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THE IMPACT OF SWITCHING COST ON PRODUCT DESIGN STRATEGY

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ABSTRACT

In the setting of two competitors who enter a market sequentially and compete on product positions and prices, this paper presents analytical results for optimal product positioning and pricing strategies. This paper shows that switching cost has no effect on firms' pricing strategies or on late entrant's profit. The paper also shows that switching cost will decrease first mover's positioning advantage and profit. Under the assumption of exogenous production costs, first mover actually has less market share and less profit than late entrant although it charges a higher price.

INTRODUCTION AND LITERATURE REVIEW

A firm's ability to adapt to changes is important to its success. Manufacturing flexibility has many dimensions and product flexibility is one of the most important ones. Work on product flexibility has been very fruitful. As suggested in Röller and Tomback (1993), and Goyal and Netessine (2006), firms often use product flexibility as a weapon to respond to competition. Almost all existing literature concludes that firms with product flexibility will implement it once they enter a market, with or without the presence of competitors.

In this paper, the pioneer company defers the use of product flexibility until it observes the competitor's strategies. Thus the first entrant fully exploits the advantages of being the pioneer and then uses flexibility later as a competitive weapon. Product flexibility allows the first mover to respond to the entry of a competitor by switching from the current product to a new one. This research explores the impact of the first mover's switching cost on product design decisions and first-mover advantages. The total switching cost is not fixed but related to both the original product decision as well as the new one. This paper shows that, in a duopoly market, it may not always be optimal for the pioneer company to use product flexibility as a competitive weapon. This finding is consistent with extant empirical studies.

Extant literature addresses first-mover advantages from many different aspects. Lieberman and Montgomery (1988, 1998) define first-mover advantages as the ability to earn profit. They also identify the mechanisms that lead to first-mover (dis)advantages. These mechanisms often arise from the first-movers' endogenous nature. There is a considerable amount of theoretical and empirical work (Urban, et. al 1986, Lambkin 1988, Kalyanaran and Urban 1992, Golder and Tellis 1993, Brown and Lattin 1994, Bowman and Gatignon 1996, Lee, et. al 2000). These articles support the notion that generally the first mover enjoys a permanent market share advantage and, further, that there is a positive correlation between the order of entries of all competitors and market shares. This paper actually shows that the pioneer may retain lower market share and lower profit with the presence of switching cost.

In the next section, the extant literature is reviewed. The model is described in Section 3. Section 4 summarizes the research and suggests directions for further work.

The Model

We model the following situation: two firms enter a market sequentially, choose their product spatial positions first, and then compete on prices. The first mover has the choice to use flexibility to respond to the entry of competitor.

Assumption 1 (Customer Preferences). *Customer preferences are described by ideal point model , the pioneering contribution of Hotelling (1929). As in Götz (2005), Lilien, et. al (1995), and Tabuchi and Thisse (1995), customer preferences are assumed uniformly distributed in an interval of [a,b].*

Without loss of generality, we rescale the interval to [-1/2,1/2] in this paper. Obviously, 0 will be the best location in the market as firms make product position decisions.

Assumption 2 (Spatial Position for Firms). *Following Lilien, et. al (1995), Tabuchi and Thisse (1995), firms are allowed to position their products anywhere along the real line* $\Re$.

To understand assumptions 1 and 2, one can consider juice as the product in question. Assumption 1 says customer' ideal points of the amount of sugar in each cup of juice is uniformly distributed in some interval, for example between 5 grams and 30 grams. Assumption 2 says the interval of [5 grams, 30 grams] does not prevent firms from producing juice that has more than 30 grams or less than 5 grams sugar per cup.

Assumption 3 (Customer Utility) *We assume customers with ideal point* t *value a product, positioned at* q *with price* p*, by using utility function* $u(q,t) = R - p - (q-t)^2$. R *is the reservation price of customers, which is assumed to be the same for all customers and high enough so that all customers buy one of two products (Tyagi 1999 & 2000).*

Note that in Hotelling's model, a higher value of position does not imply a better product. It denotes a position in the market with respect to a set of heterogenous customers. Assumption 3 says if a customer gets a cup of juice which has different amount of sugar from his/her ideal point, the customers' utility will be lower than the maximum amount of utility (s)he could get. And this disutility will increase as the difference between ideal point and the actually amount of sugar the customer gets increases.

Assumption 4 (Marginal Production Cost). *Firms may have different marginal production costs.* c_A *for first mover A and* c_B *for the late entrant B. To ensure the feasibility of duoplistic setting and make sure that no firm is so cost disadvantaged that it does not participate in the market, we assume* $0 < C_A - C_B < \frac{3}{4}$ *Tyagi 2000).*

This assumption says firms may have different production cost due to any exogenous situation.

Assumption 5 (Sequence of Actions). *Monopoly period: The first mover, firm A, chooses its position* q_{A1} *and price* p_{A1} *myopically. Competition period: The late entrant, firm B, chooses its position* q_B *as well as price* p_B. *Meanwhile firm A resets its product to new position* q_{A2} *and new price* p_{A2} *incurring a switching cost.*

Why would firms in reality act in a myopic way? Hauser, Simester, and Wernefelt (1994) note that "all employees (managers, product designers, service providers, production workers, etc.) allocate their effort between actions that influence current period sales and actions that influence sales in the future. Unfortunately, employees generally more focus on the short term than the firm would like." Mizik and Jacobson (2007) also provide evidence to show that managers often have incentives to enhance short-term performance to increase firm's short-time stock prices even if they need to sacrifice long-time profits. Hence in this paper it will be interesting to explore the myopic case in which firm A is myopic in monopoly period and does not anticipate the entry of competitor.

Assumption 6 (Switching Cost). *When firm A adjusts its product strategy in competition period, it incurs a switching cost* $k \cdot (q_{A2} - q_{A1})^2$ *for moving from old to new positions.*

Since our ideal point distribution is symmetric along 0 and a higher value of q does not imply a better position, quadratic function is used to capture the notion that position change is expensive and the cost depends on the extent of change. The more change, the higher switching cost. The parameter k captures the flexibility of firm A in changing its product design. Smaller k implies better changing capability. This one-time product and process design related switching cost is independent of production volume.

ANALYSIS

let Π_i^j, $i \in \{A, B\}$, $j \in \{1,2\}$ denote firm i's profit in period j; Π_i, $i \in \{A, B\}$ denote firm i's total profit for the planning horizon.

Monopoly Period:

Firm A can position its product anywhere along the attribute space and charge a price as high as it can as long as $R - (t - q_{A1})^2 - p_{A1} \geq 0$ for all customers. Hence firm A is facing the following problem:

$$\underset{q_{A1}, p_{A1}}{Max} \; p_{A1} - c_A$$

Subject to: $R - p_{A1} - (t - q_{A1})^2 \geq 0$, for all $t \in [-1/2, 1/2]$

It is easy to see that firm A reaches its maximal profit when $q_{A1}^* = 0$ and $p_{A1}^* = R - 0.25$ and the optimal profit is $\Pi_A^{1*} = R - c_A - 0.25$.

The value of R will affect the magnitude of firm A's optimal profit in this period and thus the total profit over the whole time horizon but will not affect the nature of decisions.

Competition Period:
Under the ideal point model, when each firms offers a product positioned at q_i with price p_i, $i=1,2$, customers with ideal point t would prefer q_1 to q_2 (assume $q_1 < q_2$) if and only if $R-(t-q_1)^2 - p_1 \geq R-(t-q_2)^2 - p_2$ which implies $t < \frac{p_2 - p_1}{2(q_2 - q_1)} + \frac{q_1 + q_2}{2}$. Hence t is the boundary of market shares.

Assume $q_{A2} < q_B$ throughout the paper (the analysis for $q_{A2} > q_B$ will be symmetric). Then $\frac{1}{2} + \frac{p_B - p_{A2}}{2(q_B - q_{A2})} + \frac{q_B - q_{A2}}{2}$ is the market share for firm A and $\frac{1}{2} - \frac{p_B - p_{A2}}{2(q_B - q_{A2})} - \frac{q_B - q_{A2}}{2}$ is the market share for firm B.

The firms' profits, Π_A^2 and Π_B, are now given by equations

$$\Pi_A^2 = \alpha \cdot (p_{A2} - c_A)(\frac{1}{2} + \frac{p_B - p_{A2}}{2(q_B - q_{A2})} + \frac{q_B - q_{A2}}{2}) - k \cdot (q_{A2} - q_{A1})^2,$$

and $\Pi_B = \alpha \cdot (p_B - c_B)(\frac{1}{2} - \frac{p_B - p_{A2}}{2(q_B - q_{A2})} - \frac{q_B - q_{A2}}{2}),$

where α is the duration of the period.

To solve the problem, prices are found first for any given q_{A2} and q_B and after inserting for the optimal prices, q_{A2}^* and q_B^* are determined. Since Π_A^2 is a concave function of p_{A2} and Π_B is a concave function of p_B, the first order conditions yield

$$P^*_{A2} = \frac{1}{3}(2c_A + \mathrm{c}_B - 3\mathrm{q}_A + \mathrm{q}_A^2 + 3\mathrm{q}_{B\_}2\mathrm{q}_{A2}\mathrm{q}_B + \mathrm{q}_B^2)$$
$$P^*_B = \frac{1}{3}(c_A + 2\mathrm{c}_B - 3\mathrm{q}_A + \mathrm{q}_A^2 + 3\mathrm{q}_{B\_}2\mathrm{q}_{A2}\mathrm{q}_B + \mathrm{q}_B^2)$$

Substitute p_{A2}^* and p_B^* into Π_{A2} and Π_B. Differentiating Π_{A2} and Π_B with respect to q_{A2} and q_B respectively, by the first order conditions,

$$q^*_{A2} = -\alpha . \frac{3 - \sqrt{9 - 12(\mathrm{C}_A - \mathrm{C}_B)}}{9K}$$
$$q^*_B = \frac{(3k - 2\alpha)(3 - \sqrt{9 - 12(\mathrm{C}_A - \mathrm{C}_B)})}{18K}$$

Hence the prices and profits of firms A and B in period 2 are

$$p^*_{A2} = \frac{1}{9}(6 + 5_{C_A} + 4_{C_B} - 2\sqrt{9 - 12(\mathrm{C}_A - \mathrm{C}_B)})$$

$$P^*_B = \frac{1}{9}(3 + 4_{C_A} + 5_{C_B} - \sqrt{9 - 12(C_A - C_B)})$$

$$\Pi^*_{A2} = \frac{4}{27k(3 - \sqrt{9 - 12(c_A - c_B)})} . \{9a^2(1 - (c_A - c_B))$$
$$+2(\alpha - 1)\,k(9 + 2c_A{}^2 + 12_{C_B} + 2C_B{}^2 - 4_{C_A}(3 + c_B))$$
$$+\sqrt{9 - 12(c_A - c_B)}((2k + 1)(3 - 2(c_A - c_B)) + a^2(c_A - c_B - 3)\}$$

$$\Pi^*_B = \frac{(1 - \alpha)(3 + 4(c_A - c_B) - \sqrt{9 - 12(c_A - c_B)})^2}{27(3 - \sqrt{9 - 12(c_A - c_B)})}$$

Following above expressions of the optimal qualities, prices and profits of firms A and B, the results are thus stated as follow.

Proposition 1 (i) Switching cost, K has no effect on $P^*{}_{A2}, P^*{}_{B2} or \prod^*_B$
(ii) $q^*{}_{A2}, q^*{}_B \; and \prod^*_{A2}$ Decrease as K increases.

Proof:(i) The expressions of $P^*{}_{A2}, P^*{}_B or \prod^*_B$ are independent of k. Hence the switching cost has no influence on them.
(ii) The expressions of $P^*{}_{A2}, P^*{}_{B2}$, and easily show that their numerators are independent of k and their denominators are the linear functions of K. Hence $q^*{}_{A2}, q^*{}_B \; and \prod^*_{A2}$ are decreasing functions of k.

Given customers' ideal points are distributed uniformly in [-1/2,1/2] , 0 is the best location in the market. As a myopic first mover, firm A will position its product at 0 in period 1 for granted. In addition, the expressions of $q^*{}_{A2}, q_B$ show that $q^*{}_{A2} < 0 \; and \; q^*{}_b > 0$ As k increases, $q^*{}_{A2}$ decreases and moves away from the best market location, losing first mover advantage. Meanwhile, $q^*{}_B$ decreases and moves toward the best market location, off-setting the first mover's advantage.

Proposition 2 (i) $p^*{}_{A2} > p_B$ for all feasible c_A and c_B.
(ii) Firm A has less market share than firm B in period 2 for all feasible c_A and c_B.
(iii) Firm A has less profit than firm B in period 2 for all feasible c_A and c_B.

Proof:(i) $P_A^{2*} - P_B^{2*} = \frac{(3 + C_A - C_B) \_ \sqrt{9 - 12(C_A - C_B)}}{9} > 0$ implies $C_A - C_B < -18$ or $C_A - C_B > 0$. Given, $0 < C_A - C_B < \frac{3}{4}$ the result follows.

(ii) $\frac{p_B - p_{A2}}{2(q_B - q_{A2})} + \frac{q_B - q_{A2}}{2}$ is the boundary of markets held by the two firms. $\frac{p_B - p_{A2}}{2(q_B - q_{A2})} + \frac{q_B - q_{A2}}{2} < 0$ is equivalent to, $-3 + 8(C_A - C_B) + \sqrt{9 - 12(C_A - C_B)}$ which implies $0 < C_A - C_B < \frac{3}{4}$

(iii)

$$\Pi^*_{A2} - \Pi_B = \frac{1}{27K}(2a^2(\sqrt{9-12(C_A - C_B)} - (3 - 2(C_A - C_B) + 3(1-\alpha)k(3 - 8(C_A - C_B) - \sqrt{9-12(C_A - C_B)})$$

, which is negative for $0 < C_A - C_B < \frac{3}{4}$

Although firm A still enjoys price advantage, it has less market share and less profit than its competitor.

CONCLUSION

Analytical results for optimal product positioning and pricing strategies are presented in the setting of two competitors who enter a market sequentially and compete on product positions and prices. This article shows that switching cost has no effect on firms' pricing strategies or late entrant's profit. The article also shows that switching cost decreases first mover's positioning advantage and profit. Under Assumption 4, first mover actually has less market share and less profit than late entrant in the competition period although it charges higher price.

In future, it will be interested to explore the effect of nonlinear production costs on product positioning and pricing strategies. It will also be interested to explore the robustness of results when late entrant can make a decision on time-to-market.

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INTEGRATION OF TWO DIFFERENT SIGNAL PROCESSING TECHNIQUES WITH ARTIFICIAL NEURAL NETWORK FOR STOCK MARKET FORECASTING

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ABSTRACT

In the area of the stock market forecasting, a number of methods have been used. One of the popular methods is Back Propagation Artificial Neural Network (BP-ANN). Exploring the previous work in this area, one can observe that predictive models suffer unreliability due to instability in security markets. We observe that this problem is analogous to a similar problem in signal processing systems where noisy signals resemble the variations and instability in the financial signals. Therefore, we believe that applying filtering techniques of signal processing should improve the quality of the financial signals before using them in predictive models such as BP-ANN. In this work, we will integrate two different pre-processing techniques: Gaussian Zero-Phase filter and Fast Fourier Transform to test their possible contributions to enhance forecasting reliability. To test these two techniques, the past 12 years data for two stock market indices, DOW30, and NASDAQ100, are used in the experimental work to verify and compare the performance of the two techniques.

Keywords: *Back Propagation Artificial Neural Network, Signal Processing, Gaussian Zero-Phase filter, Fast Fourier Transform, Stock Market Forecasting.*

INTRODUCTION

One of an active portfolio management's critical tasks is forecasting stock market variations with time. Although forecasting of the stock market is crucial, many techniques have been explored in this area but did not fully succeed to achieve satisfactory levels of prediction accuracy. Especially, during uncertain local and global circumstances and events, stock market indices behave with a high degree of uncertainty. In the challenging times of the economy, investors are very careful and conservative about their investments and their financial security. According to the Modern Portfolio Theory, non-systemic risk can be reduced by mutual funds and index funds. Whereas, the systematic risk due to the unstable economic and financial situations cannot be controlled. Technical trading techniques claim that by sending buying and selling signals on a regular basis, investors can make better investment decisions even in volatile market conditions. Given that claim, establishing a technical trading mode that can reliably predict stock market indices in very challenging and dynamic economic situations requires refined and advanced solutions.

One of the most popular models which has been investigated and used by many researchers in this area of research is Artificial Neural Networks (ANNs). ANNs are mathematical models that attempt to emulate the human brain neural network and its reasoning process to recognize patterns. The power of ANNs is represented in their learning ability from training on incomplete, imprecise, and partially incorrect examples. Its unique advantage makes it well suited to deal with unstructured problems, inconsistent information, and real-time output (Trippi &Turban, 1996). ANNs have many useful and reliable purposes, including: clustering, classification, and recognition in many fields of research. They are applied to forecast stock and commodity prices, bond ratings, foreign exchange rates, T-bills, bonds, and inflation (Aiken, 1999; Krishnaswamy et al., 2000; Sharma & Alade, 1999).

Several studies have been published in the last two decades that suggested that the ANNs is more reliable than other traditional forecasting techniques (Sharda & Patil, 1990; Tang, 1991; Trippi & Turban, 1993; Atsalakis & Valavanis, 2009). ANNs is a robust predictive model for challenging time series via training to approximate the hidden patterns in a time series. Although ANNs is a reliable predictive model, its effectiveness relies on a number of factors such as: learning algorithm, quality of training data sets, network architecture, etc. (Sharma & Alade, 1999). Further, one of the most important factors is reported to be noise content in the signal that significantly destabilizes the performance of ANNs (Kim, 2006). Therefore, it is of great interest and potential to investigate the benefits of signal processing techniques that can be used for signal de-noising as a preprocessing stage. A very interesting observation made by (Nair et al., 2010) that filtering techniques are widely used in general signals but rarely in financial signals. So, from the preceding discussion, we propose to utilize the reliability of the ANNs and the de-nosing capability of the signal processing techniques in an integrated predictive model for financial signals, especially stock market indices. In this proposed method, the feature vectors are modeled as k-entry days of the stock market close day data. Based on the multi-layer perceptron (MLP) BP-ANN architecture requirements, the classes of feature vectors are taken as the last entry of each vector. Since the stock market data is real data, the vectors are discretized into a suitable number of levels representing the range of classes. The training and testing data was collected from DOW30 and NASDAQ100 over 12 years where the experimental results demonstrated the reliability of the proposed approach with average prediction accuracy of 98.25%.

LITERATURE REVIEW

In the literature, Artificial Neural Networks (ANNs) have been a common choice of investigation for a wide spectrum of applications in business and economics especially in the stock market forecasting problems. White (1988) used ANNs for time series analysis of IBM stock daily returns. Trippi and DeSieno (1992) studied a specific ANNs trading system for S&P 500 index future contracts. Lin and Lin (1993) investigated ANNs' forecasting capability for Dow Jones Industrial Average (DJIA). Kryzanowski et al. (1993) applied the Boltzmann machine for ANNs training to classify stock returns as negative, positive, or neutral. Refenes et al. (1993) applied feed-forward network with multi-layers. Refenes et al. (1994) did a comparative study between regression models with a back-propagation network for stock forecasting. Dropsy (1996) used ANNs to build a nonlinear forecasting technique to predict international equity risk premia. Wang and Leu (1996) introduced an integrated solution of moving average (ARIMA) and ANNs for forecasting price movement of the Taiwan stock market.

Motiwalla and Wahab (2000) used BPANN in their research work. Lam (2004) studied ANNs' capability of technical analysis for financial performance prediction. Qing et al. (2005) used ANNs to predict stock price movement for companies of Shanghai stock exchange. Constantinou et al. (2006) applied MLP-ANN with two inputs. Zhu et al. (2008) investigated forecasting of stock returns and volumes from various indices by applying the ANNs technique. Atsalakis and Valavanis (2009) presented an extensive survey on the stock market forecasting models and techniques. Manjula et al. (2011) used ANNs models to forecast the daily returns of the Bombay Stock Exchange Sensex. MLP-ANN was used to build the daily return's model, and to provide a better alternative for weight initialization, the MLP network was trained using multiple linear regressions. Qing et al. (2011) conducted a comparative study on the predictive ability of several forecasting models including: a single-factor capital asset pricing model (CAPM), and Fama and French's three-factor model. All these models were compared for the forecasting ability with ANNs. Oliveira et al. (2013) applied ANNs to predict stock price and improve the directional prediction index with two case studies investigated. Park and Shin (2013) presented a complex ANNs architecture that considered many influential factors applied to the global economic index and stock prices of 200 individual companies. Ticknor (2013) introduced a novel model of Bayesian–ANN integrated solution that adds probabilistic nature to the traditional ANN weights which prevent over-fitting and over-training of the ANN model. Recently, Sharma and Rababaah (2014) proposed signal processing technique with ANN to predict stock market forecasting.

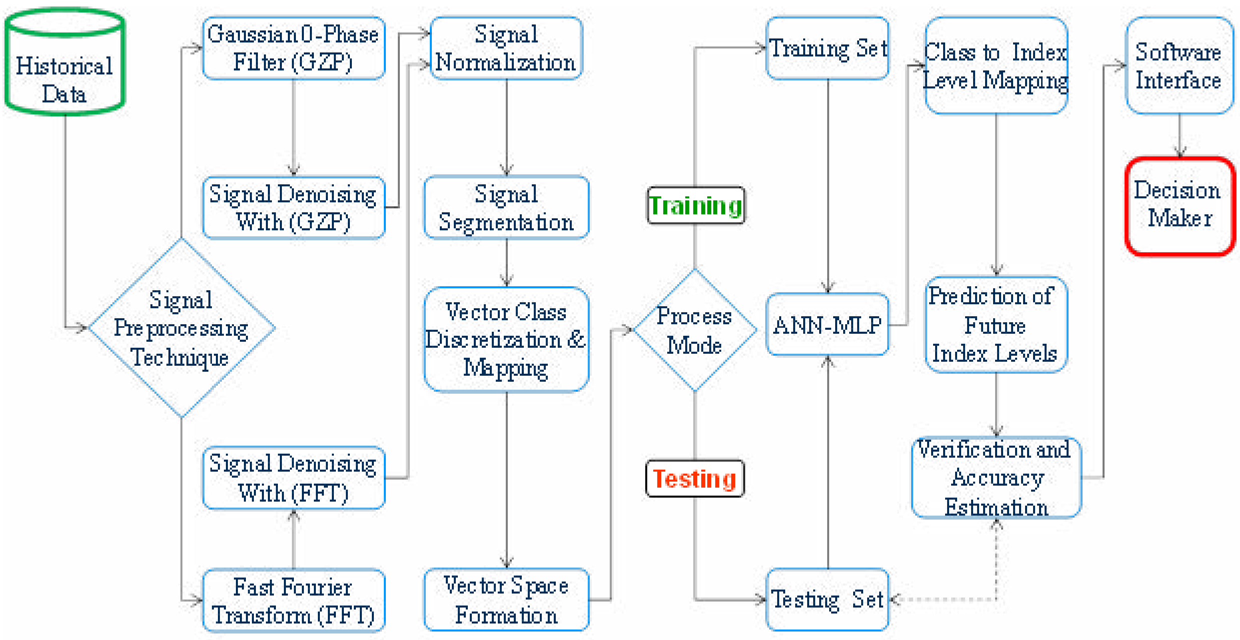
THEORY AND TECHNICAL APPROACH

In this section, we will discuss the technical aspects of the two proposed methods of Fast Fourier Transform (FFT) in the context of signal processing and BP-ANN. Further, the software implementation of both methods will be presented. The integration of the two methods in one solution for Stock Indices Prediction will be discussed as well. Figure 1 depicts the proposed process model that will be described in the following sections.

The first step in our study was to use both GZP and FFT to filter the DOW30 signal. The results of this step are shown in Figure 4 (left). To see the differences in details between the two techniques, we enlarged a snapshot of a section of the signal as illustrated in Figure 4 (right).

Overall, the two techniques produced similar performances with one observation that gave the GZP an advantage over the FFT. This observation was matching the peeks of the input and the filtered signals. The effects of this observation will be demonstrated in the experimental work section.

Figure 1
Flow Diagram of the Proposed Data Processing Models



Historical Data

The online databases of Yahoo Finance (http://finance.yahoo.com/) were utilized to collect the data sets for training and testing the proposed techniques. The collected data covered daily open, close, low, and high indexes of twelve years for NASDAQ100 and DOW30.

Signal Preprocessing Techniques

Noise content in raw data could be a challenging problem for data processing models that use these data sets for training and testing. Therefore, it is important to consider filtering raw data from noise content to make it reliable for the processing model so its forecasting capability is not negatively impacted.

Factors such as natural, political, finical, social, etc., are examples of many that affect stock index data. One of the main objectives in our study is to significantly reduce the noise content of the input signal using the aforementioned signal processing models.

We are interested in this study due to our previous work in Sharma & Rababaah (2014) when we explored this idea of using signal processing techniques in stock indexes. Our previous experience with GZP was very promising and we are interested to compare its performance with another powerful technique of FFT to explore their differences and potentials.

Fast Fourier Transform (FFT)

The fundamental concept of digital-signal filtering is the convolution. Algebraically, convolving two polynomial functions is the operation of multiplying the coefficients of these two functions. Let the coefficients of two functions be denoted as the two vectors: u and v. Further, let the lengths of these two vectors be m and n respectively. Then the output vector of the convolution operation of the two input polynomials is of a length of $m+n-1$. The k^{th} element in this output vector is expressed as:

$$w(k) = \sum_{j} u(j)v(k+1-j) \tag{1}$$

Based on the convolution theory (Quinquis, 2008), the convolution of two sequences can be obtained by the product of their Fourier transform as follows:

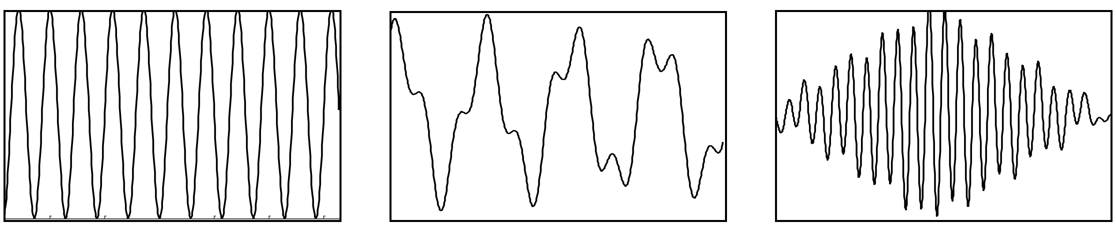
Let x be the first sequence, y be the second sequence, where it assumed that both sequences have the same length; otherwise, they need to be aligned by the zero-padding operation. Further, let X, Y be the discrete Fourier transform (DFT) of the sequences, respectively, then the convolution operation (Figure 2) of these two sequences can be obtained as:

$$w = FFT^{-1}(X \bullet Y) \tag{2}$$

Whereas,

W = the oupt signal of the convolution operation,
FFT^{1} = inverse Fourier transform, and
X•Y = the element-wise product of the two signals.

Figure 2
Illustration of convolution operation of two signals
(Left: 1st input signal; middle: 2nd input signal, and right: the output signal of the convolution operation)



The digital-signal filtering utilizes the convolution theory by designing a filter impulse response (FIR) denoted as h, and convolving it with the input signal x to produce the filtered signal y as follows:

$$y(k) = h(k) * x(k) = \sum_{l=-\infty}^{\infty} h(k-l)x(l) \tag{3}$$

To demonstrate the effect of typical filter, figure 3 illustrates an input noise signal convoluted by a typical averaging filter. It can be observed that the output signal was successfully recovered with high accuracy using convolution-based signal filtering.

Figure 3
Illustration of noise filter using convolving a noisy signal with an arbitrary averaging filter
(Left: noiseless input signal; middle: 2nd input signal with added noise, and right: the output filtered signal)

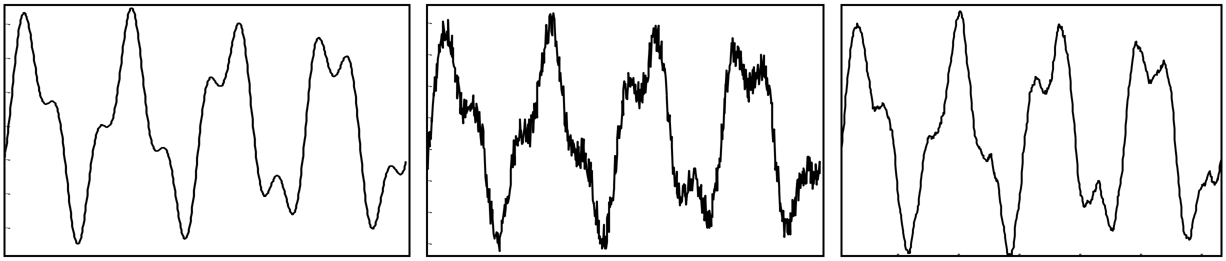
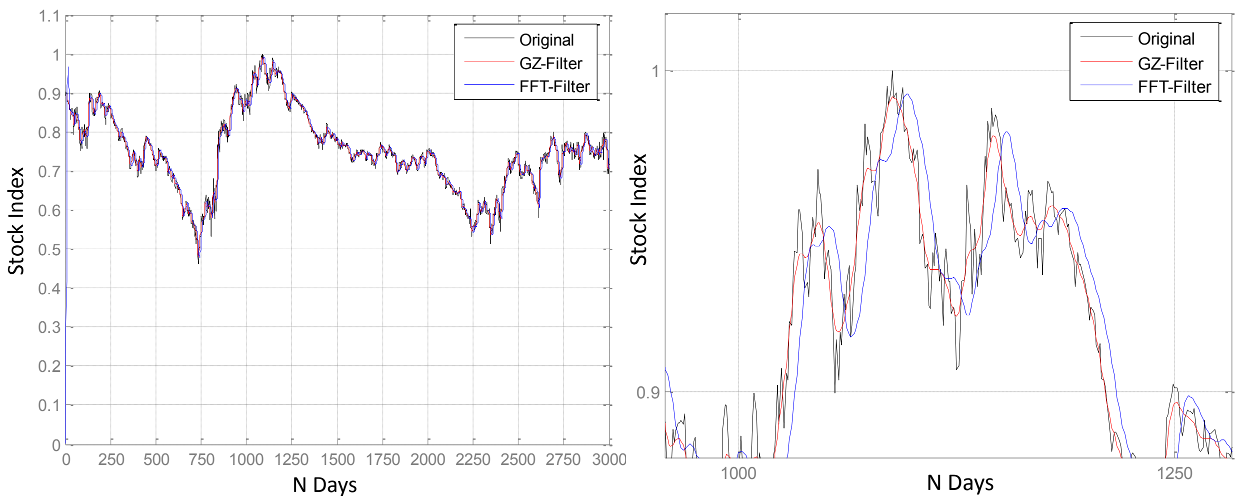


Figure 4 illustrates the preliminary testing results of the signal filtration of DOW30 with GZP vs. FFT. The overall result is depicted in the left chart where in the right chart, a zoomed-in section is chosen to demonstrate a close-up snapshot on the details of the differences between the two filters. It can be observed from the two figures that the two methods have similar filtering effects with one difference that is a forward shift in the case of FFT. The impact of this effect will be elaborated upon in the final testing section of this paper.

Figure 4
Initial Investigation between GZP and FFT de-noising Techniques



Back Propagation Artificial Neural Network (BP-ANN)

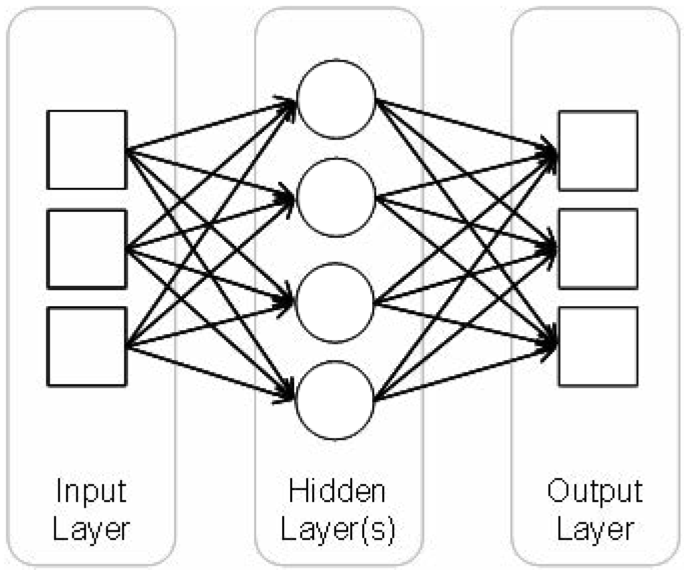
The structure of the Multi-Layer Perceptron (BP)-ANN (Figure 5) consists of three parts:

- Input Layer: the first layer of perceptrons that receives the input vector.
- Hidden Layers: located between the input and the output layer. The output of the input layer is fed into the first hidden layer; the output of the first layer is fed into the next hidden layer, and so on. The number of hidden layers needed varies based on the complexity of the application. Often, the nodes (perceptrons) of the adjacent layers are fully connected.
- Output Layer: The multiple nodes in the output layer typically correspond to multiple classes for multi-class pattern recognition problems.

Multilayer Perceptron Learning Algorithm (Back Propagation)

The most common approach is the gradient descent algorithm, in which a gradient search technique is used to find the network weights that minimize a criterion function. The criterion function to be minimized is the Sum-of-Square-Error. A complete derivation of the algorithm can be found in Haykin (1994).

Figure 5
Multilayer Perceptron Model



The algorithm described in Haykin (1994) is depicted in Figure 6 and can be summarized as follows:
Parameters definitions in the algorithm are defined for a neuron in layer *(l):*

$w^{(l)}$: Synaptic weight vector of a neuron.

$\theta^{(l)}$: Threshold of a neuron.

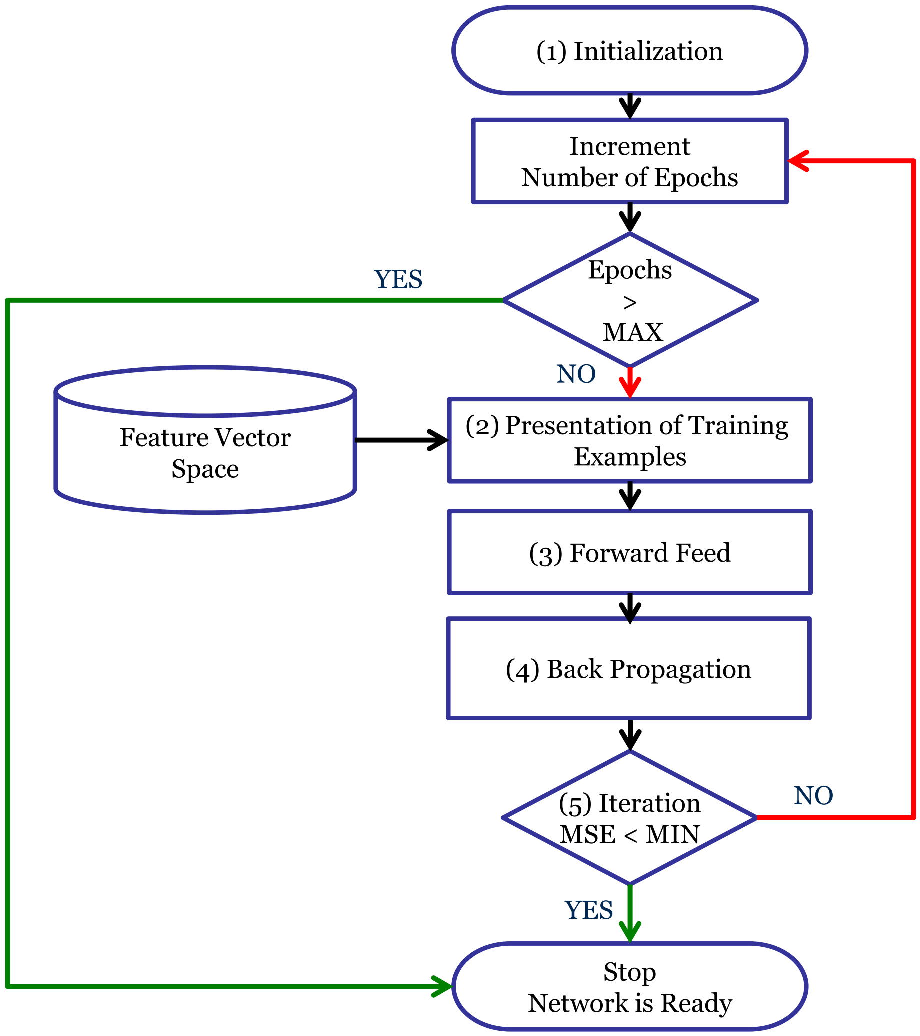
$v^{(l)}$: Vector of net internal activity levels of neurons.

$y^{(l)}$: Vector of function signals of neurons.

$\delta^{(l)}$: Vector of local gradients of neurons.

e_j : The j^{th} error vector where, j = 1, 2, 3, …, n

Figure 6
Block Diagram of the Learning Algorithm of MLP BP-ANN



1. *Initialization*: all synaptic weights and thresholds are set to small random numbers.
2. *Presentations of Training Examp*les: Present the network with an epoch of training examples. For each example in the set, step 3 and 4 are repeated.
3. *Forward Feed:* let a training example in the epoch be [x(n), d(n)], where x(n) is the input vector, and d(n) is the desired output vector on the output layer. The activation potential and function signals of the network are computed, proceeding forward through the network, layer by layer, using the following relation system:

$$v_j^{(l)}(\mathrm{n}) = \sum_{i=0}^{p} w_i^{(l)}(n) y_i^{(l-1)}(n) \tag{4}$$

Where, $w_0^{(l)}(n) = -1, \quad y_0^{(l-1)} = \theta$

$$y_i^{(l)}(\mathrm{n}) = \frac{1}{1+\exp(-v_j^{(l)}(n))} \tag{5}$$

If the neuron is the first hidden layer, then

$$y_i^{(0)}(\mathrm{n}) = x_j(\mathrm{n}) \tag{6}$$

If the neuron is in the output layer (l = L), then

$$y_i^{(L)}(\mathrm{n}) = o_j(n) \tag{7}$$

Hence, the error is computed as

$$e_j(n) = d_j(n) - o_j(n) \tag{8}$$

4. *Back Propagation*: compute the local gradients of the network, proceeding backward, layer by layer.

In the output layer

$$\delta_j^{(L)}(n) = e_j^{(L)}(n) o_j(n)[1 - o_j(n)] \tag{9}$$

In a hidden layer

$$\delta_j^{(l)}(n) = y_j^{(l)}(n)[1 - y_j^{(l)}(n)] \sum_k \delta_j^{(l+1)}(n) w_{kj}^{(l+1)}(n) \tag{10}$$

Hence, adjust the weights:

$$w_{ji}^{(l)}(n+1) = w_{ji}^{(l)}(n) + \alpha[w_{ji}^{(l)}(n) - w_{ji}^{(l)}(n-1)] + \eta \delta_j^{(l)}(n) y_j^{(l-1)}(n) \tag{11}$$

where:

η : is the learning-rate parameter

α : is the momentum constant.

The tradeoff of η is a rough approximation for faster processing, or a better approximation for slower processing. In the case where a high learning-rate is chosen, α is introduced to stabilize the system.

5. *Iteration:* Iterate the computation by presenting new epochs of training examples to the network until the free parameters of the network stabilize their values and the average square error computed over the entire training set is at minimum or acceptable small value. The order of presentation of training examples should be randomized from epoch to epoch. The momentum and the learning-rate parameter are typically adjusted (and usually decreased) as the number of training iterations increases.

Some points need to be considered in the MLP model:

- The weights typically are initialized to small random values, which gives the algorithm a safe start.
- A simple heuristic technique is used to choose learning rates, which is to make the learning rate for each node inversely proportional to the average magnitude of vectors feeding to that particular layer.

- Termination criteria includes the following:
  - A target minimum gradient is reached.
  - The Sum-of-Square-Error falls below a fixed threshold.
  - When all of the training samples have been correctly classified.
  - After a fixed number of iterations have been performed.
  - Cross Validation technique.

As usual, the available input space is randomly partitioned into a training set and a test set. The training set is further partitioned into two subsets: a subset used for estimation of the model (model training), and a subset used for evaluating the performance of the model (model validation). The validation subset is typically 10 to 20% of the training set. The goal of this technique is to validate the model on a data different from the one used for model estimation.

The best model is chosen after this validation phase, then the chosen model is trained using the full training set (Haykin, 1994).

It is worth mentioning that the last approach (Cross Validation) in contrast to all of the other approaches is not sensitive to the choice of the parameters. It not only avoids premature termination, but can improve the generalization performance. However, it is computationally intensive.

EXPERIMENTAL WORK AND RESULTS ANALYSIS

Three different settings were used in the experimentation stage these are: no signal preprocessing (NPP), Gaussian Zero-Phase Filter (GZP) and Fast Fourier Transform (FFT). The three different settings are presented in this section.

Experiments with Default Parameters for all Techniques

We wanted to test all cases of NPP, GZP and FFT without attempting to investigate the effect of tuning their parameters and set the result as our baseline for later comparisons. We used the two data sets for NASDAQ100 and DOW30 in all experiments. In the next section we will present the experiments of optimization trials for the FFT technique. Thus, Figures 7, 8, and 9 represent the results of the experiments with default parameters. As it can be observed, in the Figures 7-10 and Table 1, NPP's accuracy was the lowest. FFT performed better than NPP and the best accuracy was for GZP in both data sets of NASDAQ100 and DOW30.

Table 1
Summary of Results with Default Parameters

Experiment	Technique	Testing Accuracy	
		DOW30	NASDAQ100
1	NPP	96.86	96.52
2	GZP	98.16	97.88
3	FFT	97.53	96.54

Figure 7
Results of No Signal Preprocessing

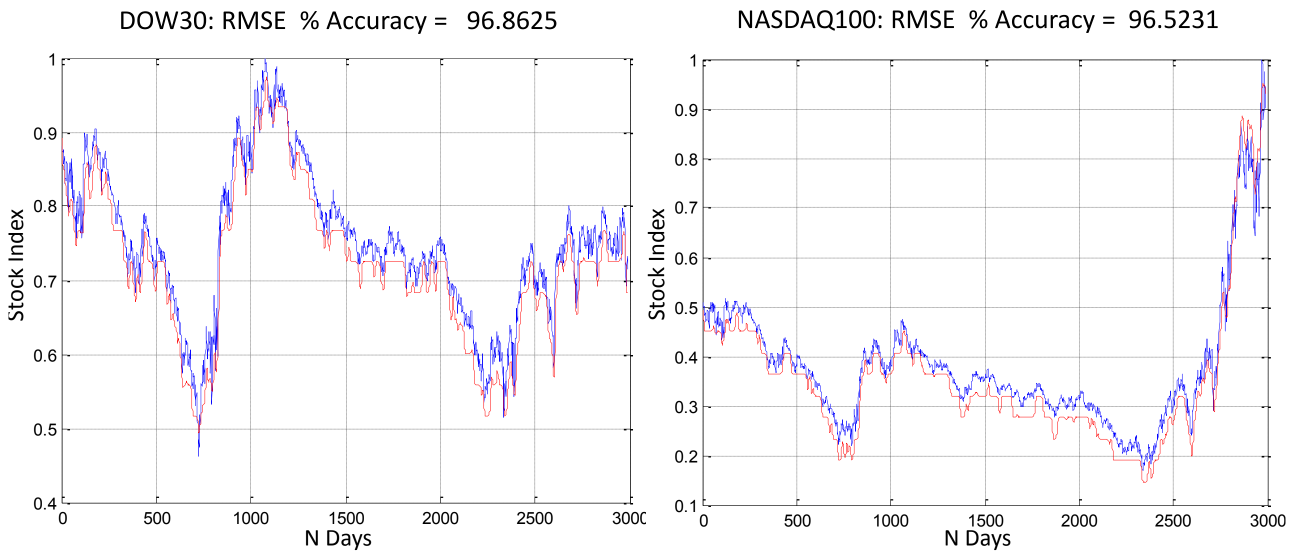


Figure 8
Results of GZP Signal Preprocessing with Default Parameters

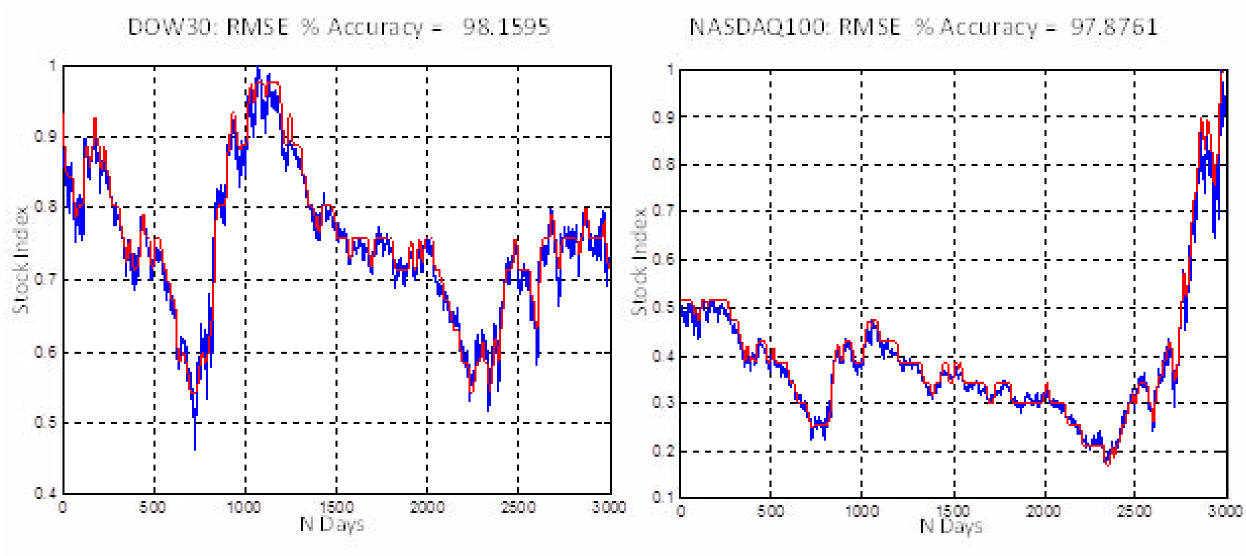


Figure 9
Results of FFT Signal Preprocessing with Default Parameters

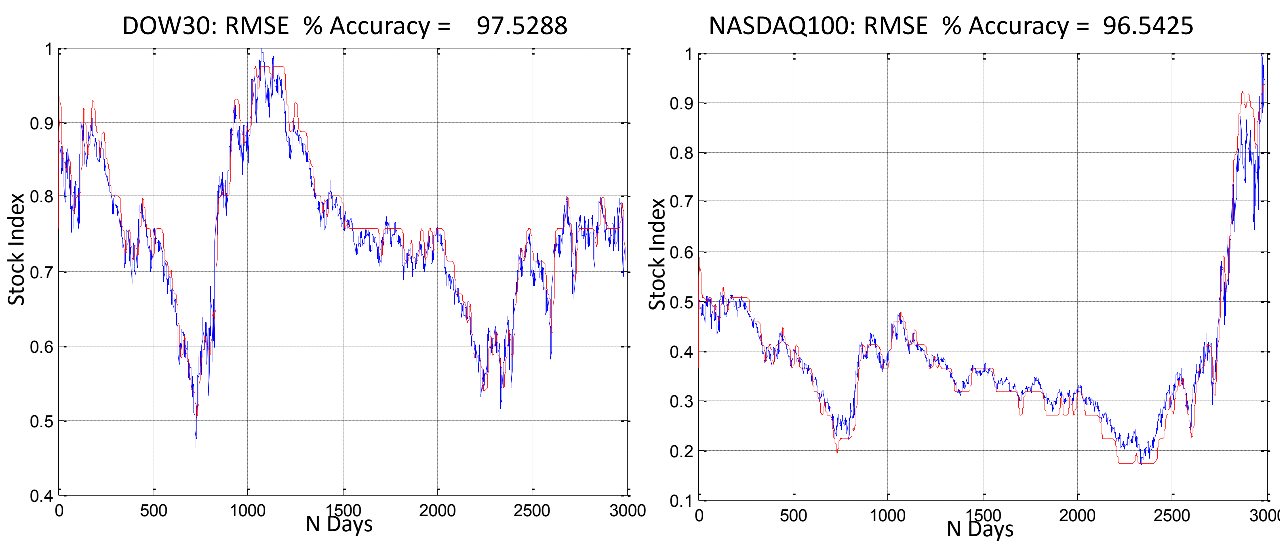
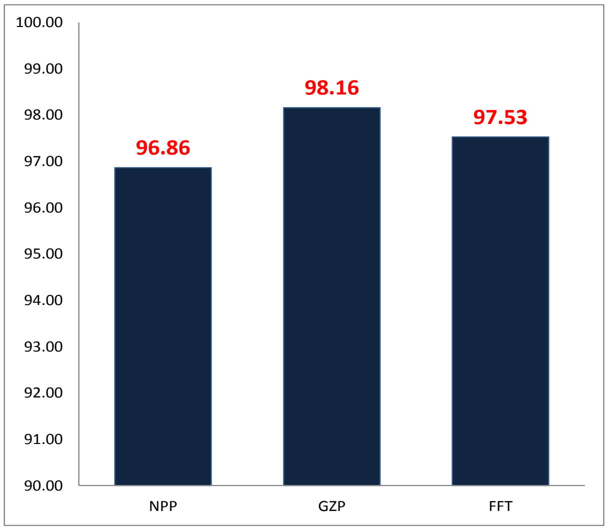
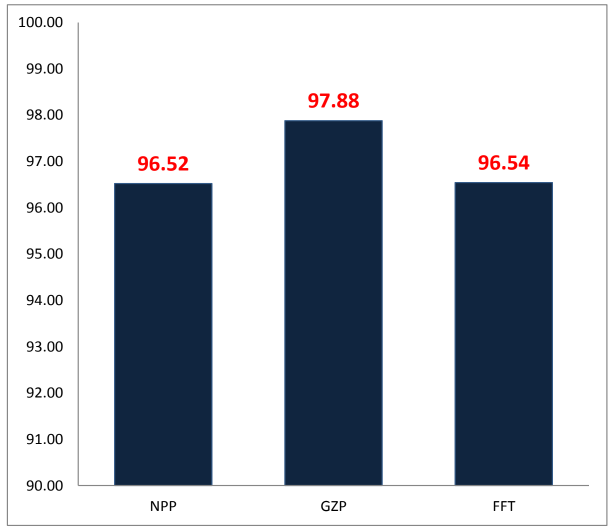


Figure 10
Summary Results with Default Parameters





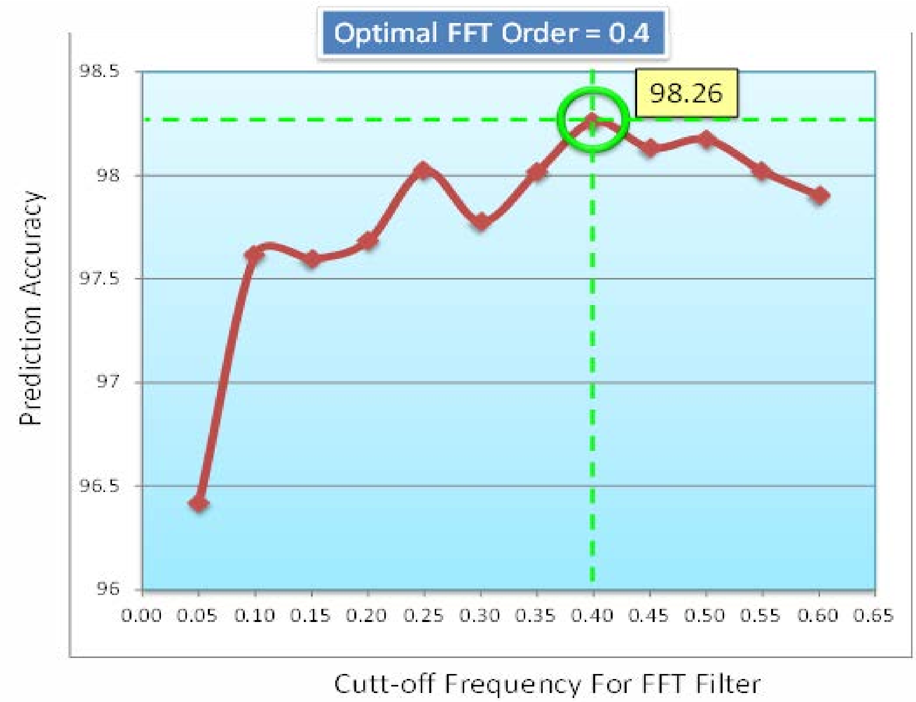
Optimization of FFT

Each model has some parameters that affect its performance and can be fine-tuned to fit a specific application. As we mentioned earlier, we will focus on a new technique, the FFT, that we propose to be compared with other previously tested GZP technique. In stock index prediction, the index signal is very noisy, i.e., it contains significant percentage of high-frequency noise. Therefore, for FFT to be optimized for signal denoising, we need to find the best cut-off frequency for a low-pass FFT-based filter. Table 2 lists all the experimental steps followed to find this best cut-off frequency. Figure 11 plots these experiments to better visualize the relation between the cut-off frequency and the prediction accuracy. As it can be observed, the optimal cut-off frequency for FFT was found to be 0.4 as it is indicated on Figure 11 with an accuracy of 98.26%.

Table 2
FFT Optimization Experiments

Experiment No.	FFT Order	RMSE % Accuracy
1	0.05	96.42
2	0.10	97.62
3	0.15	97.60
4	0.20	97.68
5	0.25	98.02
6	0.30	97.78
7	0.35	98.02
8	0.40	98.26
9	0.45	98.13
10	0.50	98.17
11	0.55	98.02
12	0.60	97.90

Figure 11
FFT Optimization Experiments

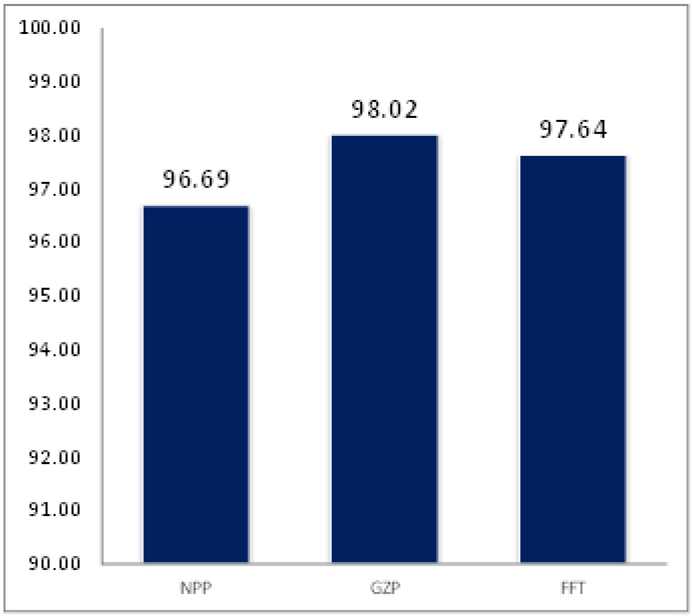


The two filters GZP and FFT were tested after we applied the optimized parameters and there final results are summarized in Table 3. It clearly can be concluded that GZP performed better than FFT in prediction accuracy as shown in Figure 12.

Table 3
Summary of Results after FFT Optimization

Technique	Testing Accuracy		
	DOW30	NASDAQ100	AVERAGE
NPP	96.86	96.52	96.69
GZP	98.16	97.88	98.02
FFT	98.26	97.01	97.64

Figure 12
Summary of Results after FFT Optimization

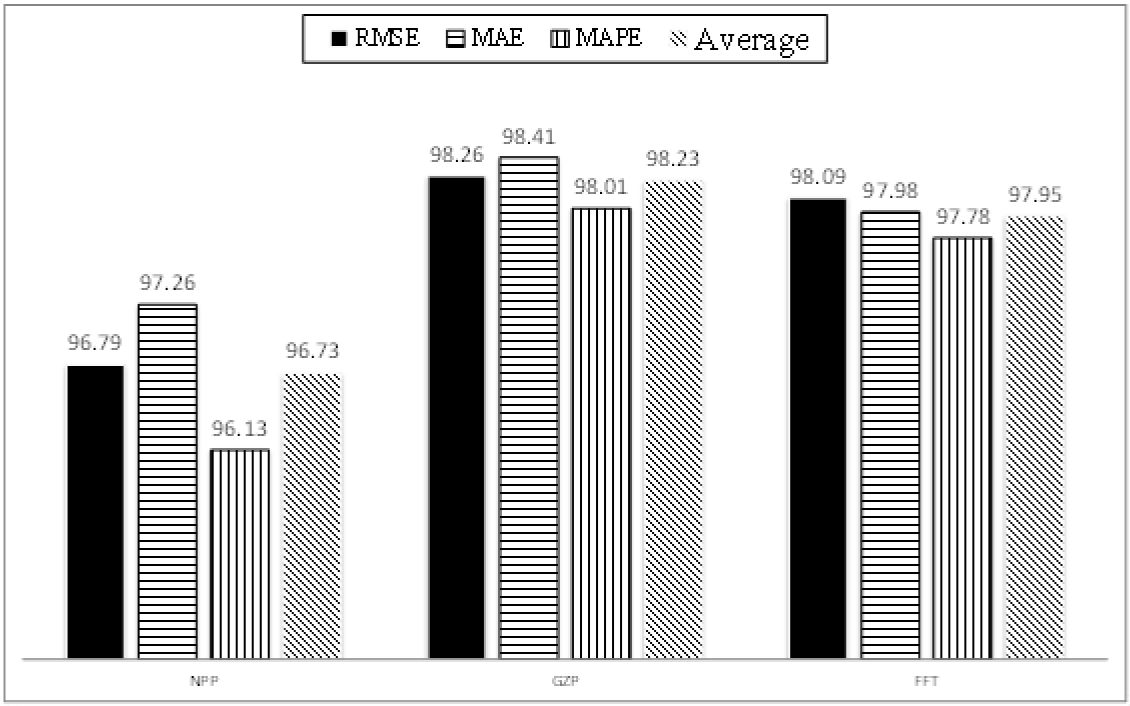


To support our finding using RMSE, we compared it with two other metrics of MAE and MAPE. As it can be seen in summary of this comparison in Table 4 and Figure 13, the average of all three metrics is consistent with our conclusion that GZP performance was better that FFT.

Table 4
Comparison of Three Performance Metrics

Technique	RMSE	MAE	MAPE	Average
NPP	96.79	97.26	96.13	96.73
GZP	98.26	98.41	98.01	98.23
FFT	98.09	97.98	97.78	97.95

Figure 13
Comparison of Three Performance Metrics



CONCLUSIONS

This work aimed at exploring more signal processing techniques in the area of predictive modeling of financial signals. Our previous work (Sharma & Rababaah, 2014) showed that integrating signal processing techniques improve the traditional methods such as Artificial Neural Networks (ANNs). Specifically, we focused on a new signal processing filter of Fast Fourier Transform (FFT) to be compared with Gaussian Zero-Phase (GZP) filter. Three different settings were used in this study as: no signal preprocessing (NPP), Gaussian Zero-Phase Filter (GZP) and Fast Fourier Transform (FFT). DOW30 and NASDAQ100 data sets were used systematically and independently to train and test all proposed techniques integrated with BP-ANN. The three techniques of NPP, GZP and FFT demonstrated the following results: 96.73%, 97.95%, and 98.23% according to RMSE, MAE and MAPE respectively. Our future work include a follow up on signal processing techniques to investigate the potentials of Discrete Wavelet Transform in comparison with all previous models we have studied so far.

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IMPROVING GOLF COURSE FLOW USING OPERATIONS RESEARCH

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ABSTRACT

Slow pace of play is a source of frustration for golf enthusiasts and course managers alike. The golfing industry is aware of this and pace has become a priority for many. For the last two years, The United States Golf Association (USGA) has hosted an annual pace of play symposium. Best practices primarily involve modifying player behavior; however, queuing theory is also being used to study and improve pace.

This paper continues the application of operations research to improving golf course flow. Two methods are presented. The first suggests augmenting course design by resequencing holes to minimize distances traveled by golfers from the previous green to the next tee box. We use the traveling salesman problem (TSP) to analyze eight golf courses to determine whether a shorter path than the current path can be found. The application of TSP leads to shorter distances traveled for four of the courses analyzed with an average decrease of 8%. Although the TSP has been successfully applied in many areas, applying to golf course design is unique. Additionally, due to sparse from-to matrices, solutions times are relatively short for spreadsheet solvers.

The second application is employing factory physics principles of small transfer batch sizes. Rather than golfers moving as a large group, usually threesomes or foursomes, from hole to hole, smaller groups such as one or two, immediately move to the next hole. For maximum benefit, the golfer CLOSEST to the hole should putt first. Additionally, once the golfer has begun putting, the golfer must complete before another golfer begins putting. The benefit is that putting time and travel time to the next hole occur in parallel instead of in series; thus, reducing round length. To accomplish, the rules of golf would need to be addressed and changed.

These two techniques, the TSP and factory physics transfer batching, continue the pursuit of addressing golf pace of play as a logistics problem. The benefits are limited, but measurable. For some courses, the benefits could lead to more enjoyable play for golfers and an increased number of rounds played and sold in a given day.

INTRODUCTION

Golf's excessively slow pace of play has been problematic for recreational and professional players as well as course managers who agree that slow play is holding back the growth of the sport. U.S. Golf Association president Glen Nager cites slow play as "one of the most significant threats" to the game and believes that "progress in improving pace of play will come only when the entire golf community is committed to working seriously to address the issue" (Leonard, 2013). Riccio (2012) suggests that slow pace of play is the result of "the interaction of many factors" including individual player factors, group interactive factors, and course design and management. Recent research by Kimes and Schruben (2002) and Southard

(2010) addresses course management emphasizing revenue considerations related to pace of play. Yates (2011) considers course design, while Tiger and Salzer (2004) consider the impact of individual player factors and course design on pace of play.

The distance from a green to the next teebox has been of concern since the beginnings of golf. The first known Rules of Golf were drawn up in 1744 in Edinburgh for the world's first open golf competition at Leith by the Gentlemen Golfers of Edinburgh, who would go on to become The Honourable Company of Edinburgh Golfers (Rules of Golf - 1744 - Scottish Golf History n.d.). The first rule is

> *You must Tee your Ball within a Club's length of the [previous] Hole*,

demonstrating that travel to the next hole was originally designed to be short. Many modern courses demonstrate the transformation of this direct path into something else entirely. Additionally, the authors interviewed members from the American Society of Golf Course Architects (http://www.asgca.org/). ASGCA member, Forrest Richardson, was quoted as follows:

> *I believe green-to-tee distance is certainly a factor, and your paper bears out the proof. Of course there are other factors that will affect flow on the course. The work you have done is great if we can also address course conditions, management, player ability (flexibility for) and the overall length and design of courses. As I believe you will agree, getting players to move quicker between a green and the next tee can have the effect to placing more players in a queue once they arrive at that next tee.*
>
> *(F. Richardson, personal communication, February 12, 2015)*

Not all golf courses are candidates for minimizing distance traveled. Topography dictates routing decisions. The front nine and back nine should be similar in distance, difficulty, and mix of par type. Equally important, a well-designed course is to be experienced in multiple ways, including enjoying the scenery and the outdoors over the duration of the match. Quite often, moving from green to the next tee is exhilarating and memorable, compelling golfers to return for another round. To discount the importance of the journey is to undermine the purpose of sound golf course design. Additionally, many courses, such as those designed by Donald Ross, are considered to be historic in nature and as such, great efforts are exerted to preserve all aspects of them, down to the contours of the bunkers.

While these issues might prevent applying TSP to route minimization for some (or many) golf courses, it should still be a tool of course designers and managers. Usefulness may only be applicable to a minority of courses, and TSP might not be the most important tool, but that is why a toolbox exists. Courses exist that the TSP is appropriate. Public courses that require a high volume of golfers to be profitable would be candidates. In addition, these courses should be located on property that allows rerouting such as parkland style courses.

In this paper, we focus on improving pace of play by considering how course design and policy could be augmented to reduce non-value added time. Both techniques presented are operations research techniques that have been applied in supply chain and operations management. The first method focuses on course design and minimizes the distance players must travel between the previous green and the next tee box. We apply the traveling salesman problem to several existing courses to investigate whether shorter routes can be developed. The second method relies on factory physics to improve flow from one hole to another.

THEORY AND APPLICATION OF THE TSP TO MANAGE PACE OF PLAY

The TSP is a well-known math problem characterized by minimizing the distance a salesman must travel between cities. Lin (1965) states the TSP as the following scenario: "A salesman is required to visit each of n given cities once and only once. What route, or tour, should he choose in order to minimize the total distance traveled?" With a given number of cities and distances between these cities known, the shortest route can be determined through optimization.

The traveling salesman problem has proven to have wide-ranging applications. Grotschel et. al (1991) applied the TSP to determine the most efficient drilling path for printed circuit boards. Bland and Shallcross (1989) discuss the application of the TSP to X-ray crystallography. Large warehouses often use TSP to determine their order picking process by computing the quickest route to visit the location where each part of the order is stored (Ratliff and Rosenthal 1983). Gorenstein (1970) applies the TSP to the problem of scheduling a printing press for periodicals with multiple editions, while Carter & Ragsdale (2002) apply the TSP to the problem of scheduling pre-printed advertising inserts in newspapers. Bank and delivery companies use the TSP to manage their routes when retrieving deposits from branches and delivering them to the main branch (Svestka and Huckfeldt 1973). Saleh and Chelouah (2004) provide an overview of the use of TSP in the design of global navigation satellite system surveying networks. TSP has been used in overhauling gas turbine engines (Plante et. al 1987) and in computer wiring and vehicle routing (Lenstra & Rinnooy Kan, 1974). Angel et. al (1972) describe how TSP can be used in school bus routing to minimize the number of routes and the total distance traveled. TSP is also used to schedule interviews between tour brokers and vendors in the tourism industry (Gilbert & Hofstra, 1992). The military has employed TSP to determine the most efficient path for military members to take in order to complete a mission (Brummit & Stentz 1996). Due to the difficulty in quickly solving large scale TSP problems, algorithms are continually being developed (Camci, 2014; Toriello, 2014).

In the context of golf course design, the traveling salesman problem can be used to determine the most efficient path for players to travel on a given course. According to Little's Law, under steady state conditions, the average number of items in a queuing system equals the average rate at which items arrive multiplied by the average time that an item spends in the system (Little 1961). Applying Little's Law to golf implies that shortening the time it takes to play of a round of golf should increase throughput and consequently, should lead to increased profits for the golf course. We suggest one way to achieve this is by using the TSP to determine optimal hole sequencing.

We apply the TSP by defining tee boxes as representative of "origin cities," greens as representative of "destination cities," and golfers as representative of "salesmen." The distance between the green of the last hole played and the next tee box are measured. A shorter path than the path currently employed by the course will reduce the time of a round of golf; thus, increasing the potential number of rounds played on a golf course during a busy day. The number of tee boxes used in the model is nineteen to allow modeling of the club house or parking lot, in addition to the eighteen tee boxes at the eighteen holes.

The mathematical structure of the traveling salesman problem is a graph where each tee box is denoted by a point and lines are drawn connecting every two points. Associated with every line is a distance. Following Lenstra and Rinnooy Kan (1975), the TSP can be expressed in the context of golf course design as follows. Let x_{ij} equal one ($x_{ij} = 1$) if a salesman leaves city i for city j; otherwise, x_{ij} equals zero ($x_{ij} = 0$). Given N tee boxes and a distance matrix $(d_{ij})(i, j \in N)$, determine

$$min_{\pi} \sum_{i=N} x_{ij} d_{ij(i)} \quad (1)$$

such that

$$\sum_{j=1}^{N} x(i, j) = 1 \qquad i = 1, 2, ..., N \quad (2)$$

$$\sum_{i=1}^{N} x(i, j) = 1 \qquad j = 1, 2, ..., N \quad (3)$$

where π runs over all cyclic permutations of N; $\pi^k(i)$ is the kth tee box reached by the golfer from tee box i. The two constraint sets ensure that each hole is visited exactly once; however, the constraint sets allow subtours.

SUBTOURS

The constraints above do not prevent subtours. A subtour is a routing that ensures that each golf hole is visited; however, more than one tour is created. Subtours are best explained with an example. Figure 1 shows a golf course with two subtours. One subtour links hole 1 through hole 6. A second subtour links hole 7 through hole 9. This solution is not a feasible solution and should not be allowed. Preventing subtours requires additional constraints to be added.

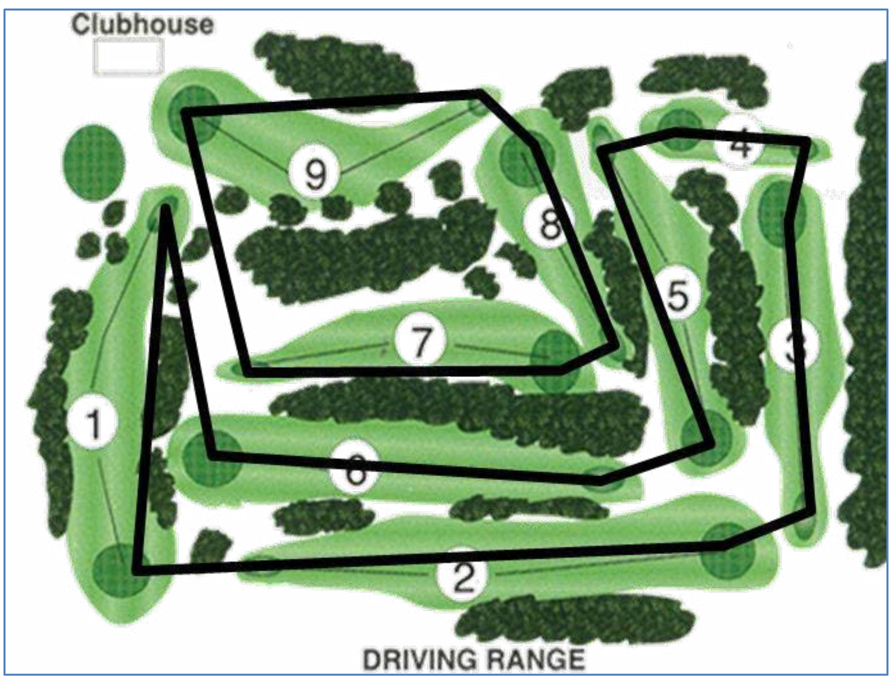

Figure 1. Subtour Example for a 9 Hole Course

Equation (4) lists a constraint set that prevents subtours, where S is a subset of holes and |S| is the number of holes in subset S. The difficulty is that 2^N constraints are theoretically required to ensure no constraints. For nineteen holes (and clubhouse), 524,288 additional constraints are potentially required to ensure no subtours!

$$\sum_{i,j \in S} x(i,j) \leq |S| - 1, \forall S \subset \{1,2,....,N\} \tag{4}$$

Fortunately, in practice, fewer constraints are needed. To prevent requiring all 524,288 constraints, the modeler must only allow routes that might be possible. For example in Figure 1, hole 1 would never be directly linked to hole 4. Knowing this, the user can reduce the number of potential routes significantly.

With the advance of spreadsheet optimization tools such as Frontline System's Solver and What's*Best!* by LINDO Systems (www.lindo.com), the ability to formulate and solve complex integer optimization problems such as the TSP within a MS Excel spreadsheet are readily available. We employed the What's*Best!* add-in for MS Excel to analyze the TSP in the context of a golf course. From their website:

> *Setting the standard in optimization software for over 21 years, LINDO Systems has been a leader in providing fast, easy to use tools for mathematical optimization. Day in and day out, LINDO Systems' optimizers provide critical answers to thousands of businesses around the world. Our Linear programming, Integer programming, Nonlinear programming, and Quadratic programming products are in use at over half the Fortune 500--including 23 of the top 25* (About LINDO Systems).

MS Excel was used to build the model. Subtours were detected using VBA code, which was also used to build the subtour constraints. In theory, 361 binary variables were required; however, in practice 100-150 binaries were used due to the sparseness of the from-to matrix. See Figures 3 and 4 below for examples of inputs.

TSP METHODOLOGY

This paper employs data collected by the authors for eight golf courses in Tennessee and Mississippi: Humboldt Golf and Country Club, Links at Galloway, Jackson National, Jackson Country Club, Links of Irene, Old Fort, Quail Ridge, and Tunica National. Distances from the previous green to the next tee box were identified and measured using Google Earth, which provides high-resolution satellite and aerial images and other geographical data available in free downloadable software. Figure 2 displays an example. We first used the zoom function to obtain a detailed view of each specific course and then used the ruler function to measure a path from the previous green to the next tee box. We assumed that most golfers use the cart path to travel the course, so we measure those distances using the paths already provided by the course or using a slight deviation from those paths if the deviation was logical and presented an opportunity for reduced driving distances.

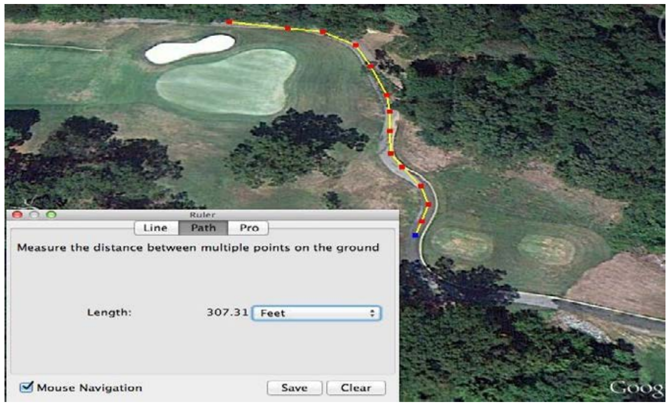

Figure 2. Google Earth Ruler Function to Measure Course Distances

TSP RESULTS

After obtaining the measurements for each golf course, we employed What'sBest! software to analyze the TSP problem. A sample of our input for one of the golf courses we analyzed is provided in the Destination to Origin Distance Matrix shown in Figure 3. The left column indicates the number of the previous green and the top row indicates the number of the next tee box, with the cells indicating the distance between these two points. For instance, in the first row of the matrix, from the green of the first hole, a golfer must travel 25 yards to reach the tee box at hole 2. From the same hole, this same golfer would need to travel 200 yards to reach the tee box at hole 3. In theory, all of the cells in the matrix should contain entries because after a golfer completes a hole, all of the remaining holes are candidate destinations. Our matrix, however, is relatively sparse and includes many blank cells because the design of the course limits the actual number of choices.

Origin	Destination →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19*
	1		25	200	100	150	100									100	50			
	2			75	150	250	150		200		50							50		40
	3		100		10	100														100
	4		75			50		75								150				
	5			50			20		50		300									75
	6		100			50		30								175				
	7	400		100			30		30		400									200
	8									20									20	
	9	300		150			30		75		300							300		30
	10											50	100	150					150	
	11												50	200						
	12	75												150	100			75		250
	13	100													200			100		300
	14		100					200								30	100			
	15		75														25			
	16	40									40			200	250			40		200
	17									75		150							30	
	18	50		100							30									200
	19*	250			200						250							250		

Figure 3 Model Inputs Destination to Origin Distance Matrix (19* is the Club House)

Using the input provided in the matrix in Figure 3, the program next minimizes the total distance traveled by golfers at the course. The results are provided in the output matrix in Figure 4 for the same course as discussed above. The cells of the matrix indicate the order in which golfers should travel from hole to hole to minimize their distance traveled with a 1 indicating the most efficient choice of tee box when leaving the previous green. For this particular course, rather than having golfers travel from the clubhouse through the eighteen holes as suggested by the existing hole sequence, the holes should be re-sequenced to allow golfers to visit the holes in the following order: Club House (19), 17, 18, 10, 11, 12, 13, 14, 15, 16, 1, 2, 3, 4, 5, 6, 7, 8, 9, Clubhouse (19).

	Destination																		
Origin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19***
1		1	0	0	0	0									0	0			
2			1	0	0	0		0		0							0		0
3		0		1	0														0
4		0			1		0								0				
5			0			1		0		0									0
6		0			0		1								0				
7	0		0			0		1		0									0
8									1									0	
9	0		0			0		0		0							0		1
10											1	0	0					0	
11												1	0						
12	0												1	0			0		0
13	0													1			0		0
14		0					0								1	0			
15		0														1			
16	1									0			0	0			0		0
17									0		0							1	
18	0		0							1									0
19*	0			0						0							1		

Figure 4 Solution Output (1 = yes; 0 = no) (19* is the Club House)

Of the eight courses we analyzed, four of the courses, Humboldt Golf and Country Club, Jackson Country Club, Jackson National, and Galloway saw reductions in distance traveled after applying the TSP solver. Humboldt had an improvement of 31%, which equated to 440 yards removed from an original between distance of 1335 yards. Jackson National and Galloway both had significant decreases of 13.8% and 14.5% respectively while Jackson Country Club realized a 3% decrease in travel distance. The other four courses did not realize any improvement in travel distances. For the eight courses, the average improvement was 8%. Figure 5 summarizes the results.

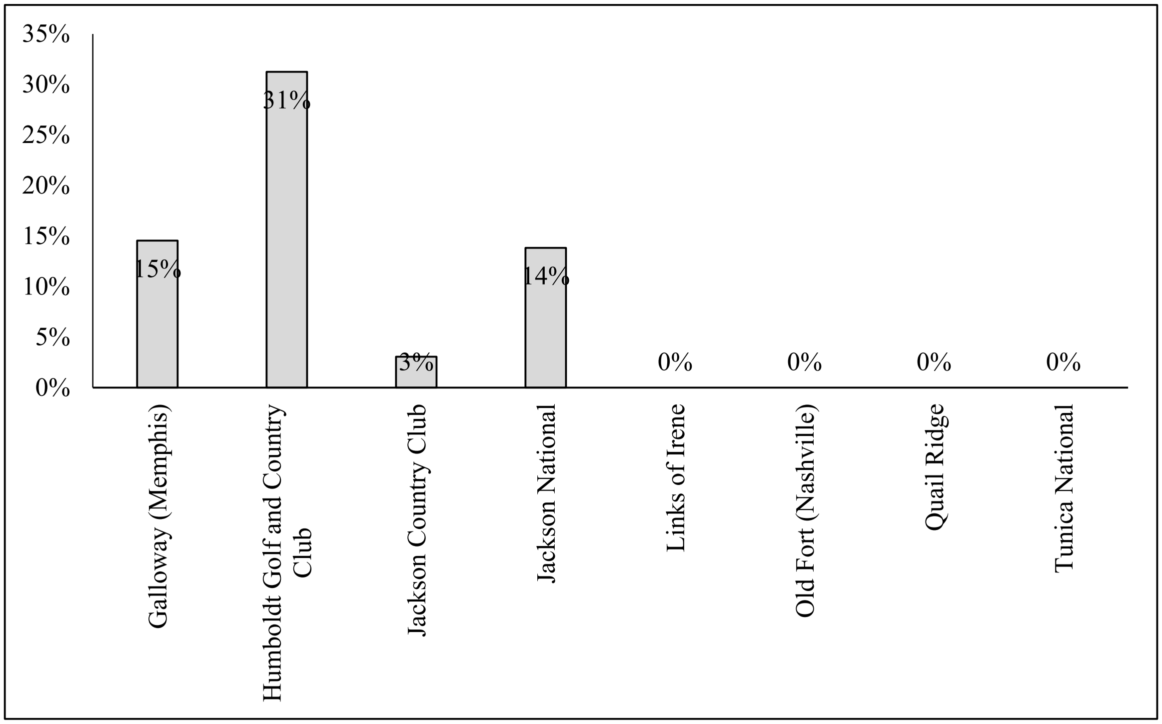

Figure 5 Distance % Improvement by Course when Applying TSP

How does a reduction in travel distance impact time and throughput? Ideally, the entire time could be eliminated from each round. Golfers using carts average approximately 8 mph depending in topography. Walkers average 3 mph. For every 100 yards saved, cart time between holes would be reduced 0.42 minutes. Walkers' savings would be 1.14 minutes per 100 yards saved. For HG&CC, the 440 yards saved based on the TSP sequence equates to about 2 and 5 minutes for cart golfers and walkers, respectively. Benefits would occur through reduced wear and tear on carts (and golfers!), additional play per day, or less time on non-value added activity.

Applying Little's Law is another way of evaluating benefits. Using Factory Physics terminology, Little's Law is

$$WIP = TH * CT \tag{5}$$

where *WIP* is average work in process; *TH* is throughput; and *CT* is average cycle time (Hopp and Spearman, 2011).

To compare the base system to the TSP sequenced system, assume that both will have the same WIP. That is, both courses will have the same average number of golfers in the system. Additionally, assume that the base system average round length is 4 hours (240 minutes) and tee time intervals are 10 minutes. With four golfers per group, throughput is 0.4 golfers per minute (4 golfers per 10 minutes). Therefore, WIP is 96 golfers (240 * 0.4) for both the base system and TSP sequenced system. If the CT can be reduced by 5 minutes, then the TH must equal 0.41 golfers per minute (96 / (240 – 5)). The tee time interval for a TH of 0.41 is 9.76 minutes (4 / 0.41). Using similar logic, a CT savings of 2 minutes would produce a tee time interval of 9.9 minutes. Therefore, to compare the base system to the system improved by shortening the cycle time, a higher throughput would be produced given the same number of golfers on the course. In practice, tee time intervals are not calculated or managed within fractions of a minute. However, the equivalent could be achieved through having variable tee time intervals. Most are 10 minutes, but a few are 9 minutes, for example.

Increased revenue would occur only on busy days when the course is fully utilized, usually on weekends and holidays. Assuming that tee times are taken for eight hours, 48 groups (192 golfers) will begin in eight hours, based on a ten minute tee time interval. For a 9.9 minute tee time interval, an additional 1.6 golfers will begin. For a 9.76 minute tee time interval, 4.72 additional golfers will begin. Table 1 shows the base system versus a savings of 2 minutes (carts) and 5 minutes (walkers) for a busy day. A busy day assumes that all tee times are filled for the first eight hours. Assuming 100 busy days per year, and a $50 green fee, TSP sequencing increases annual revenue between $8,000 and $24,000.

Table 1
Additional Annual Revenue Benefits for Busy Golfing Days

Scenario	Number of Additional Golfers Beginning within 8 Hours	Annual Revenue Increase for 100 Busy Golfing Days @ $50 Green Fees
Base (196 golfers)		
Savings of 2 minutes	1.61	1.61 * 50 * 100 = $8,067
Savings of 5 minutes	4.72	4.72 * 50 * 100 = $23,600

New sequencing could shift the golf course constraints; therefore, the benefits might be more or less than the results shown above. Tiger's pace of play simulation model (2004) could be used to estimate throughput benefits for a specific course. Although, Tiger's pace of play model does not optimize hole sequencing, the TSP-based sequence could be an input. Tiger's simulation models both within hole and between hole times, including any waiting for preceding golfers. Inputs include (1) course design characteristics: hole sequence, hole length, fairway width, hole hazards and features, green size, green speed, and distance between holes; (2) course policy such as tee time intervals; and (3) player traits such as ability, group size, and travel mode. Outputs include round length for each group and waiting times by course location for each group.

THEORY AND APPLICATION OF FACTORY PHYSICS TO MANAGE PACE OF PLAY

In this section, we propose another operations research technique for managing the flow of golfers: Factory Physics (Hopp and Spearman, 2011). Factory physics is the science of flow, whether that is material, people, or information. However, the full benefit of applying Factory Physics' techniques breaks against tradition, and to some extent, the rules of golf.

The primary idea is based on a Factory Physics law concerning transfer batching. The law (Hopp and Spearman, 2011):

> *Law (Move Batching): Cycle times over a segment of a routing are roughly proportional to the transfer batch sizes used over that segment, provided there is no waiting for the conveyance device.*

This law says that cycle times are often based on the size of the transfer batch size. We propose applying this law to how golfers move from hole to hole. For most golfers, both recreational and competitive, golfers move from the green of one hole to the tee box of the next hole as a group, whether the group is a twosome, threesome, foursome, or more! The time to move to the next hole is (usually) non-value added time and, if removed, could reduce round length.

Many golf associations, especially seen in junior golf, require the first golfer finished to immediately move toward the next hole (Tour, Tennessee Junior Golf Tour - SNEDS 2015) and tee off, if clear. This saves some time; however, since long putts are rarely made, golfers tend to mark and the golfer furthest from the hole putts next. This diminishes the benefits of the first one finished moving to the next hole. To increase time saved, a new green policy is needed. On the green, once a golfer begins putting, the golfer must hole out before the next golfer begins. To truly maximize this benefit, the golfer who is CLOSEST should putt first, until completion, and immediately move to the next hole. This would produce the shortest time to the next hole. Most importantly, transportation time to the next hole would overlap with putting time; thus, reducing non-valued added time.

Obviously issues exist. The most immediate is that the rules state that the golfer furthest away from the hole has honors (About Sports n.d.). Rules would have to be changed. Additionally, a golfer closest to the hole putting first would require walking in the line of his/her competitors. This certainly could affect performance. However soft spikes reduce impact, and the policy could be tested. Experiments could be run determining if and how much putting performance is affected by golfers walking in the line. Also, the details based on group size would have to be addressed. At least two golfers must remain on the putting green; therefore, for foursomes, two golfers could move toward the next hole immediately after finishing. For threesomes, only one could move.

Even if all transfer time could be removed, much of that time (20 to 30 minutes) would not be eliminated. Rather, it would be converted to waiting time. Speeding up only to wait in line is not the solution. However, the benefit occurs through the application of the Theory of Constraints (TOC). One of the TOC principles is to manage bottlenecks closely. For example, long par three holes are usually bottlenecks, and would be candidates for applying this transfer batching rule.

Practically, five to ten minutes could be removed from a round of golf, which might allow one more group to finish on a busy day or the ability of the course to reduce waiting and thus increase golfer satisfaction. Equally important, it creates awareness of pace on the course and provides golfers the opportunity to improve pace. Both could have long term benefits on pace.

CONCLUSION

This paper contributes by offering a set of solutions for slow pace of play that is frequently experienced during a round of golf. We contribute to the literature on pace of play by using the traveling salesman problem and optimization software to determine how hole sequencing might be altered to reduce travel times between the previous green and the next tee box at existing courses. Our results provide evidence that the TSP may be helpful for some courses in speeding up the pace of play with four of the eight courses analyzed experiencing decreased traveling distances for golfers. Although other factors influence sequencing, the results suggest that the application of TSP to existing courses could potentially provide higher revenues as a result of being able to serve more customers each day.

A potential extension of this research is applying the TSP to course redesign. The use of math models such as the TSP allow designers to test prior to implementation. Course redesign involves significant work, including shutting down a course from play. Testing prior to implementation is timely, relatively risk free, and less expensive that testing on the existing system. The TSP model could evaluate different design options prior to construction, identifying potential issues early in the design phase.

Additionally, factory physics-based transfer batching principles are shown to reduce nonvalued time during a round of golf, also allowing additional rounds of golf on busy days. For maximum benefit, the transfer batching principle would require modifying the existing rules of golf and allowing the closest golfer to putt first. Challenging the rules of golf is not trivial. Golf is steeped in tradition, and rule changes are serious decisions. However, academic research is the perfect vehicle for challenging tradition. Research should push up against tradition and current policy when seeking new and innovative solutions to problems.

These two methods demonstrate the use of operations research in a non-traditional way. Both could lead others to view the golf pace of play problem from a different perspective; thus, creating the possibility of innovative problem solving. Modeling offers the ability to think creatively, often coined out-of-the-box thinking. Even if most of the model outputs are not practical, occasionally, discoveries occur as well as additional insight. Finally, both techniques are readily demonstrated in the classroom; therefore, golf becomes an excellent teaching tool for operations research and supply chain modeling.

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A CONCEPTUAL MODEL FOR MOBILE BANKING ADOPTION

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ABSTRACT

Despite the steady growth of Internet banking and mobile banking, only half of adults in the U.S. use online banking, with the other half still visiting physical branches for their banking services (Fox, 2013). For years, studies are being conducted in the IS field using the Technology Acceptance Model (TAM) in order to determine the key factors explaining the adoption of online banking. But, due to the privacy concerns and the psychological barriers often associated with conducting transactions in a virtual world, the TAM has proven to be a limited tool. In this study, we revisited the IS literature on mobile banking adoption along with relevant theories from the areas of marketing and psychology in order to develop a conceptual model that would have a potentially greater explanation power. The proposed model emphasizes the role of subjective norms, technological readiness, trust, and perceived critical mass of users. The model is discussed along with the research propositions it implies. The theoretical and practical implications of the study are also discussed.

Keywords: mobile banking, technology adoption, technology readiness, perceived critical mass

INTRODUCTION

Mobile banking refers to the provision of banking services with the help of mobile telecommunication devices. The scope of offered services may include monitoring account balance, transferring funds between accounts, bill payments, and remote check deposit among other services. For years, driven by the need to improve the cost-effectiveness of operations, financial institutions have been using Web technology to provide mobile and Internet banking services and, substantially, reduce the need for personal interactions in the provision of their services (Elliott, Meng, & Hall, 2008). Today most financial institutions in the western hemisphere are offering Internet banking and mobile banking options to their customers. Despite the steady growth of Internet banking and mobile banking, only half of adults in the U.S. use online banking, with the other half still visiting physical branches for their banking services (Fox, 2013). In the IS field, many studies have been conducted using the technology acceptance model (TAM) to determine the key factors explaining the adoption of online banking (Amin, 2007; McKechnie, Yu, 2012). The TAM by Davis (1989) and the TAM2 by Venkatesh and Davis (2000) arguably do not include factors that are meant to capture key elements such as trust and risk associated with the adoption of e-commerce. Given the privacy concerns and the psychological barriers often associated with conducting transactions in a virtual world, the TAM has proven to be a limited tool (Shen, Huang, Chu, & Hsu, 2010). That is why recent studies are using extended versions of the TAM that include factors such as trust and security concerns. (Chiou & Shen, 2012; Kesharwani & Bisht, 2012; Wang, Hsu, Pelton, & Xi, 2014; Shen, Huang, Chu, & Hsu, 2010; Wang, Hsu, Pelton, & Xi, 2014).

The objective of the present study is to review the IS literature on the adoption of mobile banking along with relevant theories from the areas of marketing and psychology in order to develop a conceptual model that would have a potentially greater explanation power. In the next sections, we will review the relevant literature in order to lay out the theoretical justifications for the concepts to be included in the model. Then, based on the theoretical background, we will discuss the conceptual model along with the research propositions implied. Finally, the paper will discuss the theoretical and potential practical implications of the model.

THEORETICAL BACKGROUND

In the IS field, the technology acceptance model has become a cornerstone for explaining technology adoption and use.

The technology acceptance model

Grounded on the theory of reasoned action or TRA (Fishbein & Ajzen, 1975), the TAM is an implementation of the belief-attitude-intention-behavior relationship. According to the TAM, the actual use of a technology is determined by beliefs a user holds about its *perceived usefulness* and its *perceived ease of use*. Perceived usefulness refers to the extent to which people believe that a technology will help them perform their job better, while *perceived ease of use* refers to the degree to which a person believes that using a particular IT would be free of effort (Davis, 1989). According to the model, potential users' perceptions determine their attitude (favorableness or unfavorableness) toward using a specific technology. The attitude will, then, determine their behavioral intention, that is, their intention to use the technology. Finally, the intention may lead to their actual use of the technology.

Over the years, studies have been conducted using extended versions of the TAM in an attempt to explain the adoption of online banking (i.e. mobile and Internet banking). The study of Vatanasombut, Igbaria, Stylianou, and Rodgers (2008) has found that perceived security has a significant impact on trust in online banking which, in turn, has a significant impact on the continuance intention to use online banking. Shen et al. (2010) also found that technology anxiety, convenience benefit, security cost, and trust in the financial institution have a significant impact on the intention to adopt mobile banking. The study of Singer, Baradwaj, Flaherty, and Rugemer (2012) found that, through its impact on perceived ease of use and perceived usefulness, experience has a negative effect on online banking use. They concluded that as an individual gains experience with more complex and sophisticated features of a bank web site, the intensity and frequency of use diminish. Considering different aspects of risk, the studies of Wang et al. (2014) and Chiou and Shen (2012) confirmed the common sense idea that perceived risk (including financial risk, performance risk, time risk, and psychological risk) has a negative impact on engaging in online banking.

The review of those recent studies reveals a distinctive characteristic of online banking .That is, there is a high risk and a potential for monetary loss for the customer who engage in online banking. Therefore, *trust* must be a key factor at the center of any model that aims at explaining mobile banking adoption.

Trust

From the social psychology perspective, trust is characterized in terms of the expectation and willingness of the trusting party engaging in a transaction (Roca, García, & de la Vega, 2009). It is the main catalyst of most business transactions. According to Mayer, Davis, and Schoorman (1995), trust is a multidimensional concept, typically, defined as the perceived *credibility*, *benevolence*, and *integrity* of a business partner. *Credibility* is the extent to which one business partner believes that the other partner has the required expertise to perform the job effectively and reliably (Wang, Wang, Lin, & Tang, 2003). It is impersonal and relies on reputation. Mayer et al. (1995) defines *benevolence* as the extent to which a trustee is believed to intend to do good to the truster, beyond his or her own profit motives. It can be seen as the extent to which the seller or service provider is genuinely interested in the customer's welfare and has intentions and motives beneficial to the customer (Doney & Cannon , 1997). *Integrity*, on the other hand, refers to the truster's perception that the trustee will adhere to a set of principles or rules of exchange acceptable to the truster during and after the exchange (Mayer et al., 1995). Uncertainty is one of the main reasons explaining online customers' lack of trust (Roca et al., 2009). Typically, in the virtual world, there are two types of uncertainty to deal with: system-dependent uncertainty and transaction-specific uncertainty (Grabner-Kraeuter, 2002). The system-dependent uncertainty is related to all potential technological sources of errors and security gaps like faulty software or hardware devices or security vulnerabilities. System-dependent uncertainty can emerge in the data channel (i.e. the network) or on the "final points" (i.e. customers' desktop system or the seller's or provider's server). Therefore, smooth and secure online transactions depend on the reliability of the hardware and the software as well as the reliability of the technology used to secure the transactions. Transaction-specific uncertainty, on the other hand, is typically, caused by the asymmetric distribution of information between the transaction partners (Grabner-Kraeuter, 2002). In general, the customer does not have as much information as the seller or provider about (a) the quality of the product or the service or (b) the seller's or provider's ability and willingness to perform. This asymmetry is deeper in online transactions because, in part, key elements of personal interactions like facial expression, gestures, and body language are missing in the computer-mediated environment (Grabner-Kraeuter, 2002).

In a virtual world, users' technology readiness can help establish trust.

Technology readiness

Technology readiness encompasses self-efficacy which refers to belief about one's ability to successfully carry out the task at hand (Shen et al., 2010). Parasuraman (2000) defined technology readiness as "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work" (p. 308). It results from mental enablers and inhibitors that determine a person's predisposition to use a new technology. Parasuraman's 2000 study identified two enablers (optimism and innovativeness) and two inhibitors (discomfort and insecurity) that participate in determining a person's technology readiness. Optimism is the degree to which people believe that technology can benefit their lives and give them more control over their live. Innovativeness is a natural desire to experiment with new technologies. Discomfort is the feeling of lacking both control over technology and the confidence in making technology work. Insecurity was defined as the need for assurance that a technology-based product, service or process will operate reliably and accurately. Because the four dimensions are relatively independent of each other, an individual may harbor both enabler and inhibitor feelings towards technology. It can easily be argued that technology readiness can play a key role in people's intention to use mobile banking. The enabler's aspect of technology readiness can also have a positive impact on people's propensity to trust whereas the inhibitor's aspect would have the opposite impact. Parasuraman (2000) developed a composite technology readiness index that is meant to capture an individual overall readiness to adopt new technologies.

One may be technology-ready, but in order for a bank customer to actually engage in mobile banking, he or she must need it and find it useful. One of the common ways people come to know about innovations and find them useful is through social influence.

Social Influence

In the IS literature, two theoretically distinct types of social influence, *subjective norms* and *critical mass*, have been frequently employed, but typically confounded (Cho, 2011; Venkatesh et al., 2003). The two concepts share several common elements and underlying assumptions. First, both postulate that social influence shapes people's perceptions and behavior. Second, both assume that people face some uncertainty regarding the appropriateness of various actions (e.g. choosing between different technologies to perform a task). That means, usually, before using a technology or a service, people's beliefs about or knowledge of the technology or the service are vague and ill-informed. Therefore, they choose a course of action by relying more on the opinions or the actions of others (Barki & Hartwick, 1994). Third, as the number of users of a technology or a service in their social circle increases, people tend to receive increasing social information or pressure which subsequently increases the chance that they will adopt the same technology or service (Rogers, 1995). But subjective norms and critical mass differs in fundamental ways too.

Critical mass

The TAM suggests that the adoption of a technology or technology-based service depends, fundamentally, on its perceived usefulness and perceived ease of use by the potential adopters (Rogers, 1995). But, from the business perspective, no matter how useful and easy to use a technology or service is perceived to be, it will only be economically viable if there is a critical mass of people adopting it. According to Rogers (1995), critical mass refers to "the point at which enough individuals have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining" (p. 313). Lou, Luo and Strong (2000) have found that critical mass has a significant impact on groupware acceptance. Ayers, Menachemi, Ramamonjiarivelo, Matthews, and Brooks (2009) have also found that there is a significant increased utility for users of electronic medical records systems when adoption increases among other users. Other studies have found that perceived technology popularity has an impact on the adoption of instant messaging (Strader, Ramaswami, & Houle, 2007), videophone systems (Kraut, et al., 1998), and the Internet (Zhu & He, 2002). These studies seem to confirm the common sense idea that the higher the number of users of a particular technology in a specific community (workplace, circle of friends, etc.), the more pressure there may be on other people to adopt the technology in question. But how do potential users assess the critical mass? The actual critical mass threshold is difficult to determine, but a particular technology user may have a perception of whether it has been reached or how soon it will be reached (Cho, 2011). As in previous studies like Sledgianowski and (Sledgianowski & Kulviwat, 2009) and Cho (2011), in this study we will use the concept of perceived critical mass (PCM) to refer to users' perception of whether the critical mass threshold is (or how soon it will be) reached.

Subjective norm

Subjective norm refers to the perceived social pressure to engage or not to engage in a behavior (Ajzen, 1991). It is an individual's perception that most of his or her referent others think that he or she should or should not perform a specific behavior like using a specific technology to perform a task. The reason why subjective norm is so prevalent is the belief that following others often leads to better and more accurate decisions, especially when we face uncertainty Griskevicius et al. (2006). Mustonen-Ollila and Lyytinen (2003) reported 16 studies on IT adoption that include subjective norm as a factor. Over the years, consistent with the theory of reasoned actions (Fishbein & Ajzen, 1975), numerous studies have found that subjective norms have a significant impact on people's perception and beliefs about technology (e.g. Homburg et al., 2010; Karahanna and Straub,1999; Schmitz, 1991; Teo, 2010). (Homburg, Wieseke, & Kuehnl, 2010; Karahanna & Straub, 1999; Schmitz & Fulk, 1991; Teo, 2010)

Taking into account the literature reviewed in this section, we propose a research framework along with a series of research propositions.

RESEARCH MODEL AND PROPOSITIONS

Research model

Drawing on the TRA (Fishbein & Ajzen, 1975), we propose that *perceived usefulness* and *perceived ease of use* will have a direct impact on people's *intention to use mobile banking* which, in turn, will impact the *actual use* of mobile banking. As the theory of planned behavior (Ajzen, 1991) suggested, our research model, shown in Figure 1, predicts that *subjective norms* will be an antecedent of *perceived usefulness* and *perceived ease of use*. The model also predicts that people's *technology readiness* will have a direct impact on their *trust* in mobile banking. As in previous studies (e.g. Vatanasombut et al., 2008, Shen et al., 2010), *trust* is presumed to have a direct impact on the *intention to use mobile banking*. Finally, the proposed model suggests that *perceived critical mass* will have a direct impact on the *intention to use mobile banking*, as well as a moderating effect on the relationship between *perceived usefulness* and *perceived ease of use* on the one hand, and the *intention to use mobile banking* on the other hand.

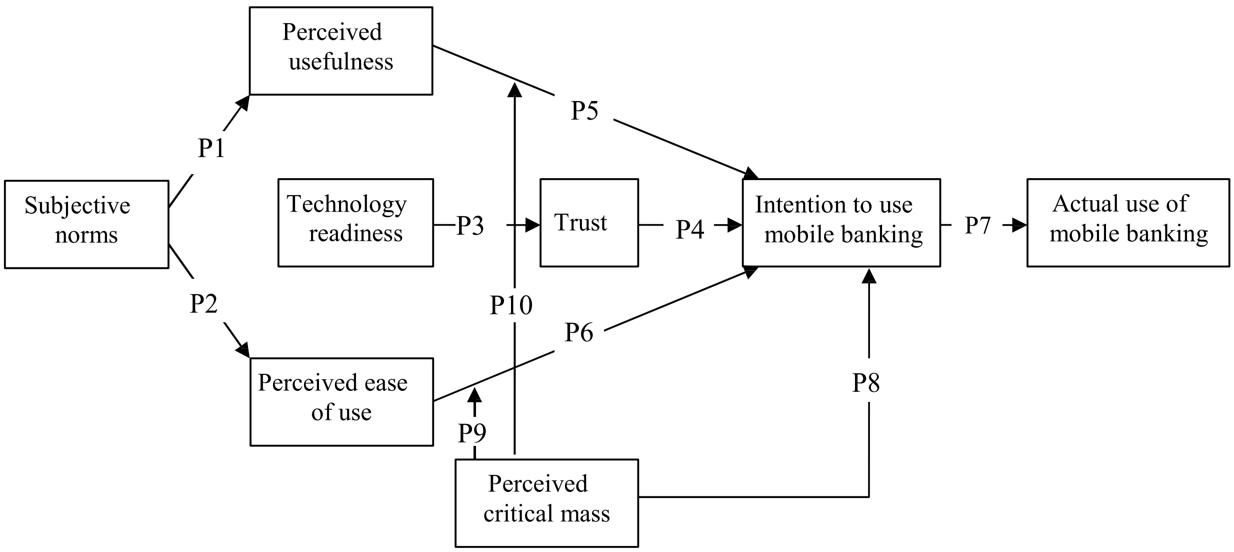

Figure 1: Research Model

RESEARCH PROPOSITIONS

According to the theory of planned behavior (Ajzen, 1991), subjective norm or perceived social pressure from referent others can impact people's behavior indirectly by shaping their perception over time. That means subjective norm may have an impact on how useful people perceive mobile banking to be. We therefore propose the following:

Proposition 1: ***Subjective norm*** *will have a significant impact on the* ***perceived usefulness*** *of mobile banking.*

If people's perception about the usefulness of mobile banking can be influenced by subjective norm, their perceived ease of use of mobile banking may also be influenced by subjective norm.

Proposition 2: ***Subjective norm*** *will have a significant impact on the* ***perceived ease of use*** *of mobile banking.*

A recent Pew Research survey found that 54% of young adults (18 to 29 years old) owning cell phones use mobile banking (Fox, 2013). The percentage drops to 40% for adults between the age of 30 and 49 despite the same level of cell phone ownership among the two groups (Fox, 2013). One possible explanation could be that younger people are more technology savvy. From that perspective, technology readiness may be a factor that helps younger people overcome the psychological barriers, take risk, and trust virtual entities. We, therefore, propose the following:

Proposition 3: ***Technology readiness*** *will have a significant impact on people's* ***trust*** *in mobile banking.*

Technology readiness has four dimensions, with two of the dimensions (optimism and innovativeness) considered enablers for technology adoption. We propose the following:

Proposition 3a: ***Optimism*** *will have a positive impact on people's* ***trust*** *in mobile banking.*

Proposition 3b: ***Innovativeness*** *will have a positive impact on people's* ***trust*** *in mobile banking.*

The two other dimensions (discomfort and insecurity) of technology readiness are considered as inhibitors for technology adoption. We, therefore propose the following:

Proposition 3c: ***Discomfort*** *will have a negative impact on people's* ***trust*** *in mobile banking.*

Proposition 3d: ***Insecurity*** *will have a negative impact on people's* ***trust*** *in mobile banking.*

Trust was proven to be an antecedent of engaging in online banking (Shen et al., 2010, Vatanasombut et al., 2008). It has multiple dimensions (Grabner-Kraeuter, 2002). In this study, we argue that transaction-specific trust (i.e. trust in the financial institution) and systems-specific trust (i.e. trust in the technology involved in providing mobile banking services) will have a significant impact on their intention to use mobile banking. We, therefore, propose the following:

Proposition 4a: ***Transaction-specific trust*** *in mobile banking will have a significant impact on the* ***intention to use*** *mobile banking.*

Proposition 4b: ***System-specific trust*** *in mobile banking will have a significant impact on the* ***intention to use*** *mobile banking.*

A strong body of research has confirmed the main idea of the TAM, which is *perceived usefulness* and *perceived ease of use* are antecedents of the intention to use IT in general (Mustonen-Ollila & Lyytinen, 2003). For mobile banking, we expect the relationship between *perceived usefulness* and *perceived ease of use* on the one hand and the *intention to use mobile banking* services to be strong. We, therefore, propose the following:

Proposition 5: ***Perceived usefulness*** *will have a significant effect on people's* ***intention to use*** *mobile banking.*

Proposition 6: ***Perceived ease of use*** *will have a significant effect on people's* ***intention to use*** *mobile banking.*

According to the theory of reasoned action, intention which is the cognitive representation of a person's readiness to perform a given behavior is the best predictor of behavior (Fishbein & Ajzen, 1975). We argue that people's intention to use mobile banking will have an impact on the both the frequency and the intensity of their mobile banking services' use. We, therefore, propose the following:

Proposition 7: The ***intention to use*** *mobile banking will have a positive impact on the* ***actual use*** *of mobile banking in terms of frequency and intensity of use.*

According to the diffusion of innovation (DOI) theory, the adoption and spread of an innovation depend on the critical mass of users defined as the point at which enough individuals have adopted the innovation so that its further rate of adoption becomes self-sustaining (Rogers, 1995). Technology users may have their own perception of whether the critical mass of users has been (or is about to be) reached (Cho, 2011). If a customer of a brick and mortar bank customer has the perception that the critical mass of mobile banking users is (or is about to be) reached, it may make him or her believe that most people are adopting mobile banking, which may have a direct impact on their intention to use the service. We, therefore, propose the following:

*Proposition 8: The **perceived critical mass** of users will have a positive direct impact on the **intention to use** mobile banking.*

Strader et al. (2007) have postulated that critical mass and usefulness, as two value-oriented factors, should be linked when exploring their impact on communication media use. This suggests that perceived critical mass may also have an indirect impact on mobile banking adoption through a possible interaction effect with perceived usefulness. It means that people who have perceived mobile banking as being useful may see their intention to use mobile banking grow stronger as a result of their perception that the critical mass has been (or will soon be) reached. We, therefore, propose the following:

*Proposition 9: The **perceived critical mass** will moderate the impact of **perceived usefulness** on the **intention to use** mobile banking, such that the higher the perceived critical mass, the stronger the impact.*

Likewise, it can also be argued that people who have perceived mobile banking as being easy to use may also see their intention to adopt mobile banking grow stronger as a result of their perception that the critical mass has been (or will soon be) reached. We, therefore, propose the following:

*Proposition 10: The **perceived critical mass** will moderate the impact of **perceived ease of use** on the **intention to use** mobile banking, such that the higher the perceived critical mass, the stronger the impact.*

IMPLICATIONS AND LIMITATIONS

One of the theoretical contributions of this research is a new conceptual model for mobile banking adoption with a potentially greater explanation power compared to the existing frameworks found in the IS literature. The proposed model contributes to the IS literature in two ways. First, it added both positive and negative impacts of technology readiness on the level of trust in mobile banking. Second, it includes a moderating effect of *perceived critical mass*. To our knowledge, this would be the first study in the IS field to include the moderating effect of *perceived critical mass* on the relationship between *perceived usefulness* and *perceived ease of use* on the one hand, and the intention to use mobile banking on the other hand. In terms of practical implications, the testing of the moderating effect of *perceived critical mass* may have some implications for marketing strategy. For example, if it turns out that *perceived critical mass* has a significant moderating effect on the relationship between the *perceived usefulness* and the *perceived ease of use* of mobile banking on the one hand, and the *intention to use to use mobile banking* on the other hand, that means *perceived critical mass* represents a key piece of information that financial institutions offering mobile banking may use in advertising and marketing in general in an attempt to increase mobile banking use. To that end, if regular bank customers are informed through advertising that more and more people are adopting mobile banking, it may have the potential of altering their perception that the critical mass of mobile banking users is (or is about to be) reached, which may have a positive impact on their intention to use the service.

This study has limitations. First, the study is conceptual in nature which means that, although there is a good theoretical foundation for the research propositions, empirical testing is needed. Second, this study didn't include the mediating effect of *attitude* as the TRA (Fishbein & Ajzen, 1975) and the initial TAM (Davis 1989) suggested. This was done for two reasons. One is because a meta-analysis done by Legris et al. (2003) has suggested that attitude does not mediate the influence of perceived usefulness or perceived ease of use on either the usage or the behavioral intention to use technology in general. The second reason is the need to keep the research model focused on the more theoretically relevant factors.

CONCLUSION

This research built on the limitations of the TAM as a tool that does not capture key factors such as the risk and trust involved in mobile banking adoption. It postulates that technology readiness, which encompasses optimism, innovativeness, discomfort, and insecurity, will have direct positive and negative impacts on people's trust in mobile banking. It also distinguishes between the two types of social influences (subjective norms and critical mass) associated with technology adoption in the IS literature. Like previous studies, this study considers the direct impact of *perceived critical mass* on people's intention to use mobile banking, but unlike previous studies, the study introduced an indirect impact that *perceived critical mass* may also have through its interaction with perceived usefulness and perceived ease of use.

Although explicit prescriptions should await empirical support for the propositions, the research model and the supporting literature suggest some potential theoretical and practical implications. In particular, if it turns out to be conclusive, the testing of the interaction effects of *perceived critical mass* may provide some ground for financial institutions offering mobile banking to revisit their marketing effort in a way that may help widen their mobile banking customers' base.

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