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Contents

A Study of the Mathematical Creativity of 4th Grade Student's in Mathematics Classroom Using Lesson Study and Open Approach

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Abstract

This research aims to a study of the Mathematical Creativity of 4th Grade Student's in mathematics classroom using Lesson Study and Open Approach. This qualitative research methodology to emphasize protocol analysis and analytical lectures for describing changes to students. Including the use of quantitative research methodology to assess the student's mathematical creativity. The target group used in this study was the 4th grade student's 1st Semester 2019 school year at Kookam Pittayasan School, Khon Kaen Primary Educational Service Area Office 4. There were 11 students divided into three groups: group 1, group 2, with a total of four students have student numbers four and group 3, with a total of 3 students. This school is a school in the Project for Professional Development of Mathematics Teachers with an innovative Lesson Study and Open Approach. The concept of teaching and learning activities based on the concept of educational classes and an open approach to teaching and learning at the school continuously since 2006. Researchers collect information in class contexts that use innovative lesson study and open approach, according to Inprasitha (2011) framework. The tool used to collect data includes A plan to learn about the triangle, video recorder, camera, still image recording, and field recording. There were five researchers and research assistants. Empirical data used for analysis were composed of protocols of the students' activity doing in the classroom, the students' work photograph, and protocol of teachers'

reflection as a one of Lesson Study team. For data analysis, the Nohda (2000)'s framework was used to Interpreting students' mathematical creativity.

The research findings revealed that in the mathematics classroom using the innovative Lesson Study and Open Approach, which teaching focuses on student self-learning and learning together with friends in the classroom. This method of teaching provides students more mathematical creativity, which could be seen from the fact that the student represented a variety of concept, could solve problems on their own, felt more comfortable expressing their opinions, had more self-confidence, dared to speak in front of the class, were more enthusiastic to participate in classroom activities, and encourage students to create a full range of mathematical creativity in the following four elements 1) Fluency: students discover a variety of answers or solutions to 62.86% 2) Flexibility: students discover the mathematical ideas are different, representing 17.14% 3) Originality: students discover how to solve the problem of requiring a novelty that different from the original idea, and have been accepted for 8.57% 4) Elegance: the solution that students discover in a simple and clear level can continue to develop as 11.43%.

Keywords: mathematical creativity, lesson study, open approach

1. Introduction

In the 21st century, global education management is a social and environmental change for students. Live in an appropriate world by providing students with knowledge, skills, abilities, and abilities. Life Skills in the 21st century, the most important are life skills and lifelong learning. Life is creativity. (the Partnership for 21st Century Learning, 2019) It is evident that in recent years, scholars and educators have emphasized the importance of preparing students to be ready for the future, the need to solve complex problems and think creatively. (Wagner, 2010) In order to comply with such changes, the Ministry of Education by the Office of the Basic Education Commission has done a review of the Basic Education Core Curriculum B.E. 2551 (A.D. 2008) is used as a frame and direction for the development of the course to be more precise. In short, the study should improve the curriculum in mathematics learning groups, which is vital to the development of the country and is a cornerstone to help humans innovate to be created. (Ministry of Education, 2017) Consistent with Leikin (2013) says that individual creative characteristics that promote human progress at all levels. Promote technological progress and inventing new things. Thus, creativity is a fundamental skill development should be at school. (Cachia & Ferrari, 2010) As a result, The Institute for the Promotion of Teaching Science and Technology (IPST.) (IPST, 2017) as the agency responsible for curriculum development and learning of mathematics, science,

and technology. Has developed a math curriculum by targeting people heading to Thailand to develop thinking skills and creative synthesis. Mann (2005) said mathematical creativity had been considered as an essential skill that should be developed to all students. As math creativity, it is essential to highly learners. In order for students to bring the solution and mathematical creative ability to apply for real-life Solutions. (Leikin, 2007, NCTM, 2000) Activities to learn math standards. There must be a balance between real knowledge. Process skills but in teaching mathematics ago. Although students will have a better understanding of the content. Nevertheless, students are not less sensitive to the initiative. This gives students can put their knowledge to use mathematics in everyday life and education more effectively. (Release, 2007) Consistent with Inprasitha (2014) says that math class in the context of the current. The culture of a teacher who described the new content. Furthermore, provide an example for students to see. Students then a solution based on a sample of students; teachers make no wakefulness. No knowledge exchange was happening. It is learned from various aspects or concepts. Another significant problem is. Mathematics Problem-based teaching in traditional classrooms, there is a downside. The problem is not wide open; the correct answer is the only answer. The student is limited to the ideas or solutions are the only way to solve the problem. Furthermore, repeat the process, others create it are no students to think creatively. (David, 1973)

The teaching that the problems with the right answer to a wide range of answers. Moreover, encourage the learner to learner is receptive to the idea. They were linking Knowledge And their experience to contribute to solving problems effectively. The problem is "The open-ended." (Shimada, 1997) Inprasitha (2003) said the situation provides an opportunity for students to solve their full potential. Moreover, the open-ended problems to help students develop the attributes of humanity. Mathematics and intelligence activities in the classroom with a wide range of math concepts. So in teaching using open-ended problems, each student will have the freedom to do as well as the freedom to think, to progress in solving their problems. The Rickards (1988), said open-end solution would enable students to use their creativity to solve problems. The solution is open-ended channels to use more creativity. Also, The open-ended to encourage students' originality, that is, during the search for a solution to a wide range and a large number of students to take math concepts ranging freely (fluency) and attempt to devise new tactics in. tackling (Flexibility) as well as the concept is bright and unexpected came up. (Originality) (Park et al., 2006) Furthermore, Beghetto & Kaufman (2011) says that in the course to support students' mathematical creativity is to create an open atmosphere in the classroom is essential. Moreover, it called for the teaching of this matter. How open-ended (Becker & Shimada, 1997) or open (Nohda, 1993).

Inprasitha (2011) said, Open Approach starting in Thailand since 2002, it has used the open end, which is above the students first. Then the class will be conducted with answers to many. The answer to the experience of finding new things. During the solution process. (Becker & Shimada, 1997;Inprasitha, 2010) By the way, open consists of 4 important steps include 1) Posing open-ended problem 2) Students'self-learning 3) Whole class discussion and comparison, and 4) Summarization through connecting students' mathematical ideas emerged in the classroom, however. The teacher will do this. Teachers must plan with your team to guess or predict the upcoming student. (Inprasitha, 2014) The Tall (2015) model creation and analysis of classroom teaching, teachers, and researchers together to design lessons and lesson forecasts. Then teach a group of observers, which presented various views on what happened during the lesson, called "Lessons Study" It Inprasitha (2011), combined with an open approach to lessons study. The teaching methods with an open approach have been used as a method of teaching (Teaching approach) by the process of the class is important Lesson Study is integrated with Open Approach the teacher can work together. I have all week to cycle to work consistently with the basic 3-step Collaborative Plan, Collaborative Do, and Collaborative See by outside experts, researchers coordinator. Schools and teachers, teachers and the school director. To participate in this process. Regularly to exchange views and offer different classes and learning about math student. (Inprasitha, 2019) To develop the role of teachers and improve student learning at Loipha and Inprasitha (2004) said that teaching methods are open to the concept of integrated development trends. The continued development and emphasize the classroom is as important as the concept of improving the teaching and development of the so-called Lesson Study and Open Approach.

Mathematics classes that use innovative and open classes are the classes that focus on the students who are focused on mathematical creativity. (Inprasitha, 2014) It can be seen from the fact that there were others. Learn about various mathematical creativity. By using innovative educational classes and an open approach, including Suttiamporn's (2006) study on An Assessment of Mathematical Creativity in Open-ended Problem-solving Situation found to allow students to be independent in their activities and independence. To think Leave time for students to solve math problems independently and continuously long enough for students to get used to the process of collaboration solutions. Students can think of spontaneity and flexibility; Jai-on (2008) studied an analysis of overcoming fixation in open-ended problem-solving situations based on an evaluation of creative thinking that. During which students solve open-ended until the creativity in the form of various elements. Shows that students can use the solution provided by the student's way of thinking. How is a new and never seen before? To assess the mathematical creativity was found. A nonuniform think logical thinking, fluent, flexible thinking. And

considered a role model, Suttiamporn (2012) studied the Students' mathematical creativity in new classroom culture that math class in the context of educational classes and an open approach. A class that does not begin to describe the teacher, but starting from the teacher preparation activities for students to focus on the idea that many different ways as possible. This is the mental aspect that pushes students to the beginning of the process of creating mathematical abilities as productive basis to assess the ability of creative math, and Wiriyapornprapas (2017) studied 11th Grade Student's Mathematical Creativity in Mathematics Classroom Using Lesson Study and Open Approach found that after the introduction of innovative educational classes and an open approach to the math class of the target appeared creative math. All four elements of the concept of Nohda (1998, cited in Inprasitha, 2004) 's.

As mentioned above, it is seen that the aim of the 21st-century study and the required education course of Thailand is that creativity is a vital purpose for studying. Furthermore, in a part of mathematics as the development of ideas in various aspects, including creativity, to manage, learn by open Approach using an open-end problem situation. Under the teacher's professional development system, called Lesson Study, is a context that enables students to solve their full potential and allow students to have a long experience in solving problems. Each student is free to do activities, as well as the freedom of thinking, which helps students solve problems and contribute to so, researchers are interested in studying of the Mathematical Creativity of 4th Grade Students in a mathematics classroom, using Lesson Study and Open Approach.

2. Research Objectives

This article has the goal of research is to study of the Mathematical Creativity of 4^{th} Grade Student's in mathematics classroom, using Lesson Study and Open Approach.

3. Definition

1. Mathematical Creativity is a variety of ways to solve the mathematical problems of students. According to the concept of Nohda (2000)'s focused on four key elements is the concept of fluency, flexibility, originality, elegance.

1.1 Fluency is the answer or how to solve all the problems that students encounter.

1.2 Flexibility is the difference of the students discover mathematical concepts.

1.3 Originality is the solution to the problem of students requiring a novelty that no one ever thought or imagined before.

1.4 Elegance is the solution to the problems of the students that are clear and easy to develop further.

2. Using a math class education and an open approach is the integration of the classroom with an open approach to creating classes focused solutions. The focus on solving the problem themselves by an open approach has been used as a method of teaching mathematics (teaching approach) in the process of studying the concept of a class. (Inprasitha (2011)

3. Lesson Study is a collaboration between teachers and researchers and research assistants. The teacher with the researcher and research assistant to jointly plan, prepare lesson plans, and then bring lesson plans to use in class is a class that uses an open approach by the research team. Moreover, Research Assistant to join the class to observe how their thinking. After teaching at a time to reflect, talk, teaching a class with a teacher and participant observation taught. The aim is to foster mathematical creativity of students consists of three necessary steps to follow the ideas of Inprasitha (2011) as follows:

3.1 The procedures of collaboration weekly teaching plan (Collaborative Plan) In this process involve researchers, school coordinators, researchers, and teachers. In the design of the research lesson, this stage is a selection of mathematical problem activities using open-end issues based on Japan's mathematical textbook.

3.2 The procedure of the Collaborative (Do) In this stage, the classroom education team will be planning to plan for the practical training plans in class. Teachers, as research and team members, observe research lessons. Also, teaching classes are observed by the researchers ' team. School Coordinator assistant researchers and other teachers; the purpose of observation focuses on a variety of solutions. A mathematical concept, the exotic approach, including doing various methods, is in general form, to find student mathematical creativity.

3.3 The process of weekly collaboration results (Collaborative See) In this step, the team together discuss and reflect the effects of research lessons and investigate the diagnosis of teaching observations to improve the research lessons. The research lessons that will keep the angle used the next year again. This process will be taken once a week. The characteristic of this process is that the school director will be the leader in this meeting, and this is motivated by all teachers in the school to attend the meeting.

4. Open Approach is a teaching method that aims to promote a student's mathematical solution and creativity using open-end troubleshooting activities. Based on the mathematical textbook of Japan, according to the concept of Inprasitha (2011), there are four steps to teach. As follows:

4.1 Posing Open-ended problems is a stage of research assistant as a teacher presenting an open-end problem, which is a mathematical problem in the classroom, and then teachers will use the questions and provide the activity leaves to students.

4.2 Students ' self-learning is the step that students use their knowledge of their ability to solve the open end and write the activity leaves. Learn from explaining and communicating within a group or a class. Teachers and researchers act to observe and take notes on students ' ideas and allow students to think independently. Do not interfere with or guide the concept of the students.

4.3 Whole-class Discussion and comparison is the stage in which each student has been presented a way of thinking and explain how to get the answer to the class. To allow students in the class to learn the concept at the same time, and provide opportunities for students in the classroom to ask questions and learn how to think at the same time, where teachers are arranging ideas. With the same concept, it is offered before going to different ideas.

4.4 summarization through connecting students' mathematical ideas emerged in the classroom is the stage of teachers and students sharing a summary of the concept and essential issues, as well as linking the concept of students happening in addition to the present.

4. Research Methodology

4.1 Target group

The target group used in this study was the 4th grade student's 1st Semester 2019 school year at Kookam Pittayasan School, Khon Kaen Primary Educational Service Area Office 4. There were 11 students divided into three groups: group 1, group 2, with a total of four students have student numbers four and group 3, with a total of 3 students. This school is a school in the Project for Professional Development of Mathematics Teachers with an innovative Lesson Study and Open Approach. The concept of teaching and learning activities based on the concept of educational classes and an open approach to teaching and learning at the school continuously since 2006.

4.2 Research Content

The content used for this research is the triangle story in the mathematical textbook for the 4th grade of the first class, which is established under the cooperation between Center for Research on International Cooperation in Educational Development (CRICED), University of Tsukuba, Japan and the Mathematics Research Center of Khon Kaen University by researchers and researchers, used as a guide for planning, learning, and designing educational activities. Knowledge of mathematics classes according to the guidelines of the Teacher Development program with innovative classes and open-plan methods, with a learning unit 7, a triangle story.

4.3 Research Instrument

This research Uses the Quality research methodology Focus on protocol analysis and analytical lectures to explain the changes to the student's impact. The tools used in research include the management plan learns according to the open method of a management plan, learning the learning team, together with the focus on the integration of content. The skills/processes and the desirable features In the learning unit of the triangle, which is in mathematical textbooks for the 4th grade of elementary School Grade 1, formed under the cooperation between Center for Research on International Cooperation in Educational Development (CRICED), University of Tsukuba, Japan and the Mathematics Research Center of Khon Kaen University, by researchers and researchers, used as a guide for planning, learning, and designing learning activities. In mathematical classes, according to the guidelines of the Teacher Development Program, with innovative classes and open-plan methods with a learning Unit 7, a triangle interview. Record-field and audio-visual recorders.

4.4 Data collection

1. The researchers studied the general context of the school and the classes in which researchers would like to use the research take four weeks by gathering the documents. Learn more about our teachers and observe classes throughout mathematical activities. From the study of educational and school contexts. Researchers have noticed that students in the target group have the right attitude to the mathematical classes. Also, the researchers went to talk about and intimate with the teachers.

2. Researchers and assistant research meeting together to determine the role of the researchers. Research assistant and teacher representative in the field record a video Capture still images and record sound during training, teaching, and interviews to prepare for the actual data collection.

3. Researchers with research assistant Students in school practice School Coordinator, Faculty of Teachers, and executives of the four schools in the high-eastern mathematical development project of the students in the north-east and northern regions. Together, create a learning management plan together according to the Lesson Study and Open Approach, which is conducted before the semester opens by caring and consulting from a project consultant and researchers team. From the Mathematical Research Center, the study was created during the school building Management plan, held every Thursday from 2.30 pm onwards during the school opening period.

Teachers will then teach the steps of an open method, which is already planned by the classroom Education team, and the teachers will observe and record the concept of the students. During the course, video recordings, still images, and voice recordings of the teacher and student are recorded. When the teacher's teaching is completed in each lesson, the researchers will gather all the activities of the students.

4. The researchers and researchers reflect the results after each tutorial to gather and observe the ideas. Students' behaviors and observe issues that occur each time to fix Find out how to prevent data collection problems in the future.

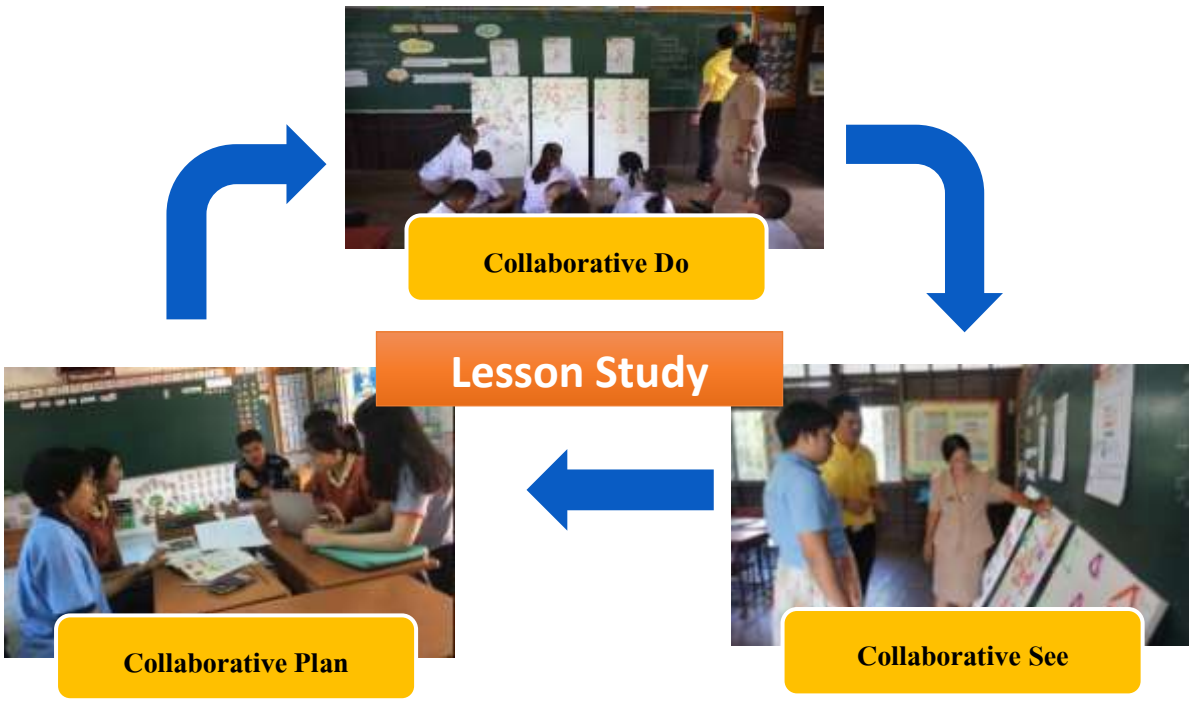

Figure 1: shows the weekly cycle of Lesson Study. (Inprasitha, 2019)

4.5 Data Analysis

The analysis of this data to study the mathematical creativity of the 4th grade student in math classes using class education and open methods is an analysis of quantitative and quality data by researchers to gather information from students' performance. Video Recorder Machine Voice recorder, the field recording slide, remove protocols, and perform the following analysis of data:

1. The researcher audiotape transcripts of the speech of students in a discussion between the students. Solutions throughout the event, teaching classes at Lesson Study and an Open Approach.

2. The researchers take a record of the field used to save all the solution behaviors and ideas while students. Solve problems with open end situations, as well as other behaviors that arise from students participating in the classroom in a discussion. Questions explaining why Use a record of the students ' ideas that research researchers have analyzed the mathematical creativity of students from the concept of thinking framing to determine the creative thinking. The mathematical concept of Nohda (2000) is mathematical creativity related to mathematical content based on a Japanese mathematical textbook.

3. The researchers put a student's removable speech at the time of dialogue during the student to resolve the problem throughout the classroom—open-style instruction with the data from the video recorder. Still, photography and work data students come together, which are written by each student group during the mathematical solution on how to find the answers and reasons for each group. Data is in the protocol image, analyzing the data by analyzing mathematical creativity. By adjusting the concept frame to consider mathematical creativity, according to the conceptual frame of the Nohda (2000), is mathematical creativity related to mathematical content based on Japanese mathematical textbooks.

5. Results of this research

The research findings revealed that in the mathematics classroom, using the innovative Lesson Study and Open Approach is the management of teaching classes focused on self-learning and learning together with friends. In class, students have mathematical creativity. Seen from students, a variety of concepts can be thought to solve the problem through self-expression. There is higher self-confidence in the course of a class page and an enthusiastic activity. We also encourage students to create the four mathematical creative elements of the following: 1) Fluency students find answers or solutions to a variety of ways. Think is 62.86% 2) Flexibility students discover several different mathematical concepts. 17.14% 3) Originality students discover how to solve problems from a newly configured problem situation. It is different from the original idea, and the student's friend accepts thinking as 8.57% 4) Elegance How to solve a problem that students find in a simple and clear level can continue to develop. Think is 11.43%

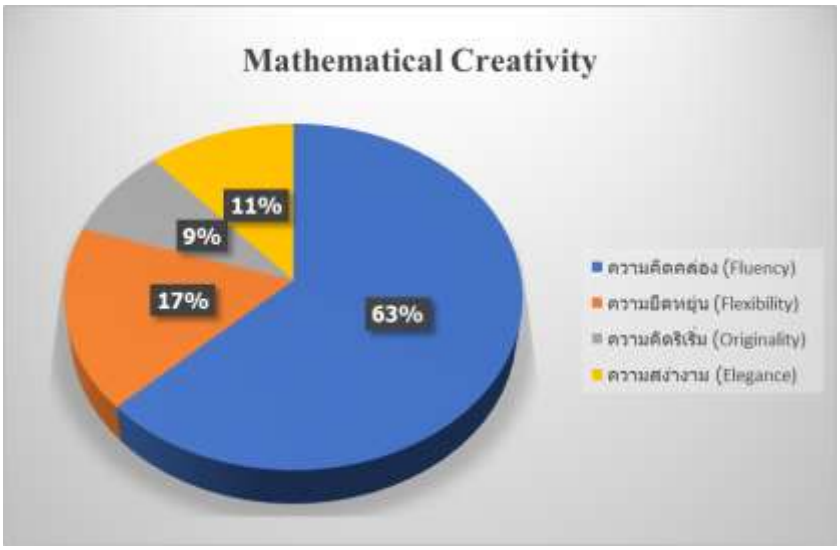

Figure 2: shows the percentage composition of Mathematical Creativity**.** (Nohda, 2000)

6. Discussion

The results of the research have found that a Mathematical Creativity of 4th Grade Student is in the mathematics classroom, using Lesson Study and Open Approach. Mathematics, according to the concept framework of the Nohda (2000), which, from protocols analysis, teaching management, is said that students have a creative mathematical score in every component. Demonstrate that students have various solutions and mathematical concepts behind the solution. It also has a high contrast due to the use of innovative classroom education that is appended to the Open method, which the group teachers. Study classes take together the concept and plan, thereby encouraging students to have different mathematical ideas. While using an open-end problem only. Encourage students to have a wide variety of ideas, but low flexibility. As a result, the research of Suttiamporn (2006), Jai-on (2008), Suttiamporn (2012), and Wiriyapornprapas (2017). The 4th grade student has shown a unique solution that nobody expected. Almost every learning plan, which such a method has been accepted by students and teachers in the education team.

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References

Becker, J & Shimada, S. (1997): **'The Open-Ended Approach, A New Proposal for Teaching Mathematics',** NCTM.

Beghetto R.A., & Kaufman J.C., (2011**). Teaching for creativity with disciplined improvisation.** R.K. Sawyer (Ed.), Structure and improvisation in creative teaching, Cambridge University Press, Cambridge (2011), pp. 94-109

Cachia, R., & Ferrari, A. (2010). **Creativity in Schools: A Survey of Teachers in Europe.** Seville: European Commission - Joint Research Centre -Institute for Prospective Technological Studies. Retrieved from http://is.jrc.ec.europa.eu/pages/EAP/iceac.html.

Guilford, J. P. (1967). **The nature of human intelligence.** New York: McGraw-Hill.

Inprasitha, (2014). **School Mathematics Problem Solving Processes.1**. Khon Kean: Penprian.

Inprasitha, M. (2010). One Feature of Adaptive Lesson Study in Thailand -Designing Learning Unit. **Proceeding of the 45th Korean National Meeting of Mathematics Education Dongkook University.** (pp. 193-204). Korea: Gyeongju.

Inprasitha, M. (2011). Lesson Study as an Innovation for Teacher Professional Development: A Decade of Thailand Experience. **Paper presentation at ICER2011, Faculty of Education,** Khon Kaen University.

Inprasitha, M. (2012). **Lesson study as an innovation for teacher professional development: A decade of Thailand experience.** URL (last checked 18 December 2012).

Jai-on, J. (2008). **An analysis of overcoming fixation in open-ended problem-solving situations based on an evaluation of creative thinking,** Master of Education Thesis in Mathematics Education, Graduate School, Khon Kaen University

Leikin, R., Lev, M. (2013**). Mathematical creativity in generally gifted and mathematically excelling adolescents: What makes the difference?**. ZDM, 45 (2) (2013), pp. 183-197, 10.1007/s11858-012-0460-8

Ministry of Education Thailand.)2517). **The Basic Education Core Curriculum B.E. 2551 (A.D. 2008).** Edition 1: A conventional printing. Agricultural Cooperatives of Thailand.

Nohda, N. (2000). **Teaching by open-approach method in Japanese mathematics classroom.** Proceeding of the 24th conference of the international Group for the Psychology of Mathematics Education, Hiroshima, Japan, July 23-27, volume 1-39-53.

Partnership for 21st Century Learning. (2019). **Framework for 21st Century Learning,** Battelle for Kids. All Rights Reserved http://www.battelleforkids.org/networks/p21

Rickards. (1988). **การทำงานของความคิดสร้างสรรค์**ประมวญ บุณยโหตระ) ., ผู้แปลโรงพิ :กรุงเทพฯ .(มพ์คุรุสภาลาดพร้าว.

Suttiamporn, W) .2006). **An Assessment of Mathematical Creativity in Open-ended Problem-solving Situation .**Master of Education Thesis in Mathematics Education, Graduate School, Khon Kaen University.]SBN 974-626-877-5]

Wagner, T. (2010). **The global achievement gap:** Why even our best schools don't teach the new survival skills our children need–and what we can do about it. Basic Books, New York

Wiriyapornprapas, P.) 2017). **11th Grade Student's Mathematical Creativity in Mathematics Classroom Using Lesson Study and Open Approach .**Master of Education Thesis in Science and Technology Education, Graduate School, Khon Kaen University.

Development of Students' Algebraic Reasoning in Classroom Using Lesson Study and Open Approach

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Abstract

This qualities research aimed to analyze development of students' algebraic reasoning in classroom using lesson study and open approach. The target groups were included 19 first-grade students in the 2^{nd} semester of 2019 academic years, where has been participated in the project for Professional Development of Mathematics Teachers through Lesson Study and Open Approach. For conducting the research, the researcher and co-researchers collaboratively participated in the process of Lesson Study that composed of three steps, namely: collaboratively plan, collaboratively do and collaboratively reflection, respectively. 8 Lesson plans of Addition (2) learning unit, field note, video and camera recorder were used as data collecting tools. To analyze, data obtained from 1) protocols of the students' activities in the classroom, 2) photographs of the students' works and 3) data from field notes. The collected data were analyzed by means of protocol analysis and analytic description. Researcher had collected the data in classroom by using algebraic reasoning of P. Moonpo et al. (2018)'s framework and Inprasitha (2016)' flow of lesson framework. The research found that in the flow of lesson showed that characteristics of first grade students' algebraic reasoning which come from the students' ideas in classroom that are real-world representation, Students using various representations to justify their ways of thinking. Semi-concrete representation, Students constructing and using a tool to find problem results more easily and extending solutions to another domain of number, and Mathematical world representation, Students using algebraic expressions to represent addition situation and posing situation to represent given expressions and

reasoning about relations among numbers. This is students' ideas that gradually develops from the concrete to abstract.

Keywords: Algebraic Reasoning, Lesson Study, Open Approach.

1. Introduction

Algebra is the gateway that leads to other important mathematics. Therefore, the algebra reform was the gateway to the mathematical reform from pre-kindergarten to Grade 12 for the next century (Kaput, 1998) accepted that students should be prepared to learn algebra at a level higher to achieve the goal that all students should have access to learning algebra (Cai et al., 2005). Any content or activity can encourage students to algebraic thinking has always been part of algebra for students in the primary school (Lins and Kaput, 2004). Algebraic thinking is important to keep students in the primary school age can learn algebra (Radford, 2012). Lins and Kaput (2004) also proposes that the characteristic of the algebraic thinking that is suitable for students in primary school is algebraic reasoning. Students should learn algebraic reasoning, since the beginning of the early grade to develop algebraic thinking.

Japan mathematics textbook and found that the textbook series can support students' relational thinking, which is considered as one kind of algebraic reasoning. Consequently, from their study it is said that we can develop students' algebraic reasoning at very early grade like first grade. Japanese mathematics textbook is well designed to support students' algebraic reasoning (Stephens & Armanto, 2010). Japanese mathematics textbook series have been used for the Mathematics Teachers Professional Development using Lesson Study and Open Approach which is initiated by Maitree Inprasitha since 2002. The textbook is consistent with the theory for teaching mathematics in Japan, problem-solving approach, which is believed that students will be able to learn through facing with difficulties in problem solving (Stigler & Hiebert, 1999).

Lesson Study and Open Approach are integrated in Thailand, it is the cooperation of 4 phases of Open Approach as a teaching approach and 3 steps of Lesson Study Process as a weekly cycle for developing teaching (Inprasitha, 2011). The aim of integration is to create problem-solving classroom in Thailand. Lesson Study and Open Approach does not mean follow those steps manually but teachers need to be aware that what their students must learn mainly is not math content but "learning how to learn".

There was an evidence that the teacher in this classroom can make her students to learn "how to learn" (Inprasitha, 2011). Inprasitha (2013) proposed the idea which is called Flow of Lesson, he mentioned that in order to make problem-based classroom students should have opportunity to learn through solving problem and making connection between representation of real world, semi-concrete world, and representation of mathematical world.

2. The objectives of research

This research is aimed to analyze development of students' algebraic reasoning in classroom using lesson study and open approach.

3. Keywords

3.1 Algebraic Reasoning means explain or reasoning about relations among numbers expressions and operation, and using various representation to justify their ways of thinking (P. Moonpo et al, 2018) as follows:

3.1.1 Using algebraic expressions to represent addition situation and posing situation to represent given expressions.

3.1.2 Constructing and using a tool to find problem results more easily.

3.1.3 Extending solutions to another domain of number

3.1.4 Using various representations to justify their ways of thinking

3.1.5 Reasoning about relations among numbers

3.2 Development of Students' Algebraic Reasoning means students' algebraic reasoning that occur continuously and connection on Flow Of Lesson (Inprasitha, 2016), This is students' ideas that gradually develops from the concrete to abstract.

3.3 Classroom by using lesson study and open approach means the classroom that emphasize on teacher collaboration continuly, consisting of processes that teachers have to do in 3 steps: 1) collaboration of research lesson design 2) collaboration observing research lessons and 3) collaboration discussion and reflection of research lesson, and using open approach as teaching approach that follow by 4 steps 1) presenting open-ended problem situations 2) self-learning of students through problem solving 3) discussing and comparing together the whole class and 4) summarizing from Linking the concepts of students occurring in the classroom (Inprasitha, 2011).

4. Research Methodology

4.1 The target groups

The target groups were included 19 first-grade students in the 2 nd semester of 2019 academic years.

4.2 The reserch tools

The tools of this research are consisting of data collection tools and data analysis tools as follow:

4.2.1 Data Collection Tools

1) First grade lesson plans in units 8 in Addition (2), there are 8 lesson plans by using Open Approach as a teaching approach. For the problem situation, students can find the answers by using the different and various methods. Students can solve problems according to individual abilities by creating problem situations and activities base on the textbook of 1 st grade Mathematics for Elementary: Study with Your Friends of GAKKHO TOSHO

2) Video recorder as the tools for recording the pictures and the voices of teachers and students during teacher use lesson plan with the process of students' mathematical representation in the classroom.

3) Cameras as the tools for recording photos during lesson study team is observing and students' idea in the classroom.

4) Field notes.

4.2.2 Data Analysis Tools

1) The data from video recorder, the researcher uses protocols from video recorders to show as the word and explain the act of teachers, analyze development of students' algebraic reasoning

2) Activities and students' work sheets pictures, as the picture that when the teacher gave students and the work sheets of students after they did the activity.

3) Field notes.

5. Results of this research

5.1 Conclusion

The research result of development of students' algebraic reasoning in classroom using Lesson Study and Open Approach, by analyzing the data, when collaboratively desiging lesson plan, observing classroom and reflecting lesson, according to the detail of algebraic reasoning framework (P. Moonpo et al., 2018) and Inprasitha (2016)' flow of lesson framework, The research found that in the flow of lesson showed that characteristics of first grade students' algebraic reasoning which come from the students' ideas in classroom that are real-world representation, Students using various representations to justify their ways of thinking. Semi-concrete representation, Students constructing and using a tool to find problem results more easily and extending solutions to another domain of number, and Mathematical world representation, Students using algebraic expressions to represent addition situation and posing situation to represent given expressions and reasoning about relations among numbers. This is students' ideas that gradually develops from the concrete to abstract.

Fig. 1 : students learn through solving problem and making connection between representation of real world, semi-concrete world, and representation of mathematical world.

The results revealed that, the algebraic reasoning occurred under the condition that teachers and students had connected among 3 worlds oriented to Inprasitha's approach: real world, semi-concrete world, and mathematical world. Real world, when a teacher posing open-ended problems, acting instead of the real world, students take information or conditions of problem situations used to interpret in order to access the problem situations in that period by themselves, in which the situation relates to things that are in daily life or things that students have experienced. Semi-concrete world, Student ideas or representation, such as a diagram drawing or blog to solving problem related to problem situations to mathematical numbers and symbols that was mathematical world.

6. Acknowledgements

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7. References

Cai, et al. (2005). The Development of Students' Algebraic Thinking in Earlier Grades: A Cross-Cultural Comparative Perspective. **Zentralblattfuer Didaktik der, 37**, 5-15

Inprasitha, M. (2011). One Feature of Adaptive Lesson Study in Thailand: Designing a Learning Unit. **Journal of Science and Mathematics Education in Southeast Asia , 34,** 47-66.

_____. (2013) Paper presented at **"Workshop for Teachers in the Project School of Mathematics Teachers Professional Development using Lesson Study and Open Approachfor conducting Lesson Study and Open Approach, Khon Kaen University"**. Khon Kean: Khon Kaen University.

Lins, R., & Kaput, J. (2004). The Early Development of Algebraic Reasoning: The Current State of the Field. In K. Stacey, H. Chick, & M. Kendal (Eds.), **The Future of the Teaching and Learning of Algebra : The 12th ICMI Study,** Dordrecht: Kluwer Academic Publishers. https://doi.org/10.1007/1-4020-8131-6_4

Kaput, J. (1998). Transforming Algebra from an Engine of Inequity to an Engine of Mathematical Power by "Algebrafying" the K-12 Curriculum. In National Council of Teachers of Mathematics. (Eds.). **The Nature and Role of Algebra in the K-14**

Curriculum: Proceedings of a National Symposium. (pp. 25-26). Washington, DC: National Academy Press.

Moonpo, P., Inprasitha, M., & Changsri, N. (2018). Algebraic Reasoning in Early Grade: Promoting through Lesson Study and Open Approach. **Psychology , 9,** 1558-1569.

Radford, L. (2012). Early Algebraic Thinking: Epistemological, Semiotic, and Developmental Issues. In: S. Cho (Eds.), **The Proceedings of the 12 th International Congress on Mathematical Education.** Cham: Springer.

Stephens, M., & Armanto, D. (2010). How to Build Powerful Learning Trajectories for Relational Thinking in the Primary School Years. In L. Sparrow, B. Kissane, & C. Hurst (Eds.), **Shaping the Future of Mathematics Education : Proceedings of the 33 rd Annual Conference of the Mathematics Education Research Group of Australasia** (523-530). Fremantle: MERGA.

Stigler, J., & Hiebert, J. (1999). **The Teaching Gap: Best Ideas from the World's Teachers for Improving Education in the Classroom.** New York: Free Press.

Prediction on the Breach Parameters and Peak Outflow for Kyeeon Kyeewa Dam

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Abstract

This study area is selected as the Kyeeon Kyeewa Dam in Mone River, Pwintphyu Township, near Wunlo village in Magway Division, Myanmar. This dam is a multipurpose earthen dam which store (319700) acre-feet of water to irrigate (82623) acres of farm lands and generate (74) Mega watt generator, and control the flood in Mone river. Kyeeon Kyeewa dam's catchment area was inundated due to cyclone "Koman" during July 2015 and too much of inflow water to the dam. Since this dam is an embankment dam, there is a probability of occurrence of dam break due to overtopping and piping (internal erosion). Therefore, this study has to deep attention for breaking of embankment dams because floods from the dam breach produce huge damages to the downstream areas. The prediction of dam breach geometry is crucial in dam break studies. The breaching of dam leads to water logging, loss of life and financial loss. The peak outflow from breached dam and flood inundation area is solely dependent on accurate prediction of breach parameters of a dam. The dam break phenomena can be understood by the prediction of breach parameters such as breach width, breach height, breach side slope and breach formation time.The main objective of this paper is to evaluate various breach parameters and peak flow prediction for the existing dam in Myanmar, namely the Kyeeon Kyeewa Dam using various empirical equations.

Keywords: Breach Parameters, Overtopping, Piping, Peak flow prediction, Kyeeon Kyeewa Dam

1. Introduction

Dams provide many benefits to civilization. However, floods resulting from dam break could lead to tremendous loss of lives and properties. The estimation of possible breach dimensions and development times is necessary in any assessment of dam safety.

Breach is defined as the opening formed in the dam body that causes the water to spread to the downstream location. The breach parameters will directly and substantially affect the estimate of the flows, inundated areas and warning times at downstream locations [2]. The geometric description of a dam breach must be estimated to simulate the resultant flood wave and downstream consequences. The available breach parameter and peak breach

flow estimation techniques can be classified into three categories, as follows: Comparative analysis, Regression-based methods based on data collected from actual dam failures, and Physically-based simulation models. All of these methods are viable techniques for estimating breach characteristics [2].

In this study, the MacDonald and Langridge-Monopolis (1984), Froehlich (2008) and Von Thun & Gillette (1990) empirical formulas, which are developed from regression analysis of collected data from various dam failure experiences, are used to estimate the dam breach parameters of Kyeeon Kyeewa Dam. Reasonable values for the breach size and development time are needed to predict the reliable outflow hydrographs and resulting downstream inundation, flood travel times, and water velocities, etc.

2. Research Methodology And Case Study Area

2.1 Research Methodology of the Study Area

In this study, three of the most common empirical approaches for predicting dam breach size and breach formation time are used to estimate breach parameters for Kyeeon Kyeewa Dam. The employed methods are the MacDonald and Langridge-Monopolis (1984), Froehlich (2008), and Von Thun & Gillette (1990). These methods are driven from statistical analysis of data extracted from historic dam failures of a wide range of dam sizes. These methods are applied to estimate Kyeeon Kyeewa dam breach under different scenarios of assumed overtopping and piping failure modes with different ranges of initial reservoir water levels. Numerous reservoir water levels for each approach were considered.

A range of water levels at 20 intervals between full tank level (103.7 m a.s.l) to the minimum operating level (83.06 m a.s.l) and between the crest reservoir storage level (115.9 m a.s.l) to full tank level (103.7 m a.s.l), maximum reservoir level (108.28 m a.s.l) and unexpected reservoir level (112.85 m a.s.l) were studied for each method. The breach location was at the center of the dam due to presence of high hydrostatic pressure for both overtopping and piping failure modes. Overtopping failure starts at full reservoir condition and piping failure starts at normal reservoir condition and develops to maximum degrees.

2.2 Geographical Description of Study Area

The Kyeeon Kyeewa Dam in Mone river, Pwintphyu Township, near Wunlo village in Magway Division, Myanmar, was used as the system under study (Figures 1 & 2). This dam is constructed across Mone river creek and is located at latitude 20º 20' N and longitude 94º 24' E. The catchment area upstream of the dam has been estimated as 5200 km². This river is

started from Mount Khaw Nu Thon which is the highest mount in the Chill hills. The area is very mountainous and most of the mountains are above 3,000 ft (90 m). The dam is a zoned earth fill with a height of 50.02 m above the original stream bed and crest width is 7.93 m at a crest elevation at 116.05 m as shown in Figure 3. The upstream slope was 3H: 1V and downstream 2.5H: 1V. All the physiographic parameters have been described in the Table 1.

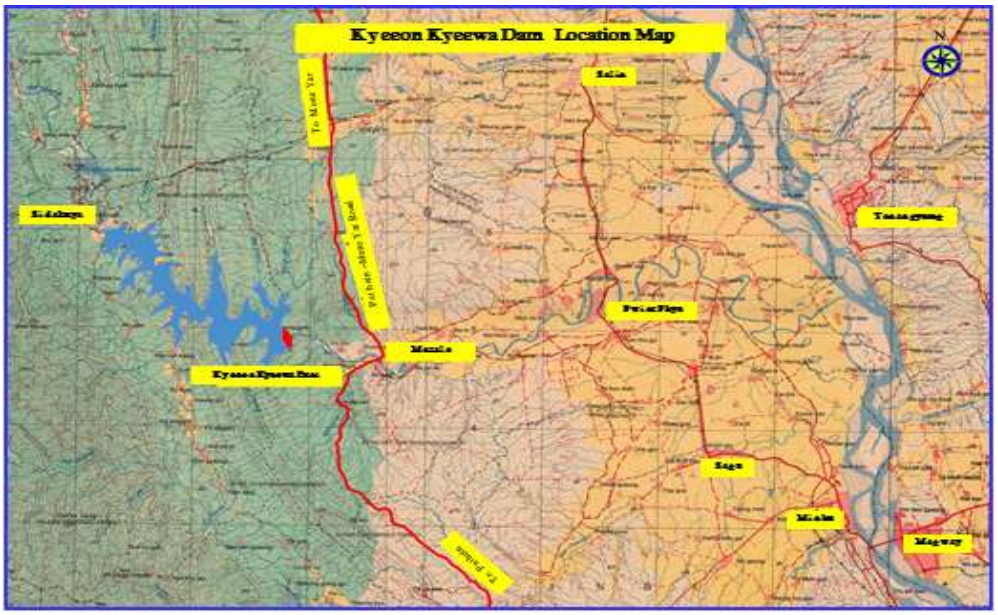

Figure 1: Location Map of the Study Area

Figure 2: Satellite View Dam

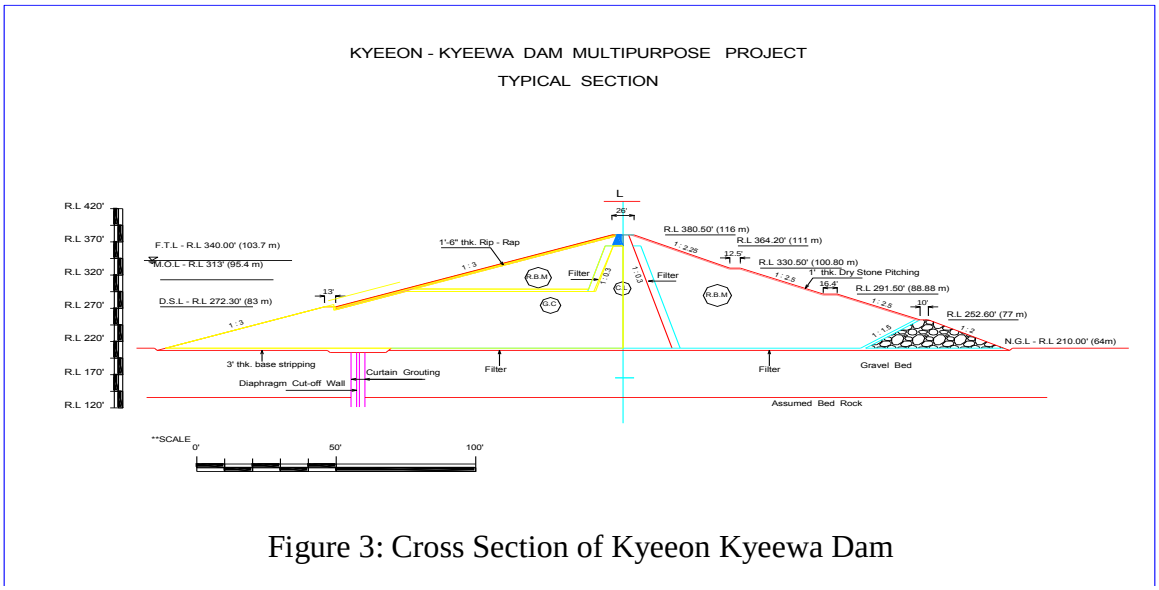

Figure 3: Cross Section of Kyeeon Kyeewa Dam

Table 1: Physiographic Parameters of Kyeeon Kyeewa Dam

Description	Value
River	Mone
Height	50.02 m
Catchment Area	1950 sq-mile
Length	1000 m
Full tank capacity	415.1 Mm^3
Full reservoir level	103.7 m
Dam Crest Level	116.05 m
Stream bed Level	66.03 m
Dead storage capacity	29.8 Mm^3
Dead storage level	83.06 m
Spillway type	Ogee

3. Failure Modes Of Earthen Dam

Failure of an embankment dam may be mainly related to (i) Hydraulic Failure, (ii) Seepage Failure and (iii) Structural Failure [7].

3.1 Hydraulic Failure (40% of Dam failure)

Hydraulic failure occurs mainly due to

(a) Downstream toe erosion

(b) Overtopping Failure

(c) Downstream side erosion by gully formation

3.2 Seepage Failure (35 % of Dam Failure):

Seepage failure is mostly related to

(a) Piping through foundation
(b) Piping through dam body
(c) Downstream portion sloughing

3.3 Structural Failure (25 % of Dam Failure):

Structural failure of an embankment dam occurs due to

(a) Embankment sliding
(b) Foundation sliding
(c) Faulty construction and poor maintenance
(d)Earthquake

4. Review Of Past Works

During the eighties, many researchers started collection of detailed breaches of dam in order to simulate models that are able to predict the effects and mechanisms of breach and estimate peak outflows [7].

Johson and Illes (1976) worked on different breach shapes of earthen, gravity and arc dams. He expounded trapezoidal breach shape and few triangular breaches shapes for the earthen dams. Singh and Snorrason (1982) with their study of 20 dam failures inferred the variation of breach width from two to five times the height of dam [3].

The following regression equations have been used for several dam safety studies:

- Froehlich (1995a, 1995b, 2008)
- MacDonald and Langridge-Monopolis (1984)
- Von Thun and Gillette (1990)

Froehlich utilized 63 earthen, zoned earthen, earthen with a core wall (i.e. clay), and rockfill data sets to develop a set of equations to estimate average breach width, side slopes, and failure time. In the application of these equations reported here in, the height of the breach is calculated by assuming that the breach goes from the top of the dam to the natural ground elevation at the centerline of the breach location.

MacDonald and Langridge-Monopolis (1984) utilized 42 data sets (predominantly earthfill, earthfill with a clay core, and rockfill) to develop a relationship for the “Breach

Formation Factor." The Breach Formation Factor is a product of the volume of water released from the dam and the height of water above the dam. They then related the breach formation factor to the volume of material eroded from the dam's embankment. The resulting ultimate breach dimensions are a function of the volume eroded and the embankment geometry. The MacDonald and Langridge-Monopolis paper states that the breach should be trapezoidal with side slopes of 0.5H: 1V. The breach size is computed by assuming that the breach erodes vertically to the bottom of the dam and then erodes horizontally until the maximum amount of material has been eroded or the abutments of the dam have been reached.

Von Thun and Gillette (1990) used 57 dams from both the Froehlich (1987) and the MacDonald and Langridge-Monopolis (1984) papers to develop their methodology. The method suggests the use of breach side slopes of 1.0H: 1.0V; except for dams with cohesive soils, where side slopes should be on the order of 0.5H: 1V to 0.33H: 1V. Von Thun and Gillette developed two different sets of equations for the breach development time depending upon the embankment material.

The impact of the breach parameters estimated by these methods on the computed breach outflow hydrographs has been previously documented (Gee and Brunner, 2007; Gee, 2009a and 2009b). Recent work by Xu and Zhang (2009) has proposed new regression equations for breach parameters based on an updated and expanded data set [6].

5. Breach Parameters Definitions

Parameters which are required to characterize the breach are known as breach parameters. Breach parameters can be divided into two categories:

(i) Geometric parameters

(ii) Hydrographic parameters

The geometric parameters define the shape and size of the breach. The hydrographic parameters include peak outflow and time of failure [3].

5.1 Importance of Breach Parameters

Variation of breach parameters can affect peak discharge and inundation levels. Change in breach formation time and breach width can produce large change in peak outflow, whereas breach height has relatively small effect on peak outflow. For locations downstream of the dam, timing of the flood wave peak can change significantly with changes in breach

formation time, but peak discharge and inundation levels are insensitive to change in breach parameters (Wahl, 1998). In general, the importance of the breach parameters will become less significant as the location of interest point move farther downstream of the dam [9].

5.2 Estimating Breach Parameters Using Empirical Equations

To carry out a dam-break flood routing simulation, breach parameters must be estimated and provided as inputs to the dam-break and flood routing simulation model. Several methods are available for estimating breach parameters; a summary of the available methods was provided by Wahl (1998) [4].

The description of the breach shape consists of the height of the breach, breach width and side slopes [6]. The breach width is described as the average breach (B_{ave}) in many equations. The breach height ($h_b = h_d$) is the vertical extent from the top of the dam to invert elevation of the breach. Many publications and equations were also used the height of water (h_w), which is the vertical extent from the maximum water surface to the invert elevation of the breach. The side slopes are expressed in H: V.

A diagram showing this generalized breach is shown in Figure 4.

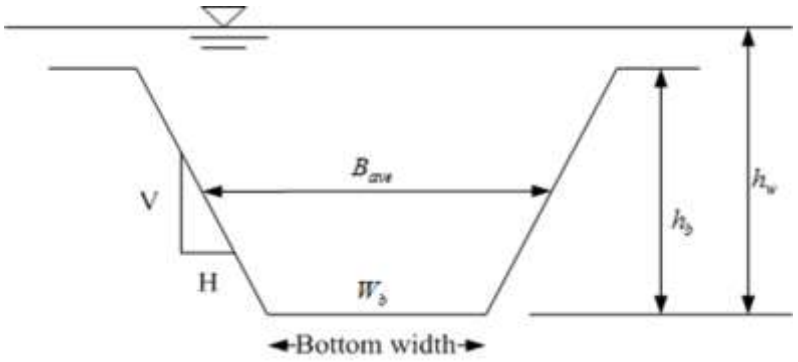

Figure 4: Description of the breach [1]

Empirical methods are used to predict breach geometry and time of failure to estimate peak breach discharges. The following is a brief discussion of each equation set.

(i) MacDonald and Langridge-Monopolis (1984): They developed a relationship called "Breach Formation Factor" using 42 data sets (earthfill dams, earthfill dams with a clay core, Rockfill dams). That is the product of height of water above dam and volume of water coming out of dam. MacDonald and Langridge–Monopolis equation for volume of material eroded and breach formation time, as reported by Wahl (1998), for earthfill dams with clay core.

$$V_{eroded} = 0.00348\left(V_{out} h_w\right)^{0.852} \quad (1)$$

$$t_f = 0.0179\left(V_{er}\right)^{0.364} \quad (2)$$

Base width of Breach, $$W_b = \frac{V_{er} - h_b^2\left(CZ_b - h_b Z_b Z_3/3\right)}{h_b\left(C + h_b Z_3/2\right)} \quad (3)$$

Average breach side slope of breach: 0.5H: 1V

(ii) Froehlich (2008) : He revised his result using 74 data sets that are related to earthen, zoned earthen, earthen with a core wall (clay), and rock fill to envisage a set of equations to predict breach parameters:

$$B_{avg} = 0.27K_0 V_w^{0.32} h_b^{0.04} \quad (4)$$

$$t_f = 63.2\sqrt{V_w / gh_b^2} \quad (5)$$

Average Breach Side Slope: 1.0H: 1V overtopping failure; 0.7H: 1V piping failure

(iii) Von Thun and Giiiette (1990): They have used the data of Froehlich (1987) and the MacDonald and Langridge-Monopolis (1984) to understand the methodology using 57 dam case studies.

$$B_{avg} = 2.5h_w + C_b \quad (6)$$

$$t_f = 0.02h_W + 0.25 \quad (7)$$

$$t_f = \frac{B_{avg}}{4h_w} \quad (8)$$

Average Breach side slope of breach: 0.5 H: 1V

C_b is coefficient which is a function of the reservoir size of the dam. Its value is ranged between 6.1 and 54.9 m. It is selected depending on the value that is listed in the Table 2 below.

Table 2: Coefficient as a function of Reservoir size [1]

Reservoir size (m^3)	C_b (m)
$< 1.23\times10^6$	6.1
$1.23\times10^6 - 6.17\times10^6$	18.3
$6.17\times10^6 - 1.23\times10^7$	42.7
$> 1.23\times10^7$	54.9

For this study since the storage capacity is greater than 1.23×10^7 m^3, the value of C_b is 54.9 m.

5.3 Recommended Approach

Many federal agencies have published guidelines in the form of possible ranges of values for breach width, side slopes, and development time. Table 3 summarizes some of these guidelines. The guidelines shown in Table 3 should be used as minimum and maximum bounds for estimating breach parameters. In general; several methods should be used to predict a range of breach sizes and failure times for each failure mode/ hydrologic event [1].

It is recommended that the modeler select several regression equations to estimate breach parameter values. Care must be taken when selecting regression equations, such that the equations are appropriate for the dam being investigated. If the dam under investigation is outside the range of data used in the development of the regression equations, resulting breach parameter estimates should be scrutinized closely for reasonableness. Additionally, breach parameter estimates should be compared to the government agency ranges provided in Table 3.

Table 3: Ranges of Possible Values for Breach Characteristics [1]

Dam Type	Average breach width (Bave)	Horizontal Breach side slope (H) , (H:V)	Failure Time, tf (hours)	Agency
Earthen/Rockfill	(0.5 to 3.0)x HD	0 to 1.0	0.5 to 4.0	USACE 1980
	(1.0 to 5.0)x HD	0 to 1.0	0.1 to 1.0	FERC
	(2.0 to 5.0)x HD	0 to 1.0	0.1 to 1.0	NWS
	(0.5 to 5.0)x HD	0 to 1.0	0.1 to 4.0	USACE 2007
Concrete Gravity	Multiple Monoliths	vertical	0.1 to 0.5	USACE 1980
	Usually < 0.5L	vertical	0.1 to 0.3	FERC
	Usually < 0.5L	vertical	0.1 to 0.2	NWS
	Multiple Monoliths	vertical	0.1 to 0.5	USACE 2007
Concrete Arch	Entire Dam	Valley wall slope	< 0.1	USACE 1980
	Entire Dam	0 to valley walls	< 0.1	FERC
	(0.8 x L) to L	0 to valley walls	< 0.1	NWS
	(0.8 x L) to L	0 to valley walls	< 0.1	USACE 2007
Slag/Refuse	(0.8 x L) to L	1.0 to 2.0	0.1 to 0.3	FERC
	(0.8 x L) to L		< 0.1	NWS

5.4 Predicting Peak Outflow

In addition to the prediction of breach parameters, many investigations have proposed simplified methods for predicting peak outflow from a breached dam. These methods are used for reconnaissance level work and for checking the reasonability of dam-break outflow hydrographs developed from estimated breach parameters [1].This paper considers the relations by:

USBR (1982) : $Q = 19.1(h_w)^{1.85}$ (9)

MacDonald and Langridge-Monopolis (1984): $Q = 3.85(V_w h_w)^{0.411}$ (10)

Froehlich (1995b): $Q = 0.607 V_w^{0.295} h_w^{1.24}$ (11)

Kirkpatrick (1977): $Q = 1.268(h_w + 0.3)^{1.24}$ (12)

Soil Conservation Service (SCS, 1981): $Q = 16.6 h_w^{1.85}$ (13)

Hagen (1982): $Q = 0.54(Sh_d)^{0.5}$ (14)

Costa (1985): $Q = 1.122(S)^{0.57}$ (15)

Evans: $Q = 0.72 V_w^{0.53}$ (16)

Where V_w is the volume of water behind the dam at failure in m^3 and h_w is the height of water above breach invert level at the time of failure and h_d is the height of dam. Dam breach flow developed from predicted breach geometry was also compared.

6. Results And Discussions

6.1 Results of Breach Parameters For Kyeeon Kyeewa Dam

By adopting the methodology described above, the three empirical equations are among the empirical equations which used to estimate breach parameters with different scenarios of assumed overtopping and piping failure modes with different ranges of initial reservoir water level. Table 4 and Table 5 show the predicted Results of average breach width, bottom width and failure time using various regression equations.

From Table 4, it may be noted that average breach width varies from -4.64 m to 584.76 m. From Table 5, breach time varies from 0.16 to 4.68 hours. In the Recommended Approach results (Table 3), the average breach width varies from 25.01 m to 250.1 m and breach time varies from 0.1 to 4 hours. MacDonald and Langridge - Monopolis (1984) outside the ranges of the breach parameters for this research dam according to the Recommended Approach results. The breach parameters estimated by Froehlich (2008) and Von Thun & Gillette (1990)

are reasonable the regression equations which is as minimum and maximum bounds for estimating breach parameters. From the results of Table 5, it can be seen that all of the equations indicate increasing bottom width and failure times as the reservoir storage increases, except the Von Thun and Gillette relation, which predicts a slight decrease in the failure time. The predicted results from Table 4 and Table 5 must be provided as inputs to the dam break and flood routing simulation model to carry out a dam break flood routing simulation. And then, the peak outflow from a breached dam and flood inundation area is dependent on accurate prediction of breach parameters of a dam. Since breach parameters will directly and substantially affect the estimate of the flow, inundated areas and warning time at the downstream locations, the estimation of possible breach dimensions and development time is also necessary in any assessment of dam safety.

Table 4: Prediction on Breach Parameters using various empirical equations

Reservoir Elevation		Froehlich (2008)		MacDonald & Langridge	Von Thun & Gillette(1990)
		Overtopping	Piping	Overtopping & Piping	Overtopping & Piping
Ft	m	B_{ave} (m)	B_{ave} (m)	B_{ave} (m)	B_{ave} (m)
380	115.9	307.56	236.59	584.76	179.58
370	112.85	287.79	221.38	461.08	171.95
355	108.28	257.26	197.89	308.15	160.58
340	103.7	226.36	174.12	193.12	149.08
320	97.6	188.62	145.09	93.9	133.83
300	91.5	152.34	117.18	35.23	118.58
280	85.4	115.93	89.18	2.91	103.33
272.3	83.06	101.16	77.82	-4.64	97.48
Breach side slope(H:V)		1.0H : 1.0V	0.7H : 1.0V	0.5H : 1.0V	0.5H : 1.0V
Recommended value		B_{ave}= 25.01 to 250.1 m , t_f = 0.1 to 4.0 hours , H = 0 to 1 H			

Table 5: Predicted Results of Bottom Width and Failure Time

Reservoir Elevation		Froehlich (2008)			MacDonald & Langridge		Von Thun & Gillette(1990)	
		Overtopping	Piping		Overtopping & Piping		Overtopping & Piping	
Ft	m	W_b (m)	W_b (m)	t_f (hours)	W_b (m)	t_f (hours)	W_b (m)	t_f (hours)
380	115.9	257.54	201.58	3.48	584.76	4.68	154.57	1.25
370	112.85	237.77	186.37	3.13	461.08	4.3	146.94	1.19
355	108.28	207.24	162.88	2.63	308.15	3.74	135.57	1.09
340	103.7	176.34	139.11	2.15	193.12	3.19	124.07	1
320	97.6	138.60	110.08	1.62	93.9	2.53	108.82	1.06
300	91.5	102.32	82.17	1.16	35.23	1.92	93.57	1.16
280	85.4	65.91	54.17	0.76	2.91	1.36	78.32	1.33
272.3	83.06	51.14	42.81	0.16	-4.64	1.14	72.47	1.43

6.2 Results of Peak Outflow For Study Area

The predicted results of peak outflow for different approaches are shown in Table 6, sorted in order of increasing peak outflow for different reservoir levels. The lowest peak flow predictions come from those equations that are based solely on dam height or depth of water in the reservoir. The highest peak flows are predicted by those equations that incorporate a significant dependence on reservoir storage. The results show that all of the equations indicate increasing the value of peak outflow as the reservoir elevation increases.

Table 6: Predicted Results of Peak Outflow for different reservoir levels

Reservoir Elevation		Peak Outflow (m^3/s)							
Ft	m	Kirkpa-trick	SCS	Froehlich	USBR	Evans	MacDonald	Hagen	Costa
380	115.9	162.81	22967.35	34560.98	26426.29	41541.97	94495.98	118473.40	148074.35
370	112.9	150.82	20476.88	30100.80	23560.75	37213.68	84583.12	106792.61	131549.45
355	108.3	132.80	16914.83	23880.24	19462.25	30904.20	70190.14	89623.76	107724.49
340	103.7	115.25	13667.84	18397.78	15726.25	25002.37	56798.84	73383.17	85769.33
320	97.6	92.75	9857.48	12491.53	11342.04	18484.20	41790.77	55187.57	61979.93
300	91.5	71.27	6626.16	7860.54	7624.07	12975.40	29079.18	39523.95	42361.65
280	85.4	50.98	3992.99	4351.91	4594.34	8254.39	18297.17	25795.46	26044.22
272.32	83.06	43.57	3146.70	3271.81	3620.60	6586.69	14567.76	20848.45	20431.31

From the results of Table 6, it may be noted that comparison purposes with model outflow hydrograph should be used for checking the reasonability of dam-break outflow hydrographs developed from estimated breach parameters.

7. Conclusion

This paper presents a quantitative analysis of various regression-based methods for predicting embankment dam breach parameters and peak breach outflows. Dam break phenomenon is relient on the assessment of breach parameters. Breach parameters are really beneficial to evaluate the extent of flooding and travel time of a flood wave to certain distances that would occur due to failure of a dam. The breach outflow hydrograph varies drastically with the variation in the breach parameters.

In this study, empirical formulas were used to predict the breach parameters of research dam. Froehlich (2008), MacDonald and Langridge -Monopolis (1984) and Von Thun & Gillette (1990) were among the empirical formulas which used to estimate the breach parameter. Failure scenarios selected for this study are overtopping and piping, because most

historical dam failures were due to those types of failure scenario. In addition, eight reservoir levels were considered for each approach. It is clearly understood that different regression equations are also based on the data sets available. In this research dam, MacDonald and Langridge -Monopolis (1984) overestimated and outside the range of recommended value (25.01 m to 250.1 m) for the breach parameters. The breach parameters estimated by Froehlich (2008) and Von Thun & Gillette (1990) are reasonable the regression equations which is as minimum and maximum bounds for estimating breach parameters. For the accurate prediction of breach parameters, breach parameter from one of the methods was selected based on the results from unsteady flow analysis, envelope curve and peak outflow regression equations [8]. The selected method is used for downstream flood impact assessment of dam break analysis. This study can be used as the reference guidelines for irrigation departments, governments and policy makers to develop the accuracy of the numerical simulations of dam-break waves. Additional research should be conducted for dam breach outflow hydrograph using hydraulic models. The evaluated results of this study can be used as inputs for the analysis of dam break studies.

References

[1] Gray Brunner, (2014). "Using HEC-RAS for Dam Break Studies", United State, Institute of Water Resource Hydrologic Engineering Center (CEIWR-HEC).

[2] Gee, D. (2008). "Comparison of Breach Parameter Estimators" U.S.A: Crops of Engineers Hydrologic Engineering Center, 609 2nd st, Davis, CA, 95616.

[3] Mayank Nema, (2016). "Dam Break - A Review", International Journal of Advanced Engineering Research and Science (IJAERS), Vol-3, Issue-6, June-2016, pp.130-134.

[4] Tony L. Wahl, (2004). "Uncertainty of Predictions of Embankment Dam Breach Parameters" Hydraulic Engineer, U.S Department of the Interior, Bureau of Reclamation, Water Resources Research Laboratory, Journal of Hydraulic Engineering, Vol -130, May-2004.

[5] Talal A. Basheer, (2017). "Dam Breach Parameters and Their Influence on Flood Hydrographs for Mosul Dam", Journal of Engineering Science and Technology, Vol-12, No 11, 2017.

[6] D. Michael Gee, (2010). "Use of Breach Process Models to Estimate HEC-RAS Dam Breach Parameters", 2nd Joint Federal Interagency Conference, Las Vegas, NV, June 27-July 1, 2010.

[7] Bhanu Sharma, (2017). “A Comparative Study of Estimation of Breach Parameters for an Embankment Dam Using Regression Equations”, IOSR Journal of Engineering (IOSR JEN), ISSN (p): 2278-8719, pp.31-37.

[8] Abimael Leoul, (2019). “Dam Breach Analysis Using HEC-RAS and HEC-GeoRAS: The Case of Kesem Kebena Dam”, Open Journal of Modern Hydrology, pp.113-142.

[9] Jiregna Nugusa, (2016). “Dam Break Analysis: The Case Study of Fincha’s Dam”, Hydraulic Engineering.

Improvement of Seismic Performance for Existing RC Building with Shear Walls

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Abstract

Seismic improvements are required for existing buildings that are vulnerable to damage by seismic forces. Low to severe earthquakes occur around the world every year. Such events lead to damage to the buildings as well as failures. This paper aims to improve the seismic performance of existing non-seismic RC school building in seismic zone 4 by considering suitable retrofit strategies. This paper examines that it is needed to retrofit or not because of the existing building that is built only for gravity loads with the absence of seismic load. This study has been carried out to investigate the performance under three earthquake hazard levels (Serviceability Earthquake, Design Basic Earthquake, and Maximum Considered Earthquake) and the vulnerability of the proposed school building. At first, the existing building is analyzed with linear static analysis. According to the results of structural stability checking, P- delta effect is not satisfactory. It was found that there was 45% and 22% deficiency in beams and columns respectively. Secondly, nonlinear static (pushover) analysis is incorporated to examine the performance level of the existing building and story drift, stiffness value, ductility demand, and performance level are checked. As the results of pushover analysis, the performance point appears only in Serviceability Earthquake (SE). Besides, its vulnerability index value was less than 0.4% and hence this building was vulnerable. The existing building was not satisfied with the performance objectives, strength, stiffness, and ductility. Therefore, the proposed school building needs to provide retrofit strategies. The global retrofit strategy is suitable for the proposed case study according to FEMA 356. Three locations of shear walls without openings (Model A, B, C) and with openings (Model D, E, F) are selected mainly depending on the centre of mass and centre of rigidity. After retrofitting, the performances of six retrofitted buildings have the little difference from each other in three earthquake hazard levels. However, Model A is the best model for the seismic performance improvement of existing RC building with shear walls due to the lowest lateral displacement value.

Keywords: Global retrofit strategy, Non-seismic, Pushover Analysis, RC school building, Vulnerability Index

A. Introduction

There are many disasters in the world including earthquake. The earthquake has no sign or warning to take precautions to damages and collapse of buildings. The addition of seismic load to gravity load is the only way to prevent these damages in both new and existing buildings. The buildings without the effect of seismic load have deficient lateral load resistance and can rapidly lose their performance during an earthquake, leading to collapse. Therefore, both gravity loads and lateral loads should be considered in the analysis of new and existing buildings.

Most of the existing buildings have been designed using gravity loads only. Mandalay is situated in seismic zone 4 near the Sagaing- fault and hence seismic load is especially important. The proposed building is Basic Education High School No-14; three-storied RC building, located on 80th street between 32nd and 33rd street, Chan Aye Thar Zan Township, Mandalay. This building was designed only on the effects of gravity loads without considering the seismic loads. When the seismic load was added to the original design, the building had poor performance and thus, retrofitting strategies had been examined.

In this study, there were two main parts. The performance levels and vulnerability of the existing buildings was the first part of the study. The second part is to improve the performance level of the existing school building by retrofitting. The existing building would be retrofitted by considering externally strengthening of structure; insertion of bracings or shear walls at the corrected location. The purpose of the study is to upgrade the seismic safety of the existing building to the desired level with the best and most appropriate techniques in a short time with minimum cost.

B. Statement of the Problem

Round about 20 years ago, the seismic load was not considered in most of the existing buildings in Mandalay. The proposed school building is also mostly focused on the effects of gravity loads. If the seismic load is not considered in school buildings, it is dangerous because students are too young to prevent themselves. According to the data collections, high-rise buildings have become popular a few years ago and these buildings are, therefore, specifically seismic design. Currently the Mandalay City Development Committee (MCDC) defines that four-storied and above must be considered a seismic load. The above conditions expressed that the structural engineers have to improve the seismic structural safety for both the newly design and existing structures.

C. Methodology and Model Development

1. Description of General Design Process

The initial considerations related to the type of structure, the seismic zone location, etc. were reviewed. Architectural and structural as-built drawings were collected. Rebound hammer test, rebar detector test, and vernier calliper test were performed. And then, the seismic evaluation was done to identify the deficiencies and performance levels of the building. Based on the results from the performance-based evaluation, a decision was made whether to repair, retrofit or demolish the building. Retrofitting aims to enhance the structural safety of the building that is deficient or vulnerable. Figure 1 shows the key steps in the performance-based design process for retrofitting the existing building.

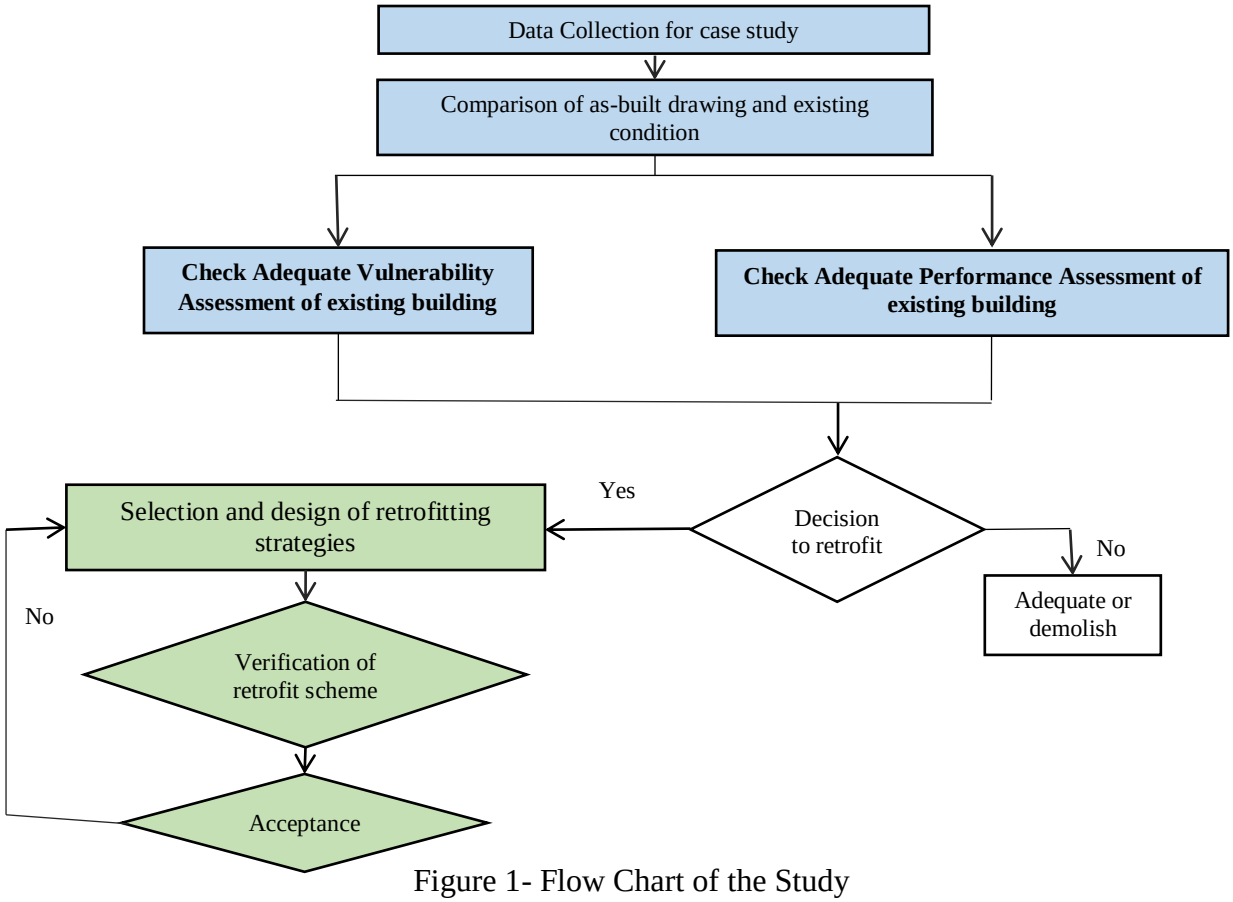

Figure 1- Flow Chart of the Study

2. Description of Existing RC School Building

In this study, the evaluation of seismic performances and strengthening for brick-nogging buildings were carried out. The aim of this study is to identify the weak links in the structures and to find out suitable strengthening processes for these types of buildings. Based on the recent earthquake, brick-nogging buildings are most vulnerable during strong earthquake shaking. So, in this study, case studies of 12 typical buildings, which are based on mostly constructed by localized, were carried out to study their performance and vulnerable states from technical point of view. In some cases, the lack of drawings and other documentation for a particular building may significantly affect the selection of an evaluation procedure [3]. And hence, the As-built drawing of the proposed building is required to correlate with the existing data. Therefore, the measurements were taken whether the actual strength, arrangement, and sizes of reinforcing bars and concrete strength were complying with a design drawing. Rebound hammer was used to examine the existing compressive strength. A rebar detector was applied to know the numbers of rebar and concrete cover. To know the diameters of rebars, a vernier calliper was used. Finally, the dimensions of building, beams, and columns were obtained with measuring tapes. Table 1 summarizes the comparisons of the as-built and existing data.

Location:	Basic Education High School No-14, 80th street, 32nd × 33rd street, Chan Aye Thar Zan Township, Mandalay.
Latitude:	21˚ 58′ 24.02″ N
Longitude:	96˚ 4′ 58.67″ E
Shape:	Regular

No of story: Three storied

L×B×H: 94′× 30′× 41′ 9″

Design Strength: f_c'= 2500psi

f_y = 40000psi

Table 1 - Comparison of existing and as-built drawing

Particular	As-built drawing	Existing data	Remark
Building dimension	94′x 30′x 41′ 9″	94′x 30′x 41′ 9″	OK
Beams	B 9″x 12″ B 9″x 15″ B 12″x 24″	B 10″x 13″ B 10″x 16″ B 13″x 25″ plastering= 1″	OK
Columns	C 12″x12″ C 15″x20″	C 13″x 13″ C 16″x 21″ plastering= 1″	OK
Beams Top & Bottom Tie bar Clear cover	3-16 mm φ 8 mm φ @6″c/c 1.5″	----	Cannot measure
Columns Rebar Tie bar Clear cover	8-20 mm φ (C1) 10-22 mm φ (C2) 8 mm φ @ 6” c/c 1.5″	8-20 mm φ (C1) 10-22 mm φ (C2) ---- 1.5″	OK OK Cannot measure OK
Concrete strength, f_c'	2500 psi	$1800 \leq f_c' \leq 3000$	OK
Steel yield strength, f_y	40000 psi	----	Cannot measure
Wall thickness	4.5″	4.5″	OK

D. Vulnerability and Performance Assessment

1. Vulnerability Assessment of Existing Building

The vulnerability assessment of the existing RC building was checked with the priority index method. This building was classified as vulnerable because the PI value is less than 0.4% in both directions as shown in the following Table 2.

Table 2 - The priority Index value of existing building

No.	∑Floor area (ft^2)	∑Col area (ft^2)	∑M.wall area (N-S) (ft^2)	∑M.wall area (E-W) (ft^2)	PI value		Remark
					N-S	E-W	
1	8460	15	45	66	0.14%	0.16%	Vulnerable

2. Performance Evaluation of the Existing Building

In this study, the performance and structural strength of a public school building in Mandalay (seismic zone 4), was evaluated. The school was designed by adding seismic load. Modelling of this building was done by using linear static and non-linear static (pushover) analysis for performance-based evaluation in SAP2000 v.14 software. Plan and 3D Configurations of Existing RC building are shown in figure 2.

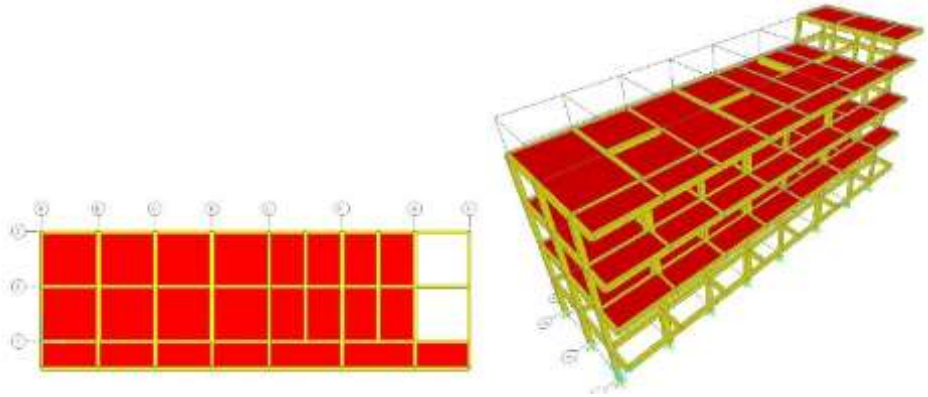

Figure 2 - Plan and 3D Configurations of Existing RC building

2.1. Linear Static Analysis

After the linear static analysis, the structural stability checkings were taken place according to the UBC 97 code. From structural stability check for this building shown in Table 3, story drift in Y-direction earthquake and the P-delta effect in both the X and Y direction earthquakes were not satisfied.

Table 3 - Structural stability check for existing building

Stability Checking	Direction	Results	Limits	Remarks
Story drift	X-direction	2.86	≤ 3.3	satisfied
	Y-direction	3.93	≤ 3.3	Not satisfied
Overturning Moment	X-direction	9.7	≥ 1.5	satisfied
	Y-direction	2.58	≥ 1.5	satisfied
Sliding	X-direction	2.01	≥ 1.5	satisfied
	Y-direction	2.01	≥ 1.5	satisfied
Torsional irregularity	X-direction	1.034	≤ 1.2	satisfied
	Y-direction	1.1	≤ 1.2	satisfied
P-delta Effect	X-direction	0.06	≤ 0.02	Not satisfied
	Y-direction	0.17	≤ 0.02	Not satisfied

2.2. Non-Linear Static (Pushover) Analysis

After linear static analysis, the existing building was analyzed with nonlinear static pushover analysis in X and Y directions and the resulting pushover curves are converted to capacity spectrum curves to investigate the performance level for three types of the earthquake such as SE, DBE, and MCE. Lateral displacement of the building is considered

for both X and Y direction. The displacement control analysis is used and maximum target displacement is kept at 2% of total structure height.

2.3. Checking for the Performance level of Existing Building

Performance points and performance levels of these buildings are determined by FEMA 356 and Capacity-Spectrum Method of ATC 40. In this study, performance objectives are basic safety performance objectives; operational (O) level and immediate occupancy (IO) level under SE, life safety (LS) performance level under DBE and collapse prevention (CP) level under MCE earthquake [4]. The capacity spectrum curves under three earthquake hazard levels in X and Y directions are shown from Figures 3 to 5.

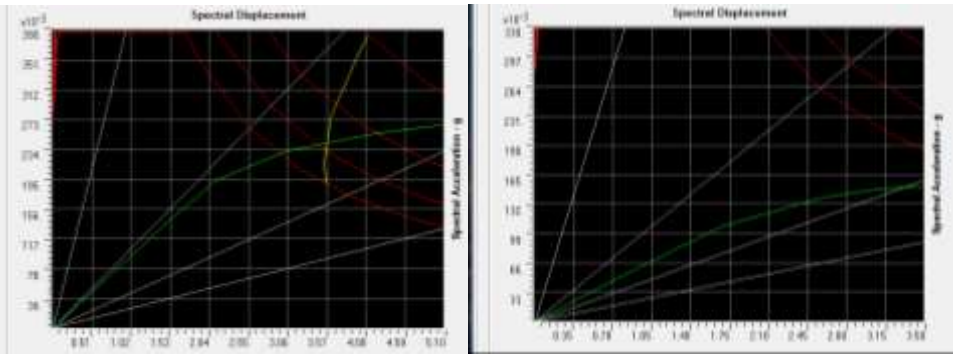

Figure 3 - ATC-40 Capacity Spectrum Curve for SE in X and Y direction

Table 4 - Performance Assessment for Existing Building

Direction	Seismic Ground Motion	Performance Point				Performance Level		Remark
		Base Shear	Displacement	S_a	S_d	Provided level	Allowable level	
Push X	SE	231.222	5.10	0.249	3.908	C	O, IO	Not OK
	DBE	NA	NA	NA	NA	-	LS	Not OK
	MCE	NA	NA	NA	NA	-	CP	Not OK
Push Y	SE	NA	NA	NA	NA	-	O, IO	Not OK
	DBE	NA	NA	NA	NA	-	LS	Not OK
	MCE	NA	NA	NA	NA	-	CP	Not OK

Based on the results from the above table, this building was situated in very weak conditions at Serviceability Earthquake (SE) because these are reached in collapse damage state even very few amounts of lateral displacement. So, it was needed to strengthen. Thus, this building did not meet performance objectives in both X and Y-direction and it needed a seismic improvement.

E. Retrofitting of Existing School Building

Retrofitting is a method to increase the resistant of structure. A seismic retrofit provides existing structures with more resistance to seismic activity due to earthquakes. Retrofitting techniques can be classified as local and global retrofitting. Local retrofitting is the

maintenance of local deficiencies in building like crushing of columns, flexure and shear failure of beams, columns and shear walls, also rebuilding infill masonry. Global retrofitting is the maintenance of global deficiencies in building like the plan and vertical irregularities. The global retrofit includes the addition of shear wall and steel bracing [5].

In this study, there are two retrofitted systems, shear wall (with and without openings) systems which were analysed. The systems were attached to the building frames with three different locations.

1. Retrofitted with shear wall

The introduction of the shear wall into an existing concrete structure is one of the most commonly employed approaches to seismic upgrading. It is an extremely effective method of increasing both building strength and stiffness. A shear wall system is often economical and tends to be readily compatible with most existing concrete structures [5]. The proposed thickness of the shear wall is 10 in with the compressive strength of concrete is 3000 psi.

2. Location of shear wall

The location of the shear wall is a key aspect. The shear wall has an impact on the centre of mass (CoM) and the centre of rigidity (CoR). It is important to minimize the distance between the centre of mass and centre of rigidity to reduce eccentricity and corresponding torsional moments. Six models with three different locations of shear walls with and without openings (Model A, B, C, D, E, F) were defined as shown in the following figure 4 and 5:

Model	CoM (ft)	CoR (ft)	Eccentricity (ft)
Existing	43.483	46.866	3.383
Model A	41.894	41.894	0
Model B	49.48	47.317	2.163
Model C	41.37	40.36	1.01

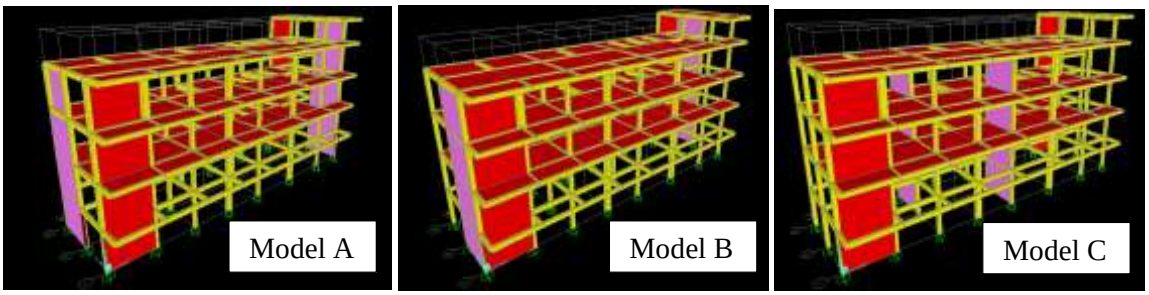

Figure 4 - 3D Modelling of Retrofitted Buildings (without openings)

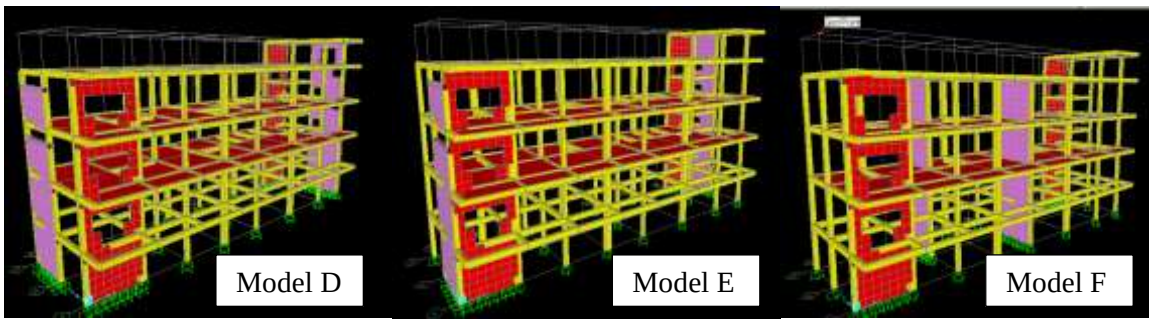

Figure 5 - 3D Modelling of Retrofitted Buildings (with openings)

3. Performance Evaluation of Retrofitted Building

Structural analysis using SAP2000 v.14 software was carried out for all models. From pushover analysis of the six retrofitted building models, model A, C, D, and F had performance points for three earthquake hazard levels (SE, DBE, and MCE) in both X and Y direction earthquakes. Model B and E had performance points for SE and DBE in X and Y direction earthquakes. Figures 6 to 17 showed the deformed shapes and capacity spectrum curves in the X and Y direction earthquakes.

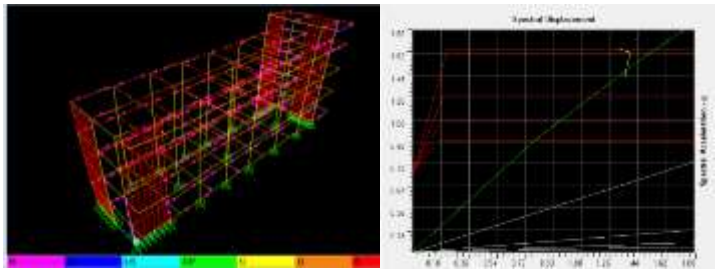

Figure 6 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PX) Model A

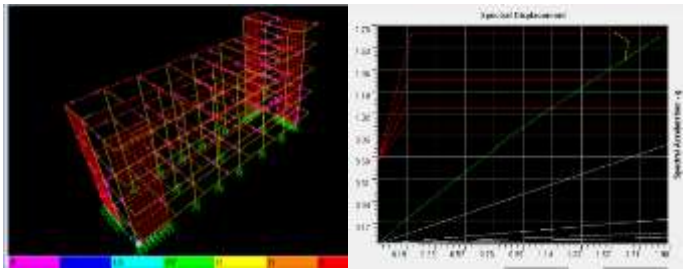

Figure 7 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PY) Model A

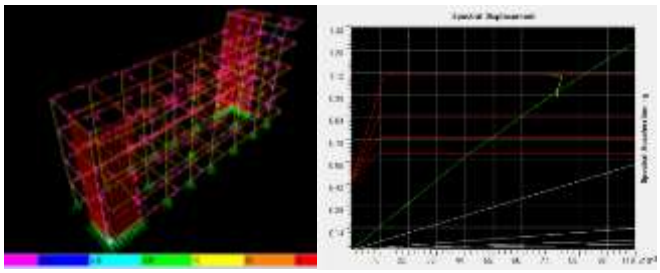

Figure 8 - Deformed Shape and Capacity Spectrum Curve in ***DBE*** (PX) Model B

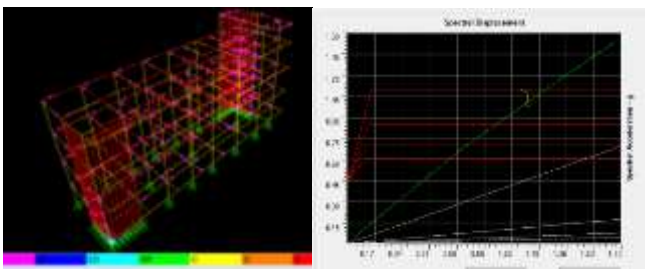

Figure 9 - Deformed Shape and Capacity Spectrum Curve in ***DBE*** (PY) Model B

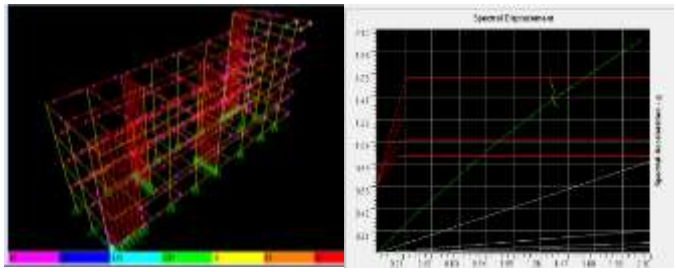

Figure 10 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PX) Model C

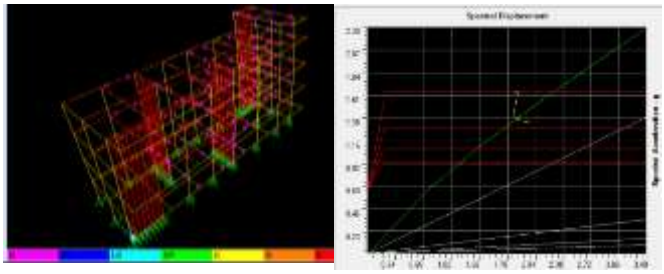

Figure 11 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PY) Model C

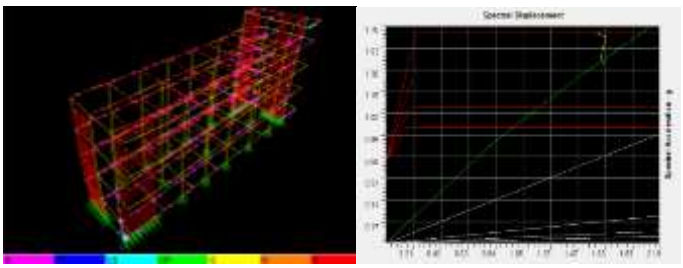

Figure 12 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PX) Model D

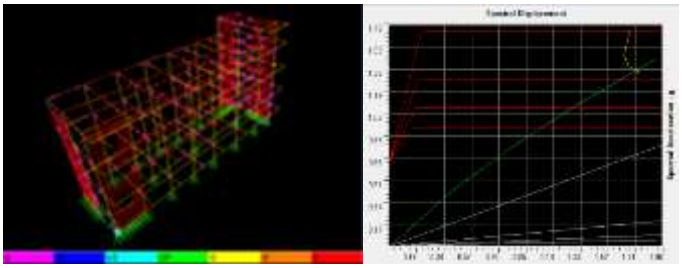

Figure 13 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PY) Model D

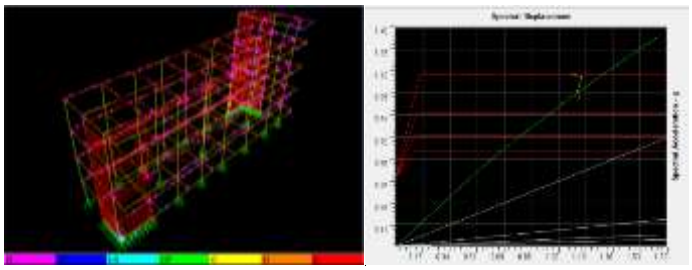

Figure 14 - Deformed Shape and Capacity Spectrum Curve in ***DBE*** (PX) Model E

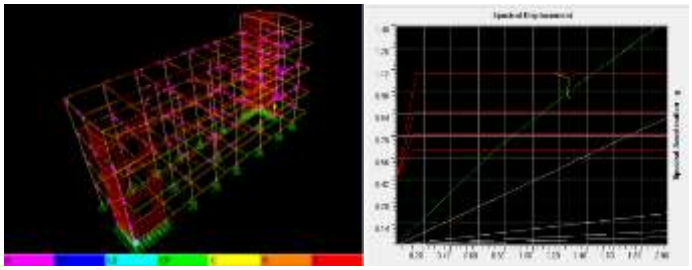

Figure 15 - Deformed Shape and Capacity Spectrum Curve in ***DBE*** (PY) Model E

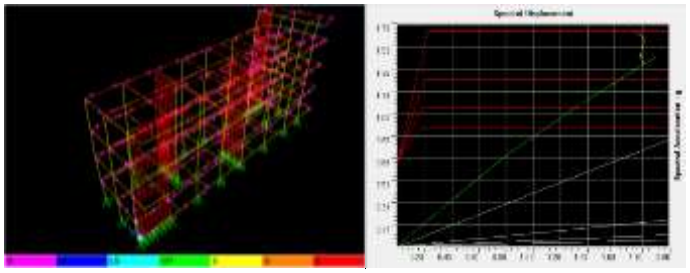

Figure 16 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PX) Model F

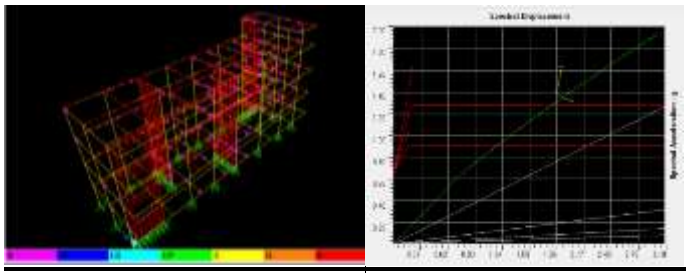

Figure 17 - Deformed Shape and Capacity Spectrum Curve in ***MCE*** (PY) Model F

4. Summary of Analytical Results for Various Reftrofitting Strategies

According to the analysis results, the following findings are discussed for existing and retrofitted structures.

- Checking Deformation Limit
- Finding Stiffness Values
- Checking Ductility Demand Class
- Checking Performance Level

Table 5 - Check Deformation Limit (Push X)

Particular	Existing	Model A	Model B	Model C	Model D	Model E	Model F
Max Interstory drift% at SE%	1.2	0.20	0.30	0.22	0.24	0.35	0.29
Allowable Interstory drift,%	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Check for IO	Not OK	OK	OK	OK	OK	OK	OK
Max interstory drift at DBE,%	NA	0.31	0.50	0.40	0.39	0.57	0.49
Allowable Interstory drift,%	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Check for LS	-	OK	OK	OK	OK	OK	OK
Max interstory drift at MCE,%	NA	0.50	NA	0.60	0.60	NA	0.80
Allowable Interstory drift,%	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Check for CP	-	OK	-	OK	OK	OK	OK

Table 6 - Check Deformation Limit (Push Y)

Model	Existing	Model A	Model B	Model C	Model D	Model E	Model F
Max Interstory drift% at SE%	NA	0.22	0.3	0.28	0.21	0.29	0.3
Allowable Interstory drift,%	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Check for IO	-	OK	OK	OK	OK	OK	OK
Max interstory drift at DBE,%	NA	0.35	0.44	0.44	0.33	0.47	0.48
Allowable Interstory drift,%	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Check for LS	-	OK	OK	OK	OK	OK	OK
Max interstory drift at MCE,%	NA	0.53	NA	0.68	0.53	NA	0.75
Allowable Interstory drift,%	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Check for CP	-	OK	-	OK	OK	-	OK

Table 7 - Stiffness Values Before and After Improvement

Push X			
Model	Base Shear (k)	Displacement (in)	Stiffness
Existing	240.749	6.103	39.447
Model A	1649.896	3.184	518.183
Model B	2004.6	3.764	532.57
Model C	1894.54	5.156	367.44
Model D	1477.661	3.74	395.09
Model E	1800.081	4.32	416.69
Model F	1421.86	4.22	336.93
Push Y			
Model	Base Shear (k)	Displacement (in)	Stiffness
Existing	137.118	4.893	28.023
Model A	1479.257	3.033	487.721
Model B	2206.16	3.364	655.814
Model C	1320.78	6.41	206.050
Model D	1173.327	2.87	408.825
Model E	1872.278	3.62	517.204
Model F	1165.046	5.97	195.150

Table 8 - Ductility Demand Classification

Push X						
Model	Capacity Sa (g)	Demand Sa (g)	Capacity> Demand	DCR Limit		
				Low <2	Moderate	High >2
Existing	0.27	0.4	No	0.67		
Model A	1.042	0.4	Yes			2.605
Model B	0.998	0.4	Yes			2.495
Model C	1.024	0.4	Yes			2.56
Model D	1.69	0.4	Yes			4.225
Model E	1.33	0.4	Yes			3.325
Model F	1.45	0.4	Yes			3.625
Push Y						
Model	Capacity Sa (g)	Demand Sa (g)	Capacity> Demand	DCR Limit		
				Low <2	Moderate	High >2
Existing	0.2	0.4	No	0.5		
Model A	1.025	0.4	Yes			2.526
Model B	1,009	0.4	Yes			2.522
Model C	0.973	0.4	Yes			2.432
Model D	1.43	0.4	Yes			3.575
Model E	1.39	0.4	Yes			3.475
Model F	1.94	0.4	Yes			4.85

Table 9 - Performance Level before and after improvement (Push X)

Model	Seismic Ground Motion	Performance Point				Performance Level		Remark
		Base Shear	Displacement	Sa	Sd	Provided level	Allowable level	
Existing	SE	231.222	5.10	0.249	3.908	C	O, IO	Not OK
	DBE	NA	NA	NA	NA	-	LS	Not OK
	MCE	NA	NA	NA	NA	-	CP	Not OK
Model A	SE	621.448	1.015	0.671	0.57	O	O, IO	OK
	DBE	964.239	1.639	1.042	0.902	IO	LS	OK
	MCE	1350.128	2.492	1.463	1.351	LS	CP	OK
Model B	SE	1065.348	1.589	0.677	0.62	IO	O, IO	OK
	DBE	1551.586	2.653	0.998	0.957	IO	LS	OK
	MCE	NA	NA	NA	NA	-	CP	Not OK
Model C	SE	642.734	1.166	0.659	0.57	O	O, IO	OK
	DBE	995.284	1.913	1.024	0.907	C	LS	Not OK
	MCE	1381.123	3.139	1.443	1.357	C	CP	Not OK
Model D	SE	607.198	1.202	0.684	0.710	O	O, IO	OK
	DBE	898.308	1.960	1.017	1.113	IO	LS	OK
	MCE	1256.862	3.022	1.433	1.657	C	CP	Not OK
Model E	SE	911.972	1.737	0.668	0.736	IO	O, IO	OK
	DBE	1329.369	2.831	0.983	1.14	C	LS	Not OK
	MCE	NA	NA	NA	NA	-	CP	OK
Model F	SE	677.96	1.471	0.676	0.77	O	O, IO	OK
	DBE	979.304	2.455	0.987	1.198	IO	LS	OK
	MCE	1372.25	4.005	1.39	1.817	C	CP	Not OK

Table 10 - Performance Level before and after improvement (Push Y)

Model	Seismic Ground Motion	Performance Point				Performance Level		Remark
		Base Shear	Displacement	Sa	Sd	Provided level	Allowable level	
Existing	SE	NA	NA	NA	NA	-	O, IO	Not OK
	DBE	NA	NA	NA	NA	-	LS	Not OK
	MCE	NA	NA	NA	NA	-	CP	Not OK
Model A	SE	618.615	1.095	0.668	0.683	O	O, IO	OK
	DBE	944.158	1.757	1.025	1.087	O	LS	OK
	MCE	1322.89	2.648	1.447	1.623	O	CP	OK
Model B	SE	1044.54	1.391	0.682	0.714	O	O, IO	OK
	DBE	1543.29	2.215	1.009	1.116	O	LS	OK
	MCE	NA	NA	NA	NA	-	CP	Not OK
Model C	SE	465.647	1.400	0.684	0.774	O	O, IO	OK
	DBE	623.144	2.210	0.973	1.192	O	LS	OK
	MCE	838.346	3.407	0.366	0.083	IO	CP	OK
Model D	SE	552.35	1.058	0.642	0.699	IO	O, IO	OK
	DBE	793.791	1.674	0.941	1.1	IO	LS	OK
	MCE	1115.208	2.659	1.349	1.716	C	CP	Not OK
Model E	SE	894.65	1.46	0.669	0.808	C	O, IO	Not OK
	DBE	1300.73	2.333	0.974	1.259	C	LS	Not OK
	MCE	NA	NA	NA	NA	-	CP	Not OK
Model F	SE	468.514	1.518	0.673	0.813	O	O, IO	OK
	DBE	623.92	2.391	0.952	1.246	O	LS	OK
	MCE	841.867	3.746	1.35	1.922	IO	CP	OK

According to Table 5, the maximum interstory drift in the existing building at SE is 1.2% which is larger than the allowable limit of 1%. In the retrofitted building of model A, B, C, D, E, and F, the interstory drift values were within the allowable limit at SE, DBE and MCE. The stiffness values were also increased after retrofitting as stated in Table 7. The DCR values were changed from low to high class as mentioned in Table 8. Finally, the performance levels of retrofitted models were mostly satisfied with the performance objectives as shown in table 9 and 10.

F. Discussions and Conclusions

In this study, the evaluation of seismic performance and strengthening for RC building was carried out. The aim of this study is to upgrade the seismic safety of the building with appropriate techniques. The existing non- seismic school RC building (20 years ago) was

selected as the case study. The reason why the proposed building was chosen is that this study investigates the performance and vulnerability of non- seismic old buildings.

In this study, the existing building was considered seismic load in addition to gravity loads by using non-linear static (pushover) analysis. After this analysis, the building was found in poor performance at the ground shaking of 0.2g (SE) because its performance level was Collapse damage state. Analysis results revealed that this building did not have sufficient structural capacity to resist even a moderate earthquake. It was also found that the existing building was classified as vulnerable because the vulnerable index value is less than 0.4%. Therefore it can be concluded that further strengthening technique must be needed to resist future earthquake shaking.

In this study, the building was strengthened to resist additional lateral force due to earthquake load with the global retrofit strategy because it is more cost effective if many numbers of components are deficient. Three locations of shear walls (with and without openings) are selected by minimizing the distance between the center of mass (CoM) and center of rigidity (CoR).

After strengthening the proposed building, it was found that there was a better performance compared with the existing situation in three seismic hazard levels. The results of the selected three locations of the shear wall are not much differing from one another. So, it was concluded that the selected three locations of the shear wall could be usable. Among these, the best location is in Model A because there is no eccentricity (i.e the distance between CoM and CoR is zero) and hence torsional moment can be reduced. Besides, Model A has the minimum displacement compared with the other models.

References

[1] Federal Emergency Management Agency (FEMA): *Prestandard and Commentary for the Seismic Rehabilitation of Buildings,* FEMA 356, Federal Emergency Management Agency, Washington, D.C., (2000).

[2] American Concrete Institute (ACI): *Building Code Requirements for Structural Concrete (ACI 318-99)* USA, (1999).

[3] Uniform Building Code (UBC): *Structural Engineering Design Provisions*, 8th Ed., International Conference of Building Officials, Vol 2, (1997).

[4] Applied Technology Council (ATC): *Seismic Evaluation and Retrofit of Concrete Buildings,* Vol 1, ATC-40 Report, Applied Technology Council, Redwood City, California, (1996).

[5] *Handbook on Seismic Retrofit of Buildings:* Central Public Works Department & Indian Building Congress in Association with Indian Institute of Technology- Madras, (April 2007).

Construct Validity and Reliability of the End-of-Course Business Interpretation Test in HUFLIT

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Abstract

During a period of over 6 years, authenticity in business interpretation tests _ relating to a required subject for students of Business English and Translation-Interpretation majors_ has been thoroughly researched in HUFLIT (Ho Chi Minh University of Foreign Languages & Information Technology) to find out the best form. All relevant components of the test, ranging from authenticity, reliability, practicality, validity, to scoring framework, have been examined and experimented. However, the best form of test is delayed to be applied due to facility problems. The following study is partially withdrawn from the hands-on experience of the writer with a hope to produce an analysis on the advantages and disadvantages of the test as the principle proposed by Brown (1994) that was quoted in Nguyen (2018) that the test-takers have a great deal to offer to the test researchers in making judgments about the value of the tests which they take. The paper mainly investigates some relating problems in the Business Interpretation test applied in the academic year of 2018-2019, in HUFLIT's Department of Foreign Languages through data from informal interviews, questionnaires and aims to find out shortcomings and also provide some recommendations that can be helpful in building up the closer-to-the-norm test.

Keywords: interpretation tests, HUFLIT, Translation-Interpretation, authenticity, reliability, construct validity, scoring framework.

1. Introduction

1.1 Background to the study

How to bridge the gap between classroom knowledge and practical skills in the job markets, a requirement from Vietnam's Ministry of Education and Training, has long been a huge problem to all institutions in the country with an aim to improve its unemployment and economic growth.

One of the HUFLIT's missions is to produce graduates, well equipped with not only good ability in their expertise but also real competence in computer and foreign language(s), to help them gain a compatible job in the competitive job market. The renovation in all aspects has been widely worked out in which improving interpreting tests is considered a top priority (Nguyen, 2018).

1.2 Statement of the problem

In the Department of Foreign Languages in Chi Minh University of Foreign Languages and Information Technology (HUFLIT), the most challenging test for students majoring in Business English and Translation-Interpretation, who account for over 70% of the total, might be Business Interpretation final test.

1.2.1 Description

Test takers are individually invited to get into the testing room, confronting 2 examiners, exactly like the face-to-face OPI test. After picking up his/her topic number at random, the testee gets ready to listen to 2 messages, one in English (4 parts) and another in Vietnamese (4 parts); then, tries to interpret them into the other language. The score given by the 2 examiners is basically based on pronunciation, intonation, fluency, and accuracy (proper use of vocabulary and structures).

BM01.QT02/ĐNT-ĐT

HO CHI MINH CITY UNIVERSITY OF FOREIGN LANGUAGES-INFORMATION TECHNOLOGY

DEPARTMENT OF FOREIGN LANGUAGES

FINAL EXAMINATION

Subject: BUSINESS INTERPRETATION

Semester: I

Academic Year: 2018 - 2019

1. SCORING CRITERIA

1. Pronunciation & intonation 20%
2. Fluency 10%
3. Accuracy (proper use of VOC & structures) 70%

TOTAL 100%

Image 1: Rubric Source: HUFLIT

Image 1: Rubric Source: HUFLIT

The test is designed for seniors and the length of each message is approximately 22-25 words. The number of words has been long experimented to identify the teaching methodology, the test takers' memory, and competence that it can be the foundation for the test design. All messages are recorded with appropriate pauses after each (exactly 22

seconds), which has also been tested for years, to provide equality and reliability to all test-takers.

1.2.3 The test problem

An inherent obstacle for the test designers comes from the bias competence between students majoring in Business English and Office Management (S1) and those follow Translation-Interpretation (S2) though all have to theoretically pass a similar regulated number of credits. The latter apparently overwhelms the former in the test owing to their advantageous familiar subject (they earned 8 credits of Translation-Interpretation 2, Translation-Interpretation 3 beforehand) while the former suffer if the test is made for Translation-Interpretation students because they just gained 2 credits of Interpretation 1, a must for everyone.

The number of credits for S1 and S2 qualified candidates is theoretically equivalent. S1 earned 8 credits of Business instead of those in Translation leading to their underdog position in the test.

The problem has been noticed to authorities, but it cannot be solved due to some governing problems.

1.3 Hypothesis

Test takers' real competence can be more accurately assessed and improved if the end-of-course Business Interpretation test tasks in HUFLIT are upgraded to produce the washback effect on teaching and learning (Rivers, 1987).

1.4 Research questions

The research question in this minor study circles around the view of Interpretation lecturers on the Business Interpretation test that all of them experienced:

What are the shortcomings of the Business Interpretation test in HUFLIT and how to solve them?

What are the implications of reliable and valid replacement?

1.5 Significance of the study

The purpose of my study is to identify the drawbacks of the traditional end-of-course Business Interpretation test in HUFLIT for modifications to upgrade the testing system, to meet the proposed learning outcomes in improving students' motivation and real competence

in English, a requirement in the job market, also one of the biggest flaws for Vietnamese job seekers, and to meet the innovation demand from the institution.

1.6 Scope and delimitation of the study

The study can be popularly employed in VN's other institutions including those of still apply various forms of the interpretation test. However, an apparent setback of my proposal is that not all universities are eager for the change that may be costly, time and effort consuming in the status of lacking adequate professionals.

This is just a pilot study with a small number of participants; therefore, its conclusions maybe not true when it is repeated on a larger scale.

2. Literature Review

Bendazzoli, C. & Sandrelli, A. (2011) stated that: " A number of challenges and opportunities…the development of CTS (corpus-based studies on written translation) has been more advanced than the development of CIS (corpus-based interpreting studies) since the very beginning of this scholarly venture (p. 1). They also added: "There is still a considerable gap between the two, both in terms of corpus size and availability and in terms of number of studies and pedagogical applications…due to the greater challenges and obstacles involved in setting up interpreting corpora, i.e. electronic corpora of transcribed speech events, which include an original (source language, hereafter SL) speech and its parallel (target language, hereafter TL) version into one or more foreign languages (p. 1). Regarding corpus data, they argued that most of these studies have been based on 'traditional' or 'manual' analyses, since computational linguistics or corpus linguistics methods have not been employed (p. 2). To prove their arguments, Vourikoski (2004) and Straniero Sergio (2007) were exemplified that the former compiled a corpus of 122 speeches in four languages (English, Finnish, Swedish and German) recorded at the European Parliament and the latter recorded a great number of "interpreter-mediated events on Italian TV in order to study talk show interpreting from a Conversation Analysis perspective" (p. 2). Bendazzoli, C. & Sandrelli, A. (2005: 2) focusing on the research of Corpus-based Interpreting stated: "The speech classification system implemented in the headers of the transcripts and searchable via the EPIC Web interface is a useful source of information for teachers when selecting class materials". They also supported their method by suggesting the use of *Cool Edit* or similar software tools to divide the clip into several portions, to slow it

down without altering the speaker's pitch, to insert pauses in the speech, etc., if a selected clip is considered too hard to interpret for the specific stage (p. 10).

Marco Cencini (2002) analyzed the problems of compiling Interpreting corpus including transcription, which poses important practical and theoretical questions before planning a corpus. Next, "it is not easy to get recordings of real events of interpretation, both because interpreters are often reluctant to be recorded and because speeches at conferences and meetings are often held as confidential material". Some related problems were also mentioned such as Transcription conventions are non-standardized, Data is not interchangeable, Tools of analysis are limited.

3. METHODS OF STUDY AND SOURCES OF DATA

3.1 Research Purpose

The poor performance of the business-majored students in the end-of-course business interpreting test for 6 consecutive years has caused not only backwash effect but also gigantic problems to test designers (Rivers, 1987). Their loss of motivation in learning the challenging subject may be the cause and, simultaneously, the result of either teaching method, governance, or the test itself. The writer conducts the study with the aims to sort out relevant problems to the test to enhance students' learning motivation, to help them gain and upgrade their real competence for fierce competitions in Vietnam's job market.

3.2 Population of the Study

Typically, instructors in the Faculty of Methodology and Translation are implicitly grouped on their age: young (under 45) and old (over 46). The old-aged are experienced instructors, who have been dealt with interpreting tests of all kinds and their contributions in various aspects in teaching and testing have been recognized.

The majority of the respondents fall into the latter, which accounts for 90% of the total. The number is rather humble, 10, not satisfactory for reliable research but it is from the small number the faculty members (22 in all) and this can be seen a pilot study in HUFLIT for further researches.

3.3 Instrument Used

With the humble scope of the article, the only tool in the study is data collection from attitude questionnaires distributed February 8 and collected February 25. The questionnaires

were sent to participants via email to assure the prompt reception and 10 were returned before the deadline for the convenience of data collection.

3.4 Statistical Treatment

Statistical data is treated with SPSS to show the percentage of agreement/disagreement and the individual solutions/proposals/personal views from the participants.

4. PRESENTATION, DATA ANALYSIS, AND DISCUSSION

4.1 Presentation and Data analysis

The survey circles around 2 groups of students, in which S1 typifies for those majoring in Business and Office Management; S2 represents those who follow Translation-Interpretation.

The test now is set up for both, comprising 8 components, 4 English messages and 4 Vietnamese messages. Examinees are supposed to transfer them to the other language with such criteria as pronunciation, intonation, fluency, and accuracy. Each has 22-25 words with a 22-second pause for responses. The number of words and the pause in the test are for seniors and have been thoroughly researched. But in reality, most S1 could not achieve the test requirements despite their equivalent number of credit.

VAR00001

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	5	50.0	50.0	50.0
	B	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Table 1

VAR00002

The respondents were, by chance, evenly divided into 2 groups: 5 females and 5 males (Table 1).

Just one of them was seen as a junior lecturer with his teaching experience falling into from 10-15 years. 9 others were very experienced with their professional duration over 15 years (some got over 30 years).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	B	1	10.0	10.0	10.0
	D	2	20.0	20.0	30.0
	E	7	70.0	70.0	100.0
	Total	10	100.0	100.0	

Table 2

VAR00003

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	B	1	10.0	10.0	10.0
	C	1	10.0	10.0	20.0
	D	1	10.0	10.0	30.0
	E	7	70.0	70.0	100.0
	Total	10	100.0	100.0	

Table 3

VAR00004

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	2	20.0	20.0	20.0
	B	1	10.0	10.0	30.0
	C	2	20.0	20.0	50.0
	D	4	40.0	40.0	90.0
	E	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Table 4

VAR00005

They all have been working with interpreting tests for a long time, enough to be aware of the advantages and disadvantages of each one (Table 2).

The third question is if there is a difference between S1 (Business-majored students and Office Management students) and S2 (Translation-Interpretation students) for S1 do not have 4 credits of Interpretation-Translation 2 and 4 credits of Interpretation-Translation 3. 80% respondents affirmed it (in which 70% completely agreed), just one said no, and the last had no opinion (Table 3).

Question 4 can be seen as the most important one in the survey, relating to if the test should be detached from each group of students. 30% of participants said no; 2 had no choice; and 5 agreed. No consensus for the problem; however, the pro outweighed the con (Table 4).

This is a technically detailed question about the construct validity of the test. The number of words in a test component represents for the level difficulty, which is proportional to the students' level. As the test

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	B	3	30.0	30.0	30.0
	E	7	70.0	70.0	100.0
	Total	10	100.0	100.0	

Table 5

VAR00006

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	1	10.0	10.0	10.0
	C	1	10.0	10.0	20.0
	D	6	60.0	60.0	80.0
	E	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Table 6

VAR00007

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	1	10.0	10.0	10.0
	B	1	10.0	10.0	20.0
	D	7	70.0	70.0	90.0
	E	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Table 7

VAR00008

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	1	10.0	10.0	10.0

regulated, 22-25 words for a component is valid enough to test a senior of S2. The result shows 30% of the population disagreed while 70% agreed (Table 5).

As described, there is a 22-second pause after each part for the S2 test taker's response. 10% of the sample disagreed, requesting longer time; 10% had no idea; 80% accepted the current duration (Table 6).

Similar to Q5, Q7 is about the validity of the test difficulty for S1, asking whether less than 20% number of words for S1 is practically acceptable. 20% showed disagreement. 80% said yes (Table 7).

Similar to Q6, Q8 is about the validity of the test difficulty for S1 asking if the same pause for fewer testing words is practically acceptable. 20% answered no. 30% had no opinion. 50% agreed (Table 8).

	B	1	10.0	10.0	20.0
	C	3	30.0	30.0	50.0
	D	4	40.0	40.0	90.0
	E	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Table 8

VAR00009

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	1	10.0	10.0	10.0
	C	3	30.0	30.0	40.0
	D	6	60.0	60.0	100.0
	Total	10	100.0	100.0	

Table 9

VAR00010

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	1	10.0	10.0	10.0
	C	4	40.0	40.0	50.0
	D	5	50.0	50.0	100.0
	Total	10	100.0	100.0	

Table 10

Q9 is that the current test difficulty should be lowered to facilitate S1 if the test cannot be detached. 30% had no idea; 10% showed disagreement; while 60% said yes (Table 9).

Q10 focuses on the testing expertise, surveying if detailed business topics should be slighter when the test is refused to be detached. 10% said no; 40% had no opinion; 50% agreed (Table 10).

4.2 DISCUSSION

The following discussion is to elicit the differences of S1 and S2 in the test that its shortcomings can be identified as posed by the research question.

4.2.1 **Test Description**

4.2.1.1 Procedures

Test takers are invited individually into the testing room according to the ready-made list issued by the management.

- Due to HUFLIT's humble facilities, the recording test in the lab proposed by Nguyen (2013) cannot be applied and the traditional two-scorer form is employed instead.

4.2.1.2 The test

- As discussed in 4.1, test takers have to provide their work in the pause duration of 22 seconds after listening to the message.

- After each message, their performance is independently rated by two examiners, based on their pronunciation, intonation, fluency, and accuracy. Each message has the highest score of 1.25; the total of 8 messages (4 in English, 4 in Vietnamese) is 10. The rationale for 8 messages instead of 10 as they are in interpretation test 1 and 2 is from its practicality: higher level requires a longer time.

- Notes (vocabulary) are provided in case candidates get problems with new terms.

- Examinees' performance used to be recorded in case of complaints, but it is no more applied from no complaints and its archival complicacy.

4.2.2 **Test participants**

All test participants are viewed qualified candidates when they finish a designed number of credits and come from various majors: Office Management, Business English, and Interpretation-Translation. The first two (S1), usually accounting for 70% of the total, do not have 8 credits specifically designed for the last (S2) such as Translation 2, Translation 3, Interpretation2, Interpretation 3, with 2 credits for each and they earn them in their major subjects. This is deemed the culprit for S1 poor performance in the test though its difficulty level is set up appropriately and all topics related are set up in business according to the specific goals of the subject.

4.2.2.1 **Knowledge**

As mentioned in 4.2.2, to assure the validity and reliability of the test, all relevant topics are of intermediate business. Through informal interviews with randomly chosen test takers after the test, the topics are not the problem at all but the vocabulary is even though keynotes were provided.

4.2.2.2 **Skill**

According to our hands-on observation, not only poor in the knowledge of vocabulary, but S2 also shows negative expression in interpretive skills, ie. simultaneity, intonation, pronunciation, and accuracy.

It has been deemed for their passive learning in the business subject or the testing system. But in order to achieve the accurate and objective result, further researches are needed.

To solve the problem, many opinions have been raised, one of which is that the test should be detached into two separate ones for S1 and S2. However, the management declined to accept it for various reasons relevant to governance. Other opinions focus on how to improve the test that can be appropriate to both S1 and S2, and secure the test norms. They include difficulty between the current test and that of the new test for S1, if any.

Most of the participants affirmed that it should be detached to meet reliability since S1 lacks 8 key skill credits; so, they cannot fulfill S2 interpreting test requirements though they get more credits on major knowledge.

Without authority acceptance for a change, due to governing problems, the Faculty of Methodology-Translation has no other choice but to reduce the difficulty for over 70% of testees, a forced move affecting reliability. It majorly relates to the number of words in a message and the duration for interpreting. 60% respondents agreed to cushion the test by reducing the word number, while just 10% disagreed. 30% showed no opinion. Most thought that topics should remain.

V. Conclusion and Recommendations

5.1 Summary of findings

Most respondents affirmed there is a difference between S1 (Business-majored students and Office Management students) and S2 (Translation-Interpretation students) for S1 do not have 4 credits of Interpretation-Translation 2 and 4 credits of Interpretation-Translation 3.

Most agreed that the test should be detached.

Most agreed on the construct validity of the test. The number of words in a test component represents the level difficulty, which is proportional to the students' level.

Most accepted the current 22-second pause after each part for the S2 test taker's response.

Most accepted about the validity of the test difficulty for S1, less than 20% number of words for S1 is practically acceptable.

Half of the participants agreed about the validity of the test difficulty for S1, the same pause for fewer testing words is practically acceptable.

Most said the current test difficulty should be lowered to facilitate S1 if the test cannot be detached.

Half of the population said that detailed business topics should be slighter when the test is refused to be separated.

5.2 Conclusion

The Business interpretation tests in HUFLIT, though have been studied and scientifically adjusted for over 10 years, are still embedded with some problems in terms of validity and reliability, especially when they are applied to both S1 and S2 at the same time.

Because the governing problems could not be solved; reliability of the test is technically dwindled for its lower difficulty, though some think that beneficial agents would be S2. That its construct validity should also be updated is another setback when some show their concerns that the test cannot help measure what has been taught; henceforth, it may lead to negative backwash in teaching and learning (Rivers, 1987).

5.3 Recommendations

5.3.1 For test designers

My proposal is that the test designers should study S1 competence further for the reliable data before working out with cutting down testing words in each message. S1 memory and treatment capacity, interpreting skills, are also need to be researched. Another crucial question in the case is the reliability of the test after being updated. Do the tests really measure what the examinees have been taught? In what aspects?

In sum, to gain better evaluation on the task, there should be a more diligent investigation and some quantitative and qualitative researches for a scientific comparison among variations and proper validity and reliability criteria.

5.3.2 For students

Students should make efforts to practice not only in the classrooms but also outside whenever and wherever they have a chance. Free English speaking clubs' activities and group work can be the perfect choice for both learning and entertainment. The job market in Vietnam is now increasingly hard. Language proficiency improvement, in general, and interpreting skills, in particular, is a certain advantage.

5.3.3 For researchers

It is just a pilot study with a humble number of respondents, unreliable for real research. There is a need for further research on whether or not Vietnamese learners, especially S1, really gain their learning outcomes as posed by the course outline before updating the new test and, in any case, trying to get closer to the international test criteria should be prior.

5.3.4 For instructors

Business interpreting is a hard task for S1 when the same teaching materials are employed for both S1 and S2. However, helping learners to get the learning outcomes set up by the course outline should be considered a core, from which various and attractive teaching techniques applied.

5.4 Limitations

The above-mentioned limitations of a small sample, the study may be seen rather distinctive case study in HUFLIT, not popularly to be applied in other English classrooms. It is also difficult to persuade busy test designers to make an update if they are unwilling to have a change, especially in testing, a controversial section in Vietnam's modern universities. Findings in the pilot study may not gain the same results when being applied to a bigger population, with different teachers, or in different institutions.

REFERENCES

Bendazzoli, C. & Sandrelli, A. (2005-2007). "An approach to corpus-based interpreting studies: developing EPIC (European Parliament Interpreting Corpus)", in Nauert S. (ed.) (2005-2007), *Proceedings of the Marie Curie Euroconferences MuTra: Challenges of Multidimensional Translation - Saarbrücken 2-6 May 2005*. <http://www.euroconferences.info/proceedings/2005_Proceedings/2005_proceedings.html >. Page consulted on date: 23.10.09.

Bendazzoli, C., Russo, M. & Sandrelli, A. (2006) "Disfluencies in simultaneous interpreting: a corpus-based analysis", to appear in Kruger, A. & K, Walmach (eds.), *Corpus-based Translation Studies: Research and Applications* (provisional title; St. Jerome Publishing). Paper delivered at Second IATIS Conference, Intervention in Translation, Interpreting and Intercultural Encounters, University of the Western Cape, South Africa.

Bendazzoli, C. & Sandrelli, A. (2011) "Corpus-based Interpreting Studies: Early Work and Future Prospects", Revista Tradumatica –Traduccio i Technologies de la Informacio i la Communicacio 07: l'aplicació del Corpus Linguistics a la Traduccio: ISSN: 1578-7559.

Cencini, Marco (2002): 'On the Importance of an Encoding Standard for Corpus-Based Interpreting Studies. Extending the TEI Scheme', *inTRAlinea Special Issue: CULT2K*, available online at http://www.intralinea.it/specials/eng_open1.php?id=P107.

Nguyen D.C. (2013) *Interpretation Test in English in the Selected Universities in Ho Chi Minh City*, Dissertation, Tarlac State University, The Philippines.

Rivers, W. (1987) *Interactive Language Teaching*, Cambridge: Cambridge University Press.

Appeals to Anthropomorphism at Tourist Sites Featuring Animals: A Case Study of Phuket, Thailand

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Abstract

Animal tourism is an important part of Thailand's economy. However, changing attitudes toward how animals should be treated are putting pressure on Thailand's tourism industry to transform its use and treatment of animals. One factor that influences our view of animals is anthropomorphism. Anthropomorphism is the assignment of human qualities to animals. A related concept is zoomorphism—the assignment of animal qualities to humans. A recent addition to these concepts is the ideas of mammolomorphism and primatomorphism. The argument is that it is misguided to argue that traits belong to either animals or humans, but that they are the shared traits of mammals and/or primates. Regardless of one's views, the ability of all four "morphisms" to influence our feelings toward animals can be explained by Kenneth Burke's concept of identification. In order to better understand the role of these rhetorical strategies in animal tourism, a case study of tourist sites featuring animals was conducted in Phuket, Thailand. Sites that featured birds, crocodiles, dolphins, elephants, fish, monkeys, and snakes were part of the case study. The case study revealed that anthropomorphism is a common rhetorical strategy at tourist sites that feature animals and that the use of anthropomorphism creates an identification with animals that leads to demands for increased animal rights.

Introduction

Tourism is a vital part of Thailand's economy and animal tourism is a key component in the tourism industry. People travel to Thailand to ride elephants, take pictures with tigers, and pet king cobras. However, recent trends show that tourists' views toward the appropriate treatment of animals are changing. Wayne Pacelle of the Humane Society believes that "'We're really seeing a rising tide of consciousness when it comes to the treatment of animals'" (Allen, May 21, 2017). For example, the Ringling Brothers and Barnum and Bailey Circus announced that they would no longer use elephants in their performances. With no elephants, business declined and the circus was forced to close in 2017.

Animal tourism in Thailand is experiencing similar trends. Chinese tourists are developing a preference for wildlife-friendly tours and, as a result, elephant rides by Chinese

tourists have declined by 13 percent and elephant show watching has dropped by 26 percent since 2016 (TTR Weekly, 2019).

Since animal tourism is important to Thailand's economy and since tourists' views of animal tourism are becoming more animal friendly, it is essential to examine the variety of factors that may be influencing tourists' views of animals. One such factor is the way one talks about animals. The goal of this particular research is to examine the use of anthropomorphism (and related concepts) when animals are presented and talked about at animal tourist sites.

Review of Literature

Anthropomorphism is the attribution of human characteristics to animals and other non-human entities. Scientists have engaged in a long running debate over whether or not it is appropriate to use anthropomorphism when describing animal behavior. However, "Among lay people, anthropomorphism is not only prevalent, it is nearly the exclusive method for describing, explaining, and predicting animal behavior . . ." (Horowitz and Beck, 2007, p. 24). Eddy, Gallup, and Povinelli (1993, pp. 90-91) explain that anthropomorphism is a way of attributing motives to the behavior of animals that is consistent with the features of attribution theory. They further explain that people are more likely to posit similarities between themselves and animals when, one, the animal is physically similar to them (such as humans and chimpanzees) and, two, they have an attachment bond to the animal (such as a pet dog or cat) (p. 96).

One problem with anthropomorphism is that it can lead to an anthropocentrism that ". . . claims moral standing to human beings, and only human beings" (Karlsson, 2012, p. 709). Keeley (2004, p. 535) suggests that anthropomorphism may become a problem when it is used to make humans the center of all things and submits that shared traits may be more appropriately ". . . thought of as 'primatomorphic' (a trait shared by and perhaps largely unique to primates) or 'mammolomorpic' (a trait shared by and perhaps largely unique to mammals)." The argument is that it is misguided to argue that traits belong to either animals or humans, but that they are the shared traits of mammals and/or primates. Another related concept that should be included with these terms is zoomorphism—the attribution of animal characteristics to humans.

Regardless of one's views, the ability of these "morphisms" to influence our feelings toward animals can be explained by Kenneth Burke's concept of identification. Burke (1969, p. 20) notes that "A is not identical with his (sic) colleague, B. but insofar as their interests

are joined, A is *identified* with B. Or he may *identify himself* with B even when their interests are not joined, if he assumes that they are, or is persuaded to believe so." Burke (1969, p. 55) continues: "You persuade a man (sic) only insofar as you can talk his language by speech, gesture, tonality, order, image, attitude, idea, *identifying* your ways with his ways." In other words, anthropomorphism (and its related "isms") is the use of language and images that allow humans to identify with animals—to see them as the same. And, if animals are seen as the same as humans, the logical conclusion is that they should be treated the same.

The use of anthropomorphism has been shown to increase empathy toward robots (Riek, Rabinowitch, Chakrabarti, and Robinson, 2009) and increase the likelihood of needy dogs being helped (Butterfield, Hill, and Lord, 2012). Chan (2012) argues that anthropomorphism can serve as a useful tool to argue for animal conservation.

However, some scientists warn that anthropomorphism can become dangerous to animals when we treat animals like humans when they should be treated like the species they are. Serpell (2002, pp. 446-447) provides the example of the bulldog. Bulldogs were bred to flatten their faces so that they looked more like humans. However, this breeding has created a nasal and respiratory system that makes breathing difficult and labored. Rose (2007, p. 152) warns: ". . . policy decisions driven by anthropomorphic mentalistic views of fishes are likely to promote misunderstanding and be detrimental to fishes and humans alike."

Research Questions

RQ1: Do animal tourism sites use anthropomorphism and zoomorphism as common rhetorical strategies?

RQ2: Do tourists, without prompting, use anthropomorphism and zoomorphism as common rhetorical strategies?

Methodology

A case study was used to investigate the possible use of anthropomorphism and zoomorphism as rhetorical strategies at animal tourism sites in Phuket, Thailand. The tourist attractions selected were Phuket Bird Park, Phuket Zoo, Dolphin's Bay, Elephant Nature Park, Tiger Kingdom, Phuket Cobra Show and Snake Farm, Phuket Crocodile World, and Phuket Aquarium. These sites were selected in order to study the use of anthropomorphism involving a wide variety of animals. These attractions belong to what Cohen (2009) calls fully-contrived settings—"Fully-contrived animal settings in Thailand include a variety of establishments, especially zoos, theme parks and elephant camps, but also much smaller

venues, in which animal shows and performances are presented" (p. 112). Cohen (2009, p. 115) notes that Thailand is moving toward fully-contrived animal settings and away from natural settings in its interactions with tourists. A wide variety of observations were made—including observations of the words used to describe animals, the images used to portray animals, and the behaviors the animals were trained to do. Each site was observed twice. The method used was close to participant-observation—however, the selection and analysis of data was strongly guided by rhetorical theory and criticism. This investigation was part of a larger project which examined the use of narratives at animal tourism sites in Phuket (Hobbs and Na Pattalung, 2018).

Results

Anthropomorphism and zoomorphism are common rhetorical strategies as they were present at all of the observed animal attractions except for the Phuket Cobra Show. That is, with only one exception, the attractions told a story where animals are like people and people are like animals. This is a method of achieving identification between people and animals. Examples of anthropomorphism include animal shows where the animals engaged in human activities. Macaws rode bicycles at the Phuket Bird Park (see picture 1), seals and dolphins danced at Dolphin's Bay, and elephants played soccer (see picture 2) while monkeys did arithmetic at the Phuket zoo.

Picture 1: Bicycle Riding Macaws at the Phuket Bird Park

Picture 2: An Elephant Kicking a Soccer Ball at the Phuket Zoo

Anthropomorphism is also presented in pictures and statues of animals in human dress and poses. For instance, Crocodiles are pictured in formal wear at Phuket Crocodile World (see picture 3) and the Phuket Zoo features a tiger in overalls hunting a rabbit (see picture 4). Anthropomorphism also occurs in the souvenirs sold in gift shops as the gift shop at Tiger Kingdom sells a toy tiger wearing a hoodie.

Additionally, the scripts presented at various attractions include references to anthropomorphism. Dolphin's Bay explains how dolphins feel the same emotions as humans—including happiness, sadness, and love. The Phuket Elephant Sanctuary explains how elephants pass down memories from one generation to the next. This makes elephants storytellers which is, perhaps, the most human of all activities.

Picture 3: A Formal Crocodile at Phuket Crocodile World

Picture 4: A Tiger Hunting A Rabbit at the Phuket Zoo

Zoomorphism is found in the mermaids at the Phuket Aquarium, the opportunity to take a picture with bird wings at the Phuket Bird Park (see picture 5), the ability to buy and wear animal skins at Crocodile World's gift shop, when Tiger Kingdom sells bags that tell one to keep calm and roar (see picture 6), and when the Elephant Nature Park informs their guests that they will eat like elephants at lunch—vegetarian.

Picture 5: A Chance to Become a Bird at the Phuket Bird Park

Picture 6: Keep Calm and Roar

While the animal tourism venues used anthropomorphism as a common strategy, was there any evidence of its use by the tourists themselves? Without prompting, two cases were observed. One example was at Dolphin's Bay where a tourist was heard saying that she liked the dolphins because they were acting like people. The second example was at the Elephant Nature Park where a tourist remarked, after hearing of the working conditions of elephants at logging camps and elephant treks, that it was just like slavery.

Discussion and Conclusions

Our research provides clear evidence of the use of anthropomorphism at animal tourism sites in Phuket by both the sites themselves and the tourists who visit those sites. The use of these rhetorical strategies leads to identification—seeing the animals as the same as us. This could explain why tourists are wanting to see animals treated more ethically. How far will these demands go? It depends on how much we identify with animals and in what ways. Oriel (2014, p. 51) explains: "If certain 'self-aware' species such as chimpanzees, dolphins, and elephants gain rights of personhood, then . . . many species would be released from and protected from captivity, enslavement in entertainment venues, and from research labs."

One animal tourism site did not use anthropomorphism—the Phuket Cobra Show. This is consistent with Eddy's, Gallup's, and Povinelli's (1993, p. 96) observation that people are more likely to posit similarities between themselves and animals when, one, the animal is physically similar to them and, two, they have an attachment bond to the animal. Snakes are far from meeting these two criteria. In addition, the Phuket Cobra Show seemed to work at exploiting the danger of the snakes—anthropomorphism would have worked against this feeling of danger. Animal tourism sites should carefully plan their strategies for using anthropomorphism and zoomorphism as these rhetorical strategies bring tourists closer to the animals, but, at the same time, creates demands for increased ethical treatment of these animals. Rewards do not come without associated costs. When animal tourism sites develop their strategies for using anthropomorphism, they need to be careful to tell a consistent story in order to be believed (Fisher, 1987, p. 5). An interesting example of a contradiction in one's story took place at Phuket Crocodile World. While presenting crocodiles as human (see picture 3), they also sold crocodile meat for consumption (see picture 7). If one becomes one with a crocodile and then eats that crocodile, does he or she become a cannibal?

Picture 7: Crocodile Meat for Sale

Additionally, anthropomorphism strategies should make use of the scientific knowledge we have of animals to make sure that people are not misled into views of animals that could lead to the harming of these animals. True differences that impact the mental and physical health of animals should be respected.

References

Allen, G. (2017, May 21). Ringling Bros. curtain call is latest victory for animal welfare activists. *NPR*. Retrieved from: https://www.npr.org/2017/05/21/528982484/ringling-bros-curtain-call-is-latest-victory-for-animal-welfare-activists/.

Burke, K. (1969). *A Rhetoric of Motives*. Berkeley: University of California Press.

Butterfield, M.E., Hill, S.E., and Lord, C.G. (2012). Mangy mutt or furry friend? Anthropomorphism promotes animal welfare. *Journal of Experimental Social Psychology*. doi:10.1016/j.jesp.2012.02.010.

Cohen, E. (2009). The wild and the humanized: Animals in Thai tourism. *Anatolia: An International Journal of Tourism and Hospitality Research*. 20(1): 100-118.

Eddy, T.J., Gallup, G.G., and Povinelli, D. J. (1993). Attribution of cognitive states to animals: Anthropomorphism in Comparative perspective. *Journal of Social Issues*. 49(1):87-101.

Fisher, W. (1987). *Human Communication as Narration: Toward a Philosophy of Reason, Value, and Action*. Columbia: University of South Carolina Press.

Hobbs, J.D., and Na Pattalung, P. (2018). Elephants and tigers and dolphins! Oh my! A case study of the narratives presented at animal tourist attractions in Phuket, Thailand. ASEAN Animal Law Conference, Chiang Mai, Thailand.

Horowitz, A.C., and Bekoff, M. (2007). Naturalizing anthropomorphism: Behavioral prompts to our humanizing of animals. *Antrozoos*. 20(1): 23-35.

Karlsson, F. (2012). Critical anthropomorphism and animal ethics. *Journal of Agricultural and Environmental Ethics*. 25: 707-720.

Keeley, B.L. (2004). Anthropomorphism, primatomorphism, mammalomorphism: Understanding cross-species comparisons. *Biology and Philosophy*. 19: 521-540.

Oriel, E. (2014). Whom would animals designate as "persons"? On avoiding anthropocentrism and including others. *Journal of Evolution and Technology*. 24(3): 44-59.

Riek, L.D., Rabinowitch, T-C., Chakrabarti, B., and Robinson, P. (2009). How anthropomorphism affects empathy toward robots. *Proceedings of the 4th ACM/IEEE International Conference on Human Robot Interaction*. San Diego, California.

Rose, J.D. (2007). Anthropomorphism and 'mental welfare' of fishes. *Diseases of Aquatic Organisms*. 75: 139-154.

Serpell, J.A. (2002). Anthropomorphism and anthropomorphic selection—Beyond the "cute response." *Society and Animals*, 10(4):437-454.

TTR Weekly. (2019, August 16). Elephant rides on the wane. *TTR Weekly*. Retrieved from https://www.ttrweekly.com/site/2019/08/elwphant-rides-on-the-wane/.

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The Effect of U.S. Presidential Elections on Stock Market Liquidity in Emerging Economies

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Abstract

This paper examines the effect of uncertainties that arises from U.S. presidential elections on emerging stock market liquidity over five period of elections from 2000 to 2016. The U.S. presidential elections created two uncertainties, which are political uncertainty and election uncertainty, before the election day. It is argued that the political uncertainty affects the emerging stock market liquidity through the change in future macroeconomic fundamentals while the election uncertainty is an uncertainty about the eventual winner of the election that affects the emerging stock market liquidity through market sentiment. Using monthly Iowa Electronic Markets data, this paper finds the evidence that the political uncertainty has a statistically impact on emerging stock market liquidity while this paper does not find the evidence for the impact of the election uncertainty. The effect of the political uncertainty still has statistically impact on the emerging stock market liquidity even I control the potential effect of macroeconomic variable to the political uncertainty. The result also implies the importance of seperating the two uncertainties during election period into the political uncertainty and the election uncertainty.

Keywords: Stock market liquidity, Political risk, Risk management

Chapter 1 Introduction

This paper investigates whether political risk from big economy affects stock market liquidity in small economy or not. This paper uses presidential election period to represent a period of political risk and use future presidential market, which is Iowa electronic market, to capture degree of the political risk. Although there many events that can induce the political risk, most of them is hardly to know when those events will occur. The presidential election is one of the events that induces the political risk and we also know when this event will occur as a presidential election must be announced and occurs every four years. In this paper, we have to choose a country that originates the political risk. The country should be the one with big economy as its' election outcome can determined the future world economic which will affect to other economic performance as well. Thus, this paper decided that the country should be United States of America. In U.S. elections, there two majors' political parties which are Republican and Democratic. Although they aim to boost U.S. economy, they have different in policy to reach their target. Thus, the

U.S. presidential elections can cause the uncertainties as they creates uncertain about the future economic policies between political parties.

Chapter 2 Literature review

2.1 Policies of Political Parties

In U.S., there are two major political parties which are Republican party and Democratic party. Although both parties' policies aim to boost U.S. economic performance, they have totally different in economic policies to reach their target. Past literatures have been confirmed on these differences. Hibbs (1977) affirmed that macroeconomic performance were not only from the result of the economy itself but the macroeconomic performance were also depending on what the policy of government has been implemented. The long-term and short-term policy give a different result of growth between long-term and short-term economic growth. As we know the policy between Democrats and Republicans is difference. For example of the evidence in real economy, Alesina and Sachs (1986) found that the first two year annual gross national product (GNP) when Democratic is incumbent government (5%) is higher than when Republican is incumbent government (1.2%). They studied on the annual gross national product (GNP) from 1948 to 1984.

Moreover, Hibbs (1986) has been argued that Democratic party is likely to implement expansionary policies than when Republican is the incumbent government. However, he argued that Republican party is better in control the inflation rate than Democratic party. For instance, Chappell and Keech (1986) presented that average inflation rate in time of Democratic as incumbent government is 2.5% higher than when Republican is incumbent government. The inflation rate affects the liquidity in the stock market as well. This shows that there is the difference in stock market liquidity if the president is change to another political party. The difference in economic policies would create uncertainty during the election about the future macroeconomic policy and may affects to the stock market performance as there might be potential that the policy will change from the elections.

2.2 U.S. Presidential Election and Stock Markets

Over the past decade, the well-known literatures have been studied on the influence of U.S. elections on U.S. stock market performance and found the significance relationship between them. Prior literatures document that there is an impact of U.S. election on U.S. stock market volatility. Li and Born (2006) study the U.S. presidential elections and found that stock market volatility become higher before elections when the election uncertainty is high or when neither of the candidates has a dominant lead in the presidential election polls. Goodell and Vähämaa (2013) found that stock market volatility of the S&P

500 index increases with the increase in the probability of the eventual winner which they use it as a proxy of political uncertainty.

The well-known literatures have been explored the influence of U.S. presidential elections on U.S. stock market and documented that the uncertainty caused by the elections is reflected in stock prices. For instance, Li and Born (2006) documented that U.S. stock prices become higher before U.S. presidential election day when there is no party has a dominant lead in the election. Goodell and Bodey (2012) found that when the election uncertainty become lower, it will lead to a decrease in stock market valuations as the decreasing election uncertainty which cause a price to earnings ratios of each stock become lower. While all these papers showed their finding that change in stock market volatility occur through the transmission of a changes in market sentiment, The transmission may from the change in the fundamental. For example, Julio and Yook (2012) found the evidence that when there is a higher uncertainty from U.S. elections, U.S. firms will reduce and delay their spending. Thus, investors may perceive in this change of firms' behavior and react it in the stock market and caused the stock price become lower. However, there are few papers that interested in the impact of U.S. presidential election on other countries' stock market as well. Nippani and Arize (2005) studied on the 2000 election where the result is delay causing investors to wonder about the delayed result. They found that the delayed result give a negative impact to stock market return to both U.S. stock market and other stock markets which are Mexican and Canadian stock market.

2.3 Measurement of Uncertainties

Past literatures that studied on uncertainties arising from presidential elections usually use the probability winning of each party to capture the uncertainty. There are two major ways to capture this probabilities which are polls and future presidential markets, which the future contract payoff in this future presidential markets depends on the election result. For instance, if investor A buy a democratic contract and the election outcome is that Democratic party win the election, investor A will receive $1 if not investor A will get zero payoff. For instance, Li and Born (2006) used Gallup Poll to capture the election uncertainty while Goodell and Bodey (2012) use future presidential market (IOWA Electronic Market) to capture political uncertainty and election uncertainty. However, there might be some question. Which one is the best approximated for the probability winning of each parties in the next coming election? The general difference is that, first, polls usually use the telephone to survey the random sample while future market only has the sample that is already interested in the U.S. election. Second, while probabilities result from polls will reflect public opinion, probabilities result from future markets will reflect all available information as participants in this future presidential market will use all available information to estimate an appropriate probability winning in each party and use that probability to speculate in the market because they need to use a real money to invest in the future presidential market.

However, there are many researchers studied on the performance for these two measurements of probability between polls and future market. They found that the future market might be better than polls. Leigh and Wolfers (2006) confirmed that the president future markets is reliable. While Berg et al. (2008) found that the probability winning of the political party resulting from president future markets is much more closer to the actual winner than the probability that calculated from the polls. He explains that both measures, the president future markets and the polls, intend to answer the different question. The president future markets usually forecast the probability of electoral college vote while the polls forecast the popular vote of each party in the coming election as the samples of polls were ask to registered and vote the political party which they want to be the president or win the election. However, there are some election year that the political party who win the election is won by having the highest number of electoral college vote not from popular vote. Thus, it is the electoral college vote not from the popular vote that determined who is the winning of the election. For instance, Obama won the 2012 U.S. presidential election. His electoral college votes in 2012 election is 61.7% while the popular vote is only 51.1%. This is why Berg et al. (2008) found that the probability from president future markets is better than polls.

Chapter 3 Hypothesis

In the literatures of determinant of liquidity, there are many factors that affect stock market liquidity. The uncertainties of U.S. presidential election is one of them. The uncertainties would affect investors perspective which influence stock market valuation and, thus, their investment decision. Ederington and Lee (1993) found that an unanticipated information cause market volatility become higher. Although the probability winning in each party from Iowa Electronic market is an anticipated information, the direction of change in this probability is the unanticipated information. Chung and Chuwonganant (2014) found that stock market volatility is a great determinant of liquidity. Thus, we could expect the change in liquidity when there is uncertainty arrival.

3.1 Political Uncertainty Hypothesis

The uncertainty on whether the incumbent government will be back in the office represent the risk of macroeconomic policy change. This is called “political uncertainty”. The political uncertainty hypothesis is about the information which involves with the probability winning of the political party. This probability can be an information that represents the future macroeconomic policy which affected to the fundamental. As Malley et al. (2007) found that political uncertainty endangers macroeconomic uncertainty as it is possible that macroeconomic fundamental will change from economic policy of each party which affects economic performance. According to Arora and Vamvakidis (2006), they found the relationship of macroeconomic performance between U.S. and other countries, especially in developing countries. The possibility of change in macroeconomic fundamental would affect stock market valuations

and investors' perspective. Thus, the political will impact on the emerging stock market liquidity. Furthermore, Næs et al. (2011) found that when the economy have a good condition, the liquidity will become higher than when the economy have a bad condition which they found that the process of change in stock liquidity is driven by a "flight to quality" when the economic have bad condition. From all of these finding, this paper concludes a transmission that when the political uncertainty arising from U.S. election become higher, the liquidity in emerging stock market will become lower.

Hypothesis 1: When the U.S. political uncertainty becomes higher, the emerging stock market liquidity become lower.

3.2 Election Uncertainty Hypothesis

Election uncertainty refers to as the uncertainty on the eventual outcome of the election. This uncertainty directly reflects on change in market sentiments. The election uncertainty hypothesis predicts a negative relationship between emerging stock market liquidity and uncertainty about the eventual winner of the election. The stock market liquidity would be lower when there is no high probability winning of the one political party, such a 50/50 percent chance for two parties. The election uncertainty hypothesis is derived from the uncertain information hypothesis that is an idea of Brown et al. (1988) who found when there is higher uncertainty, asset valuation will reduce which is associated with the higher required of return. Thus, according to Brown et al. (1988), this implies that when election uncertainty increase, it will reduce the stock valuation which reduces an incentive for the buy-side investors to enter the market as it require higher required return. This will cause liquidity in emerging stock market become lower. According to Cukierman (1980), he found that when there is higher uncertainty, investors find it is profit to delay their investment decisions in order to consider more information before they take any action. For the investors who already hold the stock in their portfolios, they will postpone their investment decision both buy more and sell what they hold. They will not take any action in the market which cause the liquidity in the emerging stock market become smaller until the election uncertainty is disappear. Thus, unlike political uncertainty, the election uncertainty affects emerging stock market liquidity through market sentiment, not through a future macroeconomic fundamental change. For these two reasons, this paper formed a hypothesis that when the election uncertainty become higher, it would affect emerging stock investors to delay their investment decision and caused a lower in stock market liquidity.

Hypothesis 2: When the U.S. election uncertainty becomes higher, the emerging stock market liquidity become lower.

3.3 Period Before the Election Hypothesis

This paper studies on the uncertainties arising from U.S. presidential elections in the period before elections from February to November. This hypothesis is about the additional effect of these two uncertainty. The effect of these two uncertainties in a month that is closer to the election date will have higher impact as people will pay more attention to the U.S. election in the month that is getting closer to election month. Moreover, in this period, a change in probability winning in each party would have higher impact on investors sentiment than other period. Thus, holding the level of uncertainty constant, as the election comes closer, we could see the higher of magnitude of effect of uncertainty. For example, we could see higher magnitude of this impact in November than in the other months as the U.S. election usually settle in November.

Hypothesis 3: As the U.S. presidential election date become closer, the effect of uncertainties on emerging stock market liquidity become higher.

Chapter 4 Methodology

4.1 Measurement of Uncertainties

First, the main variable of uncertainty in my empirical analysis, $PROBWIN_{us,t}$, measures the probability winning of the incumbent government. This variable is used as an inverse proxy for political uncertainty. The higher of this variable, $PROBWIN_{us,t}$, means that there is less potential that policy will change from this election which mean the lower the political uncertainty. The probability winning of the incumbent government, $PROBWIN_{us,t}$, is calculated by using Iowa presidential future market. The contracts in this market, IOWA presidential contract, are futures presidential contracts which the payoff is depends on the election outcome. For example, the payoff of the Republican party contract will be $1 if the Republican party wins the next coming election and $0 if the Republican party loses as same as Democratic party contract. So, the price of these contracts is already reflected as the probability winning of each party. The probabilities derived from this future market have an assumption to ignore third party. According to the assumption, when we buy one contract of both Republican and a Democratic contract, this implies we have surely received $1 in the maturity date of contracts. Thus, the price of this contract is already reflecting the probability winning in each party. For example, if the Republican contract is currently $0.60, the Democratic contract should be $0.40. The sum of price will be equal to $1 or the payoff of buying one contract of them. The result is that probability of Republican party winning would be 60% and the probability of a Democratic party winning would be 40%. Thus, the contract price from this market can be use as the probability winning in each party.

Second variable of uncertainty, $ELECUN_{us,t}$, a measure of election uncertainty. This variable will affect emerging stock market liquidity directly through investor sentiment. It is the difference between the probability winning of one political party and the probability winning of another political party. The higher of this variable means the higher the election uncertainty. This election uncertainty variable is calculated by using equation (1).

$$ELECUN_{us,t} = 1 - \left|PROBWIN_{us,t} - (1 - PROBWIN_{us,t})\right| \quad (1)$$

where $PROBWIN_{us,t}$ represents the probability winning of the incumbent government. Because the probability winning of two party can be sum up to one, the value in the absolute term is the difference or the gap between probability winning of one party compare to another and this value does not include the meaning of which party has a dominant lead in that time. So, this value will always positive and truly reflect the gap. When both parties have an equal probability to win in this election or there is no gap of the probability winning between them (i.e., $PROBWIN_{us,t}$ equal to 0.5), $ELECUN_{us,t}$ equals one which is the state when the election uncertainty is maximized. On the other hand, when one of the political party has certain probability to win the election (i.e., $PROBWIN_{us,t}$ equals to zero or one), then $ELECUN_{us,t}$ will equal to zero which is the state when the election uncertainty is minimized.

Although $PROBWIN_{us,t}$ and $ELECUN_{us,t}$ provide the same impact on the emerging stock market liquidity, they have totally different meaning in number and aspects. As shown in the table below, while the probability of the incumbent government winning changes from 0.48 to 0.52, shows a huge change in political uncertainty as there is less potential that policy will change from this election and causing the political uncertainty become lower, $ELECUN_{us,t}$ remains unchanged which 0.96 and 0.96 respectively. For example, If the $PROBWIN_{US,10}$ in October = 0.48 and $PROBWIN_{US,11}$ in November = 0.52, Election uncertainty in both October and November = 0.96. In other words, the probability of incumbent government winning, $PROBWIN_{us,t}$ increases while the difference between the probability winning of one political party and the probability winning of the another political party is the same or $ELECUN_{us,t}$ does not move.

Table 1 Example for the different direction of two uncertainties

	$PROBWIN_{us,t}$	Another candidate
OCTOBER	0.48	0.52
NOVEMBER	0.52	0.48

4.2 Measurement of Liquidity

Liquidity is a loose word so that this paper uses few of liquidity measure to capture two aspect of liquidity which are price impact aspect and trading activity aspect. First, this paper uses Amihud (2002)

illiquidity ratio as a proxy for the illiquidity because this measurement has been used in many literatures on stock market liquidity and asset pricing. Moreover, according to Goyenko et al. (2009), the found that Amihud illiquidity ratio is the best liquidity measure among the liquidity measurements in price impact aspect. The Amihud (2002) illiquidity ratio captures the sensitivity of price change to traded volume. This ratio will show an ability of investors to trade amount of share with current price in the market. The higher of this ratio means the lower of this ability and lower of liquidity.

$$Amihud_{i,t} = \frac{|r_t|}{Volume_t} \quad (2)$$

where r_t is return on day t and Volume is dollar volume on day t. As you can see from the equation (2), this illiquidity ratio uses the absolute return which means that no matter return is positive or negative. This ratio will see the magnitude of the price change compare to the volume. If the volume is high while there is no change in price or not change at all, this mean that this stock has high liquidity. However, this Amihud illiquidity ratio still have disadvantage. It needs to assume that there is a disagreement between traders about new information which means that when there is good news or bad news come out, the stock price change with volume as well. So, this paper uses other liquidity ratio as the additional test as well.

This paper will use another liquidity proxies which is from trading activity aspects. Unlike Amihud (2002), this liquidity measurement is a proxy foe liquidity in stock market. The higher of stock turnover rate, the higher liquidity of the stock. The stock turnover rate ($Turnover_t$) has been used by many literature as it easily to use and has standardized rather than used trading volume alone. It should be note that stock turnover rate disentangles the effect of firm size from trading volume alone. This measure calculated by divided the monthly sum (over D_t days in that month) of the daily number of shares traded (ST_t) by the number of share outstanding ($Share\ Outstanding_t$) as the equation (3). Thus, this ratio will show how investors trade in the market or how easily of investors to get match in the stock market in particular time. This ratio can interpret as the reciprocal of average holding period of the investors. The higher of stock turnover rat, the shorter time period of investors hold the stock in their portfolio and, thus, the higher the liquidity in stock market. However, the result of this question below will the stock turnover rate of each stock in each month. Then I will use equally-weighted average for all of stock to calculate the monthly stock turnover rate of that stock market.

$$Turnover_{i,t} = \frac{\sum_{d=1}^{D_t} ST_t}{Share\ Outstanding_t} \quad (3)$$

This paper will compute monthly illiquidity (liquidity) measure for each stock by using an equally-weighted averages of them. For the illiquidity (liquidity) measure of stock market, I also compute them by using the equally-weighted averages. The replacement characters LIQ are each of the above

described liquidity measures. Note that LLIQ represents for illiquidity measures and LIQ represents for liquidity measures. The calculation shows in equation (4) and (5).

$$LLIQ_{iym} = \frac{1}{D_{iym}} \sum_{d=1}^{D_{iym}} LLIQ_{iymd} \text{ or } LIQ_{iym} = \frac{1}{D_{iym}} \sum_{d=1}^{D_{iym}} LIQ_{iymd} \quad (4)$$

$$LLIQ_{ym} = \frac{1}{N_{ym}} \sum_{i=1}^{N_{ym}} LLIQ_{iym} \text{ or } LIQ_{ym} = \frac{1}{N_{ym}} \sum_{i=1}^{N_{ym}} LIQ_{iym} \quad (5)$$

Where D_{iym} is the total number of days of stock i in month m of year y, and N_{ym} is the total number of all stocks in month m of year y.

4.3 Model specification

As the data shows as a panel data, this paper will use Hausman test to find whether the fixed effect model is an appropriate model or not. I empirically examine the relationship between uncertainties arising from U.S. presidential elections and emerging stock market liquidity by regressing emerging stock market liquidity ($SL_{i,t}$) on the probability winning of the incumbent government ($PROBWIN_{us,t}$), a measure of election uncertainty ($ELECUN_{us,t}$), and a set of control variables. The equation (6) is shown below. However, it should be note that model are more like cross-sectional than time series. The industrial production, the proxy of Gross Domestic product, use as a level to control the stock market liquidity for the different in each countries size. The bigger size of industrial production would result in higher stock market liquidity in natural. It means that all observations are independent through time.

$$SL_{i,t} = \alpha_{i,t} + \beta_1 PROBWIN_{us,t} + \beta_2 ELECUN_{us,t} + \beta_3 REP_{us,t} + \beta_4 INF_{i,t} + \beta_5 IP_{i,t} + \beta_6 ER_{i,t} + \beta_7 lnMV_{i,t-1} + \beta_8 PI_{i,t} + \beta_9 NOV_{i,t} \cdot PROBWIN_{us,t} + \beta_{10} NOV_{i,t} \cdot ELECUN_{us,t} + \sum_{i=1}^{n-1} \gamma_i Country_{i,t} + \varepsilon_{i,t} \quad (6)$$

where $SL_{i,t}$ is the emerging stock liquidity at market level in country i and the month m, $PROBWIN_{us,t}$ is the probability winning of the incumbent government which is an inverse proxy of political uncertainty, $ELECUN_{us,t}$ is the a measurement of election uncertainty, $REP_{us,t}$ is a dummy variable that equals one if the incumbent government of the election is Republican party, $INF_{i,t}$ is inflation rate as a change in Consumer Price Index (CPI), $IP_{i,t}$ is monthly change in industrial production which is a proxy of Gross domestic product (GDP), $ER_{i,t}$ is equity return in each market, $lnMV_{i,t-1}$ is the natural logarithm of market capitalization and $PI_{i,t}$ is net portfolio investment in balance of payment (BOP). I also include the slope dummy variable ($NOV_{i,t} \cdot PROBWIN_{us,t}$) to see whether the effect of uncertainty higher when the sample getting closer to the election date or not. Moreover, in the model specification, this paper will include a dummy variable to capture the country fixed effect and account for potential heterogeneity across countries. The intercept in the model will represent for first country and dummy will represent as intercept for the other countries.

Table 2 Variable description

Variables	Descriptions	Transmissions	Effect on Liquidity
$PROBWIN_{us,t}$	The probability winning of the incumbent government winning, which is a proxy of political uncertainty	The higher this variable, the lower political uncertainty which would increase stock market liquidity through macroeconomic uncertainty or policy change from hypothesis 3.1.	+
$ELECUN_{us,t}$	The measurement of election uncertainty	The higher this variable, the higher election uncertainty which would reduce stock market liquidity through uncertain information hypothesis of Brown et al. (1988) from hypothesis 3.2.	-
$REP_{us,t}$	A dummy variable that is equals to one when the incumbent government during election is Republican party	Marshall et al. (2018) find that asymmetric information is higher under Republican presidents and Glosten and Milgrom (1985) find the asymmetric information is a determinant of liquidity. I expect that the liquidity will be lower in the time of republican as government.	-
$INF_{i,t}$	The inflation rate as a change in Consumer Price Index (CPI)	The higher inflation would reduce purchasing power and, in turn, stimulate investors to invest in financial market for more return to compensate the inflation, higher liquidity.	+
$IP_{i,t}$	The monthly change in industrial production as a proxy of GDP	The countries that has higher GDP should have more level of stock market liquidity. The increasing in GDP will ensure the investors' confidence about the market which create a willingness of investors to enter the market.	+
$ER_{i,t}$	Equity return	The decline in stock price reduces the aggregate collateral of the market making sector and higher margin requirement, which cause lower in liquidity.	+
$lnMV_{i,t-1}$	The natural logarithm of market capitalization	A larger stock issue has smaller price impact for a given order flow which return is used in Amihud illiquidity ratio.	+
$PI_{i,t}$	The natural logarithm of net portfolio investment in balance of payment (BOP).	The negative net portfolio investment means there is higher investment from foreign investors which will cause the liquidity in stock market become higher.	-

Chapter 5 Data

This paper considers liquidity of five stock markets among emerging countries, namely Indonesia, Malaysia, Philippines, Singapore and Thailand. Using a five-time period of election between 2000 to 2016, I investigate the data from February to November in each election, ie. 2000, 2004, 2008, 2012 and 2016. The stock data include all Indonesia stocks traded at Indonesia stock exchange (IDX), all Malaysia stocks traded at Bursa Malaysia (BM), all Philippines stocks traded at Philippine Stock Exchange (PSE), all Singapore stocks traded at Singapore Exchange Limited (SGX) and all Thailand stocks traded at The Stock Exchange of Thailand (SET). The source of the stock market data including the stock liquidity and stock characteristic variables is derived from Bloomberg database. All macroeconomic variables are also from Bloomberg database except for the industrial production where the data is derived from World Bank database. The capital flow variables are from International Monetary Fund (IMF) database. The probability winning in each parties, which used to calculate the political uncertainty and election uncertainty, are derived from the IOWA future presidential market.

Chapter 6 Results

Table 3 shows the correlation coefficients between the variables used in an empirical analysis. We can see on the table that the $PROBWIN_{us,t}$ and $ELECUN_{us,t}$ has a negative and low correlation. This is why this paper wants to separate this two uncertainty and put those two uncertainties in the same model. $PROBWIN_{us,t}$ is about the policy change in the future due to the new incumbent government while $ELECUN_{us,t}$ only capture the market sentiment. It should be note that the stock market liquidity ($SL_{i,t}$) in the table is Amihud illiquidity ratio, my main liquidity measure, which the higher of the Amihud ratio means the lower the stock market liquidity. $PROBWIN_{us,t}$ is an inverse proxy of political uncertainty which the higher of this variable means the lower political uncertainty. The stock market liquidity ($SL_{i,t}$), which is represented by the Amihud illiquidity ratio, has a negative correlated with the political uncertainty ($PROBWIN_{us,t}$) as same as my hypothesis of political uncertainty. While the $ELECUN_{us,t}$ seem to show a different from my hypothesis of election uncertainty which the sign of correlation should be positive. For other control variables, they seem to consistent with the literature like shown in Table 2. $REP_{us,t}$ appears to have a positive correlated with stock market liquidity, Amihud illiquidity ratio, and $INF_{i,t}$, $IP_{i,t}$, $ER_{i,t}$ and $lnMV_{i,t-1}$ appear to have a negative correlated with stock market liquidity as expected which consist with the existing papers. However, the sign of correlation between $PI_{i,t}$ and $SL_{i,t}$ seems to difference from Table 2

Table 3 Correlations among variables

	$SL_{i,t}$	$PROBWIN_{us,t}$	$ELECUN_{us,t}$	$REP_{us,t}$	$INF_{i,t}$	$IP_{i,t}$	$ER_{i,t}$	$lnMV_{i,t-1}$
$PROBWIN_{us,t}$	-0.2819							
$ELECUN_{us,t}$	-0.0470	-0.2038						
$REP_{us,t}$	0.1587	-0.6359	0.1811					
$INF_{i,t}$	-0.2406	-0.1521	0.2873	0.1972				
$IP_{i,t}$	-0.0296	-0.1521	-0.2873	-0.1359	-0.0332			
$ER_{i,t}$	-0.2481	0.3380	0.0923	-0.1950	0.0015	0.0253		
$lnMV_{i,t-1}$	-0.2047	0.4125	-0.4681	-0.1941	-0.0630	0.1829	0.0684	
$PI_{i,t}$	-0.0311	-0.0519	0.0582	-0.0146	-0.0280	-0.3627	-0.0148	0.0002

6.1 Regression Results

This paper will first to find the political uncertainty which many papers overlooked it and usually study on the election uncertainty. I define it as the possibility of macroeconomic policy change in the future which is represented by the probability winning of the incumbent government winning ($PROBWIN_{us,t}$). In Table 5, I run a regression of the emerging stock market liquidity, which use Amihud illiquidity ratio to measure the liquidity, and the political uncertainty with no election uncertainty variable. This table reports the results of the alternative models of equation (6). In each model, I will increase the stepwise of the control variables. For example, in first model, I will include only the stock characteristics which are equity return and market capitalization. All of the model shows in the Table 5 give a results of F-statistics that are significant at the 1% level in all model. The R-square in each model is around 25% except for the first model. All of 4 models has 215 observation and number of group is 5 which represented as the countries. As I mention above, this paper will use Hausman test to identify whether I use the fixed effect specification or random effect specification. The Hausman tests are also reports on the table for each model. It indicate that the first model should use the random effected specification as it more efficient than fixed effected specification while the other three models use fixed effect specification. The results shows that $PROBWIN_{us,t}$ is statically significance at 1% level except for model 1. This implies that there is an effect of political uncertainty on emerging stock market liquidity where the higher probability winning of incumbent government, the higher the liquidity in the market.

However, there is more uncertainty rather than the political uncertainty which is election uncertainty. Although they have the same impact on emerging stock market liquidity, they can move in the different direction through time as mention above. Moreover, past literature did not separate these two

Table 3 Regression results of the political uncertainty

	Model 1	Model 2	Model 3	Model 4
$PROBWIN_{us,t}$	-0.855**	-1.051***	-1.050***	-0.944**
	(0.011)	(0.002)	(0.002)	(0.021)
$REP_{us,t}$				0.0446
				(0.658)
$INF_{i,t}$		-36.26***	-36.34***	-36.82***
		(0.000)	(0.000)	(0.000)
$IP_{i,t}$		-0.0530	-0.0527	-0.0498
		(0.456)	(0.460)	(0.487)
$ER_{i,t}$	-2.191***	-2.094***	-2.093***	-2.100***
	(0.001)	(0.001)	(0.001)	(0.001)
$lnMV_{i,t-1}$	-0.118**	-0.124**	-0.123**	-0.125**
	(0.026)	(0.016)	(0.017)	(0.016)
$PI_{i,t}$			1.417	1.677
			(0.851)	(0.825)
Constant	3.877***	4.245***	4.226***	4.210***
	(0.004)	(0.001)	(0.001)	(0.001)
Hausman test	Random	Fixed	Fixed	Fixed
	0.07	69.09***	68.28***	68.02***
	(0.965)	(0.000)	(0.000)	(0.000)
R-squared	0.169	0.256	0.256	0.257
F-stat	42.40***	14.09***	11.69***	10.01***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of obs.	215	215	215	215
No. of groups	5	5	5	5

P-value is in parentheses and ***, **, * Denote significance at the 1%, 5% and 10% levels, respectively. The table reports the estimates of alternative versions of the following regression specification:

$$SL_{i,t} = \alpha_{i,t} + \beta_1 PROBWIN_{us,t} + \beta_2 REP_{us,t} + \beta_3 INF_{i,t} + \beta_4 IP_{i,t} + \beta_5 ER_{i,t} + \beta_6 lnMV_{i,t-1} + \beta_7 PI_{i,t} + \varepsilon_{i,t}$$

uncertainties clearly and did not put these two variables in the same model. The impact of these two uncertainties may be misunderstand. As you can see on Table 4, The correlation between the proxy of political uncertainty and election uncertainty is quite low. This also support the different between these two uncertainties. Therefore, in next model, I include this election uncertainty ($ELECUN_{us,t}$) to control for the uncertainty that change the market sentiment in Table 6. In Table 6, it show the regression result when I consider both the political uncertainty and the election uncertainty. The R-square of these three model are around 26%. The F-statistics gave a statistically significant at 0.01 level of significance. The Hausman-test shows that the fixed effect specification is more efficient than random effect for all three models.

In model 5 where I include the election uncertainty ($ELECUN_{us,t}$) into model 4, the result find that there is no effect of election uncertainty on emerging stock market liquidity. I expected that the effect of political uncertainty may be greater than or already include the effect of election uncertainty. So, I will

exclude the inverse proxy of the political uncertainty ($PROBWIN_{us,t}$) and put only election uncertainty as shown in model 6. However, the result is the same. It shows that the election uncertainty is not statistically significance. This implies that it is the risk from government policy change that affects emerging stock market liquidity, not the risk from election uncertainty which directly impacts on investors sentiment in emerging stock markets. Moreover, in model 7 and model 8, I include the slope dummy variables of each uncertainty ($NOV_{i,t} \cdot PROBWIN_{us,t}$ and $NOV_{i,t} \cdot ELECUN_{us,t}$) to find whether the month closer to election have higher magnitude of this effect or not. The result shows the both coefficients of $NOV_{i,t} \cdot PROBWIN_{us,t}$ and $NOV_{i,t} \cdot ELECUN_{us,t}$ are not statistically significance. This means the impact of political uncertainty and election uncertainty is not higher when the election come closer. The magnitude of the political uncertainty and election uncertainty is the same for all time before election.

Table 4 Regression results of the political uncertainty and election uncertainty

	Model 5	Model 6	Model 7	Model 8
$PROBWIN_{us,t}$	-0.917**		-0.937**	-0.953**
	(0.025)		(0.022)	(0.022)
$ELECUN_{us,t}$	-0.414	-0.442	-0.420	-0.424
	(0.133)	(0.112)	(0.128)	(0.126)
$REP_{us,t}$	0.0577	0.192**	0.0531	0.0525
	(0.567)	(0.020)	(0.600)	(0.605)
$INF_{i,t}$	-33.42***	-32.73***	-33.68***	-33.65***
	(0.000)	(0.000)	(0.000)	(0.000)
$IP_{i,t}$	-0.0500	-0.0566	-0.0529	-0.0545
	(0.484)	(0.433)	(0.461)	(0.450)
$ER_{i,t}$	-1.967***	-2.387***	-1.936***	-1.914***
	(0.002)	(0.000)	(0.003)	(0.003)
$lnMV_{i,t-1}$	-0.165***	-0.213***	-0.165***	-0.166***
	(0.005)	(0.000)	(0.005)	(0.004)
$PI_{i,t}$	1.920	2.854	2.133	1.975
	(0.800)	(0.709)	(0.779)	(0.795)
$NOV_{i,t} \cdot PROBWIN_{us,t}$			-0.120	
			(0.607)	
$NOV_{i,t} \cdot ELECUN_{us,t}$				-0.0855
				(0.603)
Constant	5.514***	6.238***	5.538***	5.596***
	(0.000)	(0.000)	(0.000)	(0.000)
Hausman test	Fixed	Fixed	Fixed	Fixed
	68.60***	68.57***	68.34***	68.34***
	(0.000)	(0.000)	(0.000)	(0.000)
R-squared	0.265	0.246	0.266	0.266
F-stat	9.098***	9.472***	8.087***	8.088***
	(0.000)	(0.000)	(0.000)	(0.000)
No. of obs.	215	215	215	215
No. of groups	5	5	5	5

P-value is in parentheses and ***, **, * Denote significance at the 1%, 5% and 10% levels, respectively. The table reports the estimates of alternative versions of the following regression specification:

$$SL_{i,t} = \alpha_{i,t} + \beta_1 PROBWIN_{us,t} + \beta_2 ELECUN_{us,t} + \beta_3 REP_{us,t} + \beta_4 INF_{i,t} + \beta_5 IP_{i,t} + \beta_6 ER_{i,t} + \beta_7 lnMV_{i,t-1} + \beta_8 PI_{i,t} + \beta_9 NOV_{i,t} \cdot PROBWIN_{us,t} + \beta_{10} NOV_{i,t} \cdot ELECUN_{us,t} + \varepsilon_{i,t}$$

6.2 Additional Test

This paper also have two additional test as a robustness of the finding. First, it has been studied and found that macroeconomic variable affect to voter behavior in both the presidential election and the congressional elections. If this is true, previous result that political uncertainty affect emerging stock market liquidity may be driven by macroeconomic variables. In order to see whether the earlier results are reliable and subject to this problem or not. I will regress the probability of success of the incumbent government ($PROBWIN_{us,t}$) with one-month lag of macroeconomic variables as shown in equation (7).

$$PROBWIN_{us,t} = \alpha_{i,t} + \beta_1 INF_{i,t-1} + \beta_2 IP_{i,t-1} + \varepsilon_{i,t} \quad (7)$$

The residual term ($\varepsilon_{i,t}$) from equation (7) is political uncertainty that is uncorrelated with the economic variables "$PROBWINRES_{us,t}$". Then, I regress like I do in model 5 but, this time, I will replace with residual term ($PROBWINRES_{us,t}$) from previous regression. The result, which shown in in Table 7, will be the impact of political uncertainty on emerging stock market liquidity which I already exclude the potential effects of the probability winning of the incumbent government ($PROBWIN_{us,t}$) being influenced by changes in macroeconomic variable. The result of additional test is in Table 7. The R-square is 26% and F-statistics is significant at 1% level. The inverse proxy of the political uncertainty that has been exclude the potential effect of macroeconomic is negatively and statistically significance at 5% level. This suggest that the decrease in political uncertainty or the increase of a probability of the incumbent government winning ($PROBWIN_{us,t}$) is associated with an increase in emerging stock market liquidity or lower Amihud illiquidity ratio ($SL_{i,t}$). This finding also support my political uncertainty hypothesis. The election uncertainty still not statistically significance at any level. However, this additional test give a robust to my finding on the relationship between the political uncertainty arising from U.S. presidential election and stock market liquidity in emerging economies.

Table 5 Additional test: Control the change in PROBWIN due to macroeconomic variables

	Model 9
$PROBWINRES_{us,t}$	-0.910**
	(0.026)
$ELECUN_{us,t}$	-0.417
	(0.130)
$REP_{us,t}$	0.0624
	(0.532)
$INF_{i,t}$	-33.29***
	(0.000)
$IP_{i,t}$	-0.0410
	(0.567)
$ER_{i,t}$	-1.992***
	(0.002)
$lnMV_{i,t-1}$	-0.165***
	(0.005)
$PI_{i,t}$	2.032
	(0.788)
Constant	5.010***
	(0.002)
Hausman	Fixed
	68.51***
	(0.000)
R-squared	0.265
F-stat	9.084***
	(0.000)
No. of obs.	215
No. of groups	5

P-value is in parentheses and ***, **, * Denote significance at the 1%, 5% and 10% levels, respectively. The table reports the estimates of alternative versions of the following regression specification:

$$SL_{i,t} = \alpha_{i,t} + \beta_1 PROBWINRES_{us,t} + \beta_2 ELECUN_{us,t} + \beta_3 REP_{us,t} + \beta_4 INF_{i,t} + \beta_5 IP_{i,t} + \beta_6 ER_{i,t} + \beta_7 lnMV_{i,t-1} + \beta_8 PI_{i,t} + \beta_9 NOV_{i,t} \cdot PROBWIN_{us,t} + \beta_{10} NOV_{i,t} \cdot ELECUN_{us,t} + \varepsilon_{i,t}$$

However, liquidity is a loose word. There are more than on aspects of liquidity. This paper uses the trading activity aspect, which are stock turnover rate, to capture the liquidity as the robustness check. In Table 8, I run a regression like model 5 in Table 6. The regression results show that when capture the stock liquidity by using stock turnover rate, the inverse proxy of political uncertainty is statistically insignificance. This means the political uncertainty tend to affect emerging stock market liquidity in price impact aspect, not trading activity aspect. This implies that the political uncertainty is not affecting an ability of investors to get match easily in the market but it is an ability of investors to trade a stock at current market.

Table 6 Additional test: other liquidity measures

	Turnover rate
$PROBWIN_{us,t}$	0.0275 (0.696)
$ELECUN_{us,t}$	-0.0257 (0.590)
$REP_{us,t}$	0.0267 (0.127)
$INF_{i,t}$	1.707 (0.214)
$IP_{i,t}$	0.0103 (0.408)
$ER_{i,t}$	0.291*** (0.009)
$lnMV_{i,t-1}$	0.0515*** (0.000)
$PI_{i,t}$	-0.817 (0.534)
Constant	-1.218*** (0.000)
Hausman test	Fixed 165.8*** (0.000)
R-squared	0.224
F-stat	7.277*** (0.000)
No. of obs.	215
No. of groups	5

P-value is in parentheses and ***, **, * Denote significance at the 1%, 5% and 10% levels, respectively. The table reports the estimates of alternative versions of the following regression specification:

$$SL_{i,t} = \alpha_{i,t} + \beta_1 PROBWIN_{us,t} + \beta_2 ELECUN_{us,t} + \beta_3 REP_{us,t} + \beta_4 INF_{i,t} + \beta_5 IP_{i,t} + \beta_6 ER_{i,t} + \beta_7 lnMV_{i,t-1} + \beta_8 PI_{i,t} + \varepsilon_{i,t}$$

Chapter 7 Conclusion

This paper finds that the uncertainties arising from U.S. presidential elections affects emerging stock market liquidity. This paper finds that when the political uncertainty become higher, the emerging stock market liquidity will become lower and vice versa. However, my finding does not find the evidence that the election uncertainty has an impact on emerging stock market liquidity. This implies that it is the uncertainty in future macroeconomic fundamental that affects the emerging stock market liquidity, not market. Nevertheless, this paper does not find that there is additional effect of the political uncertainty when getting closer to election day. This implies that the magnitude of the effect of these two uncertainties are the same for this period.

This paper clearly shows the political uncertainty and the election uncertainty are difference. So, when the researchers want to study on the impact of political risk which stem from U.S. presidential elections, researchers should separate the two uncertainties. Failing to do it will likely lead to a biased. Moreover, this paper provide an evidence of the relationship between U.S. election and emerging stock market performance. Moreover, this papers would benefit to all short horizon investors and large portfolio investors as these kinds of investors faced with the liquidity risk.

References

Alesina, Alberto and Jeffrey Sachs (1986). "Political Parties and the Business Cycle in the United States, 1948-1984." Journal of Money, Credit and Banking **20**: 63-82

Amihud, Yakov and Haim Mendelson (1986). "Asset pricing and the bid-ask spread." Journal of financial Economics **17**(2): 223-249

Arora, Vivek and Athanasios Vamvakidis (2006). "The impact of US economic growth on the rest of the world: How much does it matter?" Journal of Economic Integration **19**(1): 1-18.

Berg, Joyce E., Forrest D. Nelson and Thomas A. Rietz (2008). "Prediction market accuracy in the long run." International Journal of Forecasting **24**(2): 285-300.

Brown, Keith C., W.V. Harlow and Seha M. Tinic (1988). "Risk aversion, uncertain information, and market efficiency." Journal of financial Economics **22**(2): 355-385.

Chappell, Henry W. and William R. Keech (1985). "A new view of political accountability for economic performance." American Political Science Review **79**(1): 10-27.

Chung, Kee H. and Chairat Chuwonganant (2014). "Uncertainty, market structure, and liquidity." Journal of financial Economics **113**(3): 476-499.

Cukierman, Alex (1980). "The Effects of Uncertainty on Investment under Risk Neutrality with Endogenous Information." Journal of Political Economy **88**(3).

Ederington, Louis H. and Jae Ha Lee (1993). "How Markets Process Information: News Releases and Volatility." Journal of Finance **48**(4): 1161-1191.

Glosten, Lawrence R. and Paul R. Milgrom (1985). "Bid, ask and transaction prices in a specialist market with heterogeneously informed traders." Journal of financial Economics **14**(1): 71-100.

Goodell, John W. and Richard A. Bodey (2012). "Price–earnings changes during US presidential election cycles: voter uncertainty and other determinants." Public Choice **150**(3-4): 633-650.

Goodell, John W. and Sami Vähämaa (2013). "US presidential elections and implied volatility: the role of political uncertainty." Journal of Banking and Finance **34**(3): 1108-1117.

Goyenko, Ruslan Y., Craig W. Holden and Charles A. Trzcinka (2009). "Do liquidity measures measure liquidity." Journal of financial Economics **92**(2): 153-181.

Leigh, Andrew and Justin Wolfers (2006). "Competing approaches to forecasting elections: Economic models, opinion polling and prediction markets." Economic Record **82**(258): 325-340.

Li, Jinliang and Jeffery A. Born (2006). "Presidential election uncertainty and common stock returns in the United States." Journal of Financial Research **29**(4): 609-622.

Næs, Randi, Johannes A. Sjkeltorp and Bernt Arne Ødegaard (2011). "Stock market liquidity and businesscycle." Journal of Finance **66**(1): 139-176.

Malley, Jim, Apostolis Philippopoulos and Ulrich Woitek (2007). "Electoral uncertainty, fiscal policy and macroeconomic fluctuations." Journal of Economic Dynamics and Control **31**(3): 1051-1080.

Marshall, Ben R., Hung T. Nguyen, Nhut H. Nguyen and Nuttawat Visaltanachoti (2018). "Politics and liquidity." Journal of Financial markets **38**: 1-13.

Hibbs, Douglas A. (1977). "Political parties and macroeconomic policy." American Political Science Review **71**(4): 1467-1487.

Hibbs, Douglas A. (1986). "Political parties and macroeconomic policies and outcomes in the United States." The American Economic Review **76**(2): 66-70.

Julio, Brandon and Youngsuk Yook (2012). "Political uncertainty and corporate investment cycles." Journal of Finance **67**(1): 45-83.

Nippani, Srinivas and Augustine C. Arize (2005). "US presidential election impact on Canadian and Mexican stock markets." Journal of Economics and Finance **29**(2): 271-279.

Optimal Investment Strategy of High-Risk/High-Return and Low-Risk/Low-Return Stocks in the Presence of Proportional Transaction Costs

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Abstract

In an optimal investment problem with one risk-free asset (money market account) and one risky asset (stock) whose return has a constant mean and variance, Merton (1969) finds that it is optimal to keep the constant proportion of stock in the portfolio or constant *portfolio weight*. This portfolio weight, called the Merton weight, is proportional to the ratio between the expected excess return and the variance. The result of Merton (1969) implies that it is optimal to keep the same portfolio weight for a stock with higher mean and variance (high-risk/high-return) and a stock with lower mean and variance (low-risk/low-return) as long as the ratio between the expected excess return and the variance of the two stocks are the same. However, when there are proportional transaction costs, it is no longer optimal to keep the portfolio weight constant, but rather to trade only when the weight in the stock is too far away from the Merton weight. In particular, the investor should keep the portfolio weight within a given *no-trade* region with minimal trading. The aim of this paper is to investigate the behavior of the no-trade region for stocks with the same Merton weight but different mean and variance. Interestingly, we find that the investor should maintain a relatively high proportion in the high-risk/high-return stocks while maintain a relatively low proportion in the low-risk/low-return stocks. This suggests that the mean excess return outweighs the variance in the presence of proportional transaction costs.

Keywords: optimal investment problem, proportional transaction costs, risk-return tradeoff

1. Introduction

Merton (1969) studies optimal investment and consumption problems in a market with one risk-free asset (i.e. money market account) and multiple risky assets (i.e. stocks). The stock prices are assumed to follow Geometric Brownian motion with constant rates of return and volatilities. He considers a problem in which an investor chooses how much to invest in the risk-free and risky assets, and how much to consume at each instance to maximize the expected utility of consumption and the bequest function over a finite horizon. He is able to provide a closed-form optimal investment decision in terms of the proportion of wealth to be invested in each asset at each point in time, or the *portfolio weights*. In the case of one risky

asset and Constant Relative Risk Aversion (CRRA) utility, Merton (1969) shows that it is optimal for the investor to keep the constant portfolio weight in the absence of transaction costs. The optimal risky weight is proportional to the ratio between the expected excess return and the variance of the stock return. We refer to this as the *Merton weight*.

One of the common principles among participants in the real stock markets is the risk-return tradeoff. Stocks with high risk are expected to have high returns, or *high-risk/high – return* stocks, and stocks with low risk are expected to have low returns, or *low-risk/low-return* stocks. However, the Merton weight suggests investors to invest more in stocks with high return and low variance. If each stock is either of high-risk/high-return and low-risk/low-return stock, the optimal Merton weight for each stock should be similar given the same level of risk aversion.

One of the main assumptions in Merton (1969) is the absence of transaction costs. When there are transaction costs, it is obvious that maintaining the portfolio weight at the Merton weight the entire time is impossible and definitely suboptimal since continuously trading would incur infinite trading costs. There are many types of transaction costs considered in the literature. The first one is proportional transaction costs. With proportional costs, investors have to pay a proportion of the trading value as the transaction cost. Davis and Norman (1990) study optimal investment problems with proportional transaction costs, and show that it is optimal to buy the stock whenever the portfolio weight is lower than the *buy boundary* just to bring the position back to the buy boundary, and to sell the stock whenever the portfolio weight is higher than the *sell boundary* just to bring the position back to the sell boundary. The investor should not trade when the portfolio weight is between the two boundaries. This region is referred to as the *no-trade region.* See also Magill and Constantinides (1976), Taksar, Klass, and Assaf (1988), Shreve and Soner (1994), Akian, Menaldi, and Sulem (1996), and Tourin and Zariphopoulou (1997) for studies of optimal investment with proportional transaction costs.

Another type of transaction costs which is quite different from the first is fixed transaction costs. Unlike proportional transaction costs which depend on the trading size, fixed transaction costs depend on trading frequency. The more often one trades, the higher cost incurred. With this type of transaction costs, Shaikhet (2003) shows that when the portfolio weight is above (below) the buy (sell) boundary, the investor should buy (sell) the stock to bring the portfolio weight up (down) to a certain target buy (sell) level lying inside the no-trade region. Challathurai and Draviam (2007) consider the combination of the two

types of transaction costs and show that the solution structure slightly differs from each of the two cases with a generally wider no-trade region. Other works that study optimal investment problems with both fixed and proportional transaction costs include, for example, Eastham and Hastings (1988), Korn (1998), and Oksendal and Sulem (2002).

In this research, we focus on optimal investment and consumption problems with proportional transaction costs. The objective is to discover whether the optimal investment policy for stocks with the same Merton weight remains the same under the presence of proportional transaction costs. In particular, we compare the buy and sell boundaries for stocks having the same ratio between expected excess return and variance. Our numerical results show that the buy and sell boundaries in the case of high-risk/high-return stocks are higher than those in the case of low-risk/low-return stocks with the same Merton ratio. This implies that the optimal policy accepts underinvestment in low-risk/low-return stocks more than that in high-risk/high-return stocks and accepts overinvestment in high-risk/high-return stocks more than that in low-risk/low-return stocks. In other words, the expected return outweighs the variance in the presence of proportional transaction costs.

The rest of this paper is organized as follows: In Section 2, we describe our investment and consumption problems and formulate them as free-boundary stochastic control problems. We explain the method for solving the problems based on the method of Muthuraman (2007) in Section 3. We present our numerical results and discuss them in Section 4. Conclusions are provided in Section 5.

2. Investment Problems

Consider an investor who invests in a market with one risk-free asset (money market account) and one risky asset (stock). Let P_t denote the price of the risk-free asset at time t, and S_t denote the price of stock at time t. We assume that the prices follow the following stochastic differential equations:

$$dP_t = rP_t dt \tag{1}$$

$$dS_t = S_t(\alpha dt + \sigma dB_t) \tag{2}$$

where $r > 0$ denotes a constant continuously compounded interest rate, α denotes the instantaneous mean return of stock, σ denotes the instantaneous volatility of stock return, and B_t denotes a standard Brownian motion driving the stock price.

At each time t, the investor chooses how to allocate his wealth between the risk-free and risky assets, and how much to consume. More precisely, let X_t denote the investment value in the money market account, and Y_t the investment value in the stock. There is a cost associated with buying and selling the stock. Let λ denote the buying proportional transaction cost, and μ the selling proportional transaction cost. The investor chooses the rate of consumption c_t at each time t as a proportion of the current value of X_t. It can be shown that the dynamics of X_t and Y_t are given by

$$dX_t = (rX_t - c_tX_t)dt - (1+\lambda)dL_t + (1-\mu)dD_t \tag{3}$$

$$dY_t = Y_t(\alpha dt + \sigma dB_t) + dL_t - dD_t \tag{4}$$

where L_t denotes a non-decreasing process representing cumulative dollar-amount spent when buying stock, and D_t denotes a non-decreasing process representing cumulative dollar-amount received when selling stock. The goal of the investor is to maximize the expected utility of consumption over the infinite horizon. The value function associated with this problem is

$$V(x,y) = \max_{(c_s,L_s,D_s)\in\mathcal{A}(x,y)} \mathrm{E}\left[\int_0^\infty e^{-\theta s}U(c_sX_s)ds \mid X_0 = x, Y_0 = y\right] \tag{5}$$

where x and y are the initial dollar-amounts in the money-market account and stock, respectively, $\mathcal{A}(\cdot)$ denotes a set of all admissible policies, θ is the discount rate of utility or the impatience factor, and

$$U(c) = \frac{c^{1-\gamma}}{1-\gamma} \tag{6}$$

is the power utility with relative risk aversion coefficient γ with $\gamma > 0, \gamma \neq 1$. The optimality conditions are characterized by the following HJB equation

$$\max_{(c_s,L_s,D_s)\in\mathcal{A}(x,y)}[\mathcal{J}V + \mathcal{M}V,\ \mathcal{L}V,\ \mathcal{B}V] = 0 \tag{7}$$

where $\mathcal{J}V = \frac{1}{2}\sigma^2y^2V_{yy} + \alpha yV_y + rxV_x - \theta V,$

$$\mathcal{M}V = \frac{(c_sx)^{1-\gamma}}{1-\gamma} - c_sxV_x\,,$$

$$\mathcal{L}V = (1-\mu)V_x - V_y\,,$$

$$\mathcal{B}V = -(1+\lambda)V_x + V_y.$$

Here V_x and V_y denote the first order partial derivative of V with respect to x and y, respectively, and V_{yy} denotes the second order partial derivative of V with respect to y. The

term $\mathcal{J}V + \mathcal{M}V$ represents the expected change of the value function when it is optimal not to trade, while $\mathcal{B}V$ and $\mathcal{L}V$ represent the expected changes of the value function when it is optimal to buy and to sell, respectively. The optimal solution is characterized by the three regions on the $X - Y$ space. The first region is the no-trade region. When the value of (X, Y) falls into this region, it is optimal not to trade. The other two regions are the buy and the sell regions. When the value of the dollar-amount invested in the stock is too high, the value of (X, Y) falls into the sell region, and makes it optimal to sell the stock just to bring the value (X, Y) back to the no-trade region. By the same token, when the value of the dollar-amount invested in the stock is too low, the value of (X, Y) falls into the buy region, and makes it optimal to buy the stock just to bring the value (X, Y) back to the no-trade region.

3. Optimal Policies

The HJB equation (7) in the previous section can be classified as a *free-boundary* problem, of which the unknown buy and sell boundaries need to be discovered simultaneously with the solution function. This type of problems is typically difficult, and there are many proposed numerical methods to approximate the boundaries (see, for example, Davis and Norman (1990) and Shreve and Soner (1994)). In this study, we follow the fast-computational scheme for approximating the solution of the equivalent one-dimensional problem proposed by Muthuraman (2007).

According to the *homothetic property* of CRRA utility function as shown in Davis and Norman (1990) and Shreve and Soner (1994), we can reduce the dimensionality of the problem by defining

$$V(x, y) = x^{1-\gamma} W\left(\frac{y}{x}\right). \tag{8}$$

for some function W. Let $Z_t = Y_t / X_t$ denote the ratio between the amount invested in the risky asset and the amount invested in the risk-free asset. It can be shown that the HJB equation (7) reduces to the following one-dimensional HJB equation in z

$$\max_{(c_s, L_s, D_s) \in \mathcal{A}(z)} [\mathcal{J}W + \mathcal{M}W,\ \mathcal{L}W,\ \mathcal{B}W] = 0 \tag{9}$$

where $\mathcal{J}W = \frac{1}{2}\sigma^2 z^2 W'' + \alpha z W' - r z W' + r(1-\gamma)W - \theta W$

$$\mathcal{M}W = \frac{c_s^{1-\gamma}}{1-\gamma} - c_s[(1-\gamma)W - zW']$$

$$\mathcal{L}W = (1-\mu)[(1-\gamma)W - zW'] - W'$$

$$\mathcal{B}W = -(1+\lambda)[(1-\gamma)W - zW'] + W'.$$

Solving the one-dimensional HJB equation for $W(z)$ where $z = y/x$ is equivalent to solving the original two-dimensional HJB equation for $V(x, y)$.

The idea behind the method of Muthuraman (2007) is to solve a free-boundary problem by iteratively solving a sequence of fixed boundary problems. By starting with reasonable buy and sell boundaries, one can solve an ordinary differential equation using a standard technique such as the finite element method to obtain the value function associated with the chosen boundaries. Then the new boundaries are determined based on the solution function previously obtained. Muthuraman (2007) shows that his boundary-update method is a policy improvement method and the boundaries will finally converge to the optimal boundaries. Moreover, the term $\mathcal{M}W$ can be tackled using an iterative search method for the optimal consumption. In conclusion, the algorithm consists of the outer loop for boundary search and the inner loop for optimal consumption search. Figure 1 outlines the algorithm of Muthuraman (2007). For more details, we refer the reader to Muthuraman (2007).

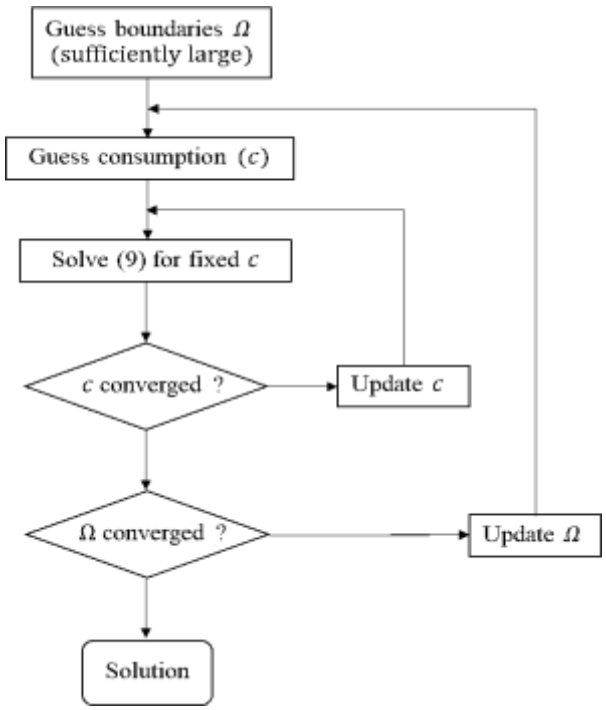

Figure 1: Muthuraman (2007)'s fast computational scheme.

4. Numerical Results

In this study, we aim to examine the optimal no-trade region when the levels of volatility and excess mean return of stock vary, but the Merton weight remains the same. We assume that the risk-free rate $r = 0.03$, the impatience factor $\theta = 0.02$, the proportional buying cost $\lambda = 0.05$, the proportional selling cost $\mu = 0.05$, and risk aversion coefficient $\gamma = 2$. We assume also that the expected return α is a linear function of variance σ^2 and is given by

$$\alpha = r + \beta\sigma^2 \tag{10}$$

where β is the constant price of risk of this stock, and is set to 0.5. By varying the level of volatility σ from 0.2 to 0.4 in (10), we investigate the resulting no-trade regions. Figure 2 shows the buy and sell boundaries for each set of (α, σ^2).

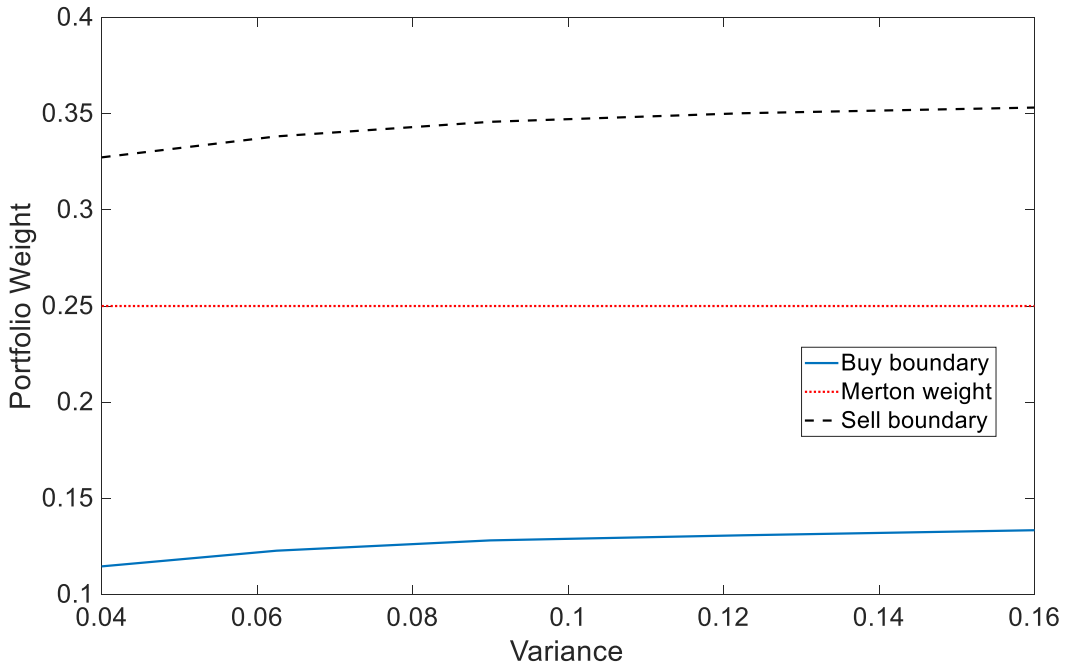

Figure 2: Optimal buy and sell boundaries for various values of mean and variance of stock return with the same Merton weight.

As we can see from Figure 2, the buy and sell boundaries increase in the variance, and hence in the expected return. Recall that without the transaction costs, it is optimal to maintain the portfolio weight at the Merton weight (dashed line). However, with transaction

costs, the investor trades less and accepts some deviation from the Merton weight to save the trading costs. The results shown in Figure 2 imply that the investor should allow more upward deviation from the Merton weight (overinvestment) for high-risk/high-return stocks than for low-risk/low-return stocks. However, the investor should allow more downward deviation from the Merton weight (underinvestment) for low-risk/low-return stocks than for high-risk/high-return stocks. This suggests that when there are proportional transaction costs, the optimal investment policy puts more weight on the expected return than the variance.

5. Conclusions

We consider optimal investment and consumption problems when there are proportional transaction costs, and study how the optimal investment policy changes when the risk and return of stock vary. Merton (1969) suggests that it is optimal to keep the portfolio weight at a constant level which depends on the ratio between the expected excess return and variance. We show that in the presence of transaction costs, the optimal investment policy no longer depends solely on this ratio. The results suggest that the expected returns become more important than the variance when there are proportional transaction costs.

References

Akian, M., Menaldi, J.L., and Sulem, A., 1996. On an investment-consumption model with transaction costs. SIAM Journal of Control and Optimization 34, 329-364.

Chellathurai, T. and Draviam, T., 2007. Dynamic portfolio selection with fixed and/or proportional transaction costs using non-singular stochastic optimal control theory. Journal of Economic Dynamics and Control 31, 2168–2195.

Davis, M.H.A. and Norman, A.R., 1990. Portfolio selection with transaction costs. Mathematics of Operations Research 15, 676-713.

Eastham, J.E. and Hastings, K.J., 1988. Optimal impulse control of portfolios. Mathematics of Operation Research 13, 588-605.

Korn, R., 1998. Portfolio optimization with strictly positive transaction costs and impulse control. Finance and Stochastics 2, 85-114.

Magill, M.J.P. and Constantinides, G.M., 1976. Portfolio selection with transaction costs. Journal of Economic Theory 13, 245-263.

Merton, R.C., 1969. Lifetime portfolio selection under uncertainty: the continuous time case. The Review of Economics and Statistics 51, 247-257.

Muthuraman, K., 2007. A computational scheme for optimal investment-consumption with proportional transaction costs. Journal of Economic Dynamics and Control 31, 1132-1159.

Oksendal, B. and Sulem, A., 2002. Optimal consumption and portfolio with both fixed and proportional transaction costs. SIAM Journal on Control and Optimization 40 (6), 1765-1790.

Shaikhet, G., 2003. Portfolio optimization under transaction costs. Master Thesis. Israel Institute of Technology.

Shreve, S. E., and Soner, H. M., 1994. Optimal investment and consumption with transaction costs. The Annals of Applied Probability 4, 609-692.

Taksar, M., Klass, M.J., and Assaf, D., 1988. A diffusion model for optimal portfolio selection in the presence of the brokerage fees. Mathematics of Operation Research 13 (2), 277-294.

Tourin, A. and Zariphopoulou, T., 1997. Viscosity solutions and numerical schemes for investment/consumption models with transaction costs. In: Rogers, L.C.G. and Talay, D. (Eds.), Numerical Methods in Finance. Cambridge University Press, Cambridge, 245-269.

Allocating the Tracking Error for the Multi-Asset-Class Fund by Reconciling Bottom-Up Model with Top-Down Model

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Abstract

In the management of passive funds, the fund manager is given a benchmark index to follow. However, the manager may want to be more active if opportunity arises. To prevent the manager from being overly active, the manager is given an upper limit of the TE. Also, with a multi-asset-class portfolio, the manager may be subjected not only to a TE limit on the overall portfolio, but also to a TE limit on each asset class. The manager is allowed to invest in each asset class in a manner that slightly differs from that asset class's benchmark if he sees an opportunity to generate the excess return, as long as he does not violate the TE limit of the asset class or the TE limit of the entire portfolio. So this study want to answer how to allocate the TE limit on each asset class to maximize the excess return. To answer that problem, we use the top-down model instead of the bottom-up model. These two models are equivalent when the TEs of asset classes are loose. However, the top-down model can dramatically decrease the computational time for optimization.

Keywords**:** Tracking error, Multi-asset-class fund, TE allocation, Bottom-up model, Top-down model, Optimization

1. Introduction

In the management of passive funds, the fund manager is given a benchmark index to follow. Sometimes, however, the manager may want to be more active (over-weight or under-weight certain risk factors relative to benchmark) if opportunity arises. But to prevent the manager from being overly active, the manager is given an upper limit of the *tracking error*. In other words, the portfolio has the benchmark, but the manager is given room to be active up to the certain limit. (Note that our situation here is not the same as an index fund in which the manager attempts to minimize the tracking error.)

In this work, the tracking error (TE) is defined as the standard deviation of the difference between the portfolio return and its benchmark return (this difference return is called the excess return). Also, a multi-asset-class portfolio is the focus of this work. The multi-asset-class portfolio is a portfolio investing in various asset classes. The manager's performance on each asset class is usually reported along with the total portfolio's performance. And because each asset class usually has its own widely-accepted benchmark, the manager may be subjected not only to a TE limit on the overall portfolio, but also to a TE limit on each asset class. The manager is allowed to invest in each asset class in a manner that slightly differs from that asset class's benchmark if he sees an opportunity to generate the excess return, as long as he does not violate the TE limit of the asset class or the TE limit of the entire portfolio. Provided that the weights invested in each asset class are fixed, we are interested in finding the TE utilized by each asset class, so that the portfolio achieves the maximum expected excess return, while at the same time satisfying both the TE limit of the portfolio and the TE limits of asset classes.

One of the first studies about the asset allocation with the constraint on the TE limit of the portfolio was Roll (1992). Based on Roll's study, there were many studies that added more constraints to the Roll's model, such as Jorion (2003), Alexander and Baptista (2008) and Bajeux-Besnainou, Belhaj, Maillard and Portait (2011). These studies, however, had only one benchmark. Chen, Jiang and Zhu (2009) and Xu, Zheng, Natarajan and Teo (2014) were the examples of the studies having multiple benchmarks but their studies still had only the constraint on the TE limit of the portfolio.

All studies stated above had only the constraint on the TE limit of the portfolio. It is obvious that our study is different from the previous studies because our study takes the TE limit of each asset class into consideration. We can claim that our study is one of the first studies that have the constraints on the TE limits both of the portfolio and of each asset class. Besides, the previous studies focused on finding the investment weights that maximize the expected excess return of the portfolio. However, our study focuses on the risk budgeting not the asset allocation. That is to say, the focus of this work is to find how much TE is utilized by each asset class in order to maximize the expected excess return of the entire portfolio. Moreover, we only focus on the situation that the TE limits of the asset classes is tight, which means a TE limit of an asset class is less than or equal to the TE limit of the portfolio.

To solve this problem, we initially propose the bottom-up model. In the bottom-up model, the return of an asset class is built up from a set of risk factors, and the decision variables of the model are the factor loadings. That means the number of the decision variables of the model is the number of asset classes time the number of risk factors. After we get the factor loadings, we can compute the TE utilization of each asset class. Unfortunately, there is no closed-form solution, so we have to use numerical searching approach to solve the problem. This means that the computational time for optimization depends on the number of the decision variables.

The bottom-up model is straightforward to solve the problem. However, the number of the results we will get from that model are more than the number of the results we want, which is just equal to the number of asset classes. Therefore, we propose the other model called the top-down model to solve the problem instead and this model also give us the same results as the bottom-up model. In the top-down model, the decision variables are the TE utilization of each asset class directly. Although the top-down model has no closed-form solution, it dramatically decreases the computational time for optimization.

The paper is organized as follows. Section 2 is literature review. In Section 3 which is methodology, we clarify how to formulate the bottom-up model and the top-down model. The results can be found in Section 4. Finally, Section 5 summarizes this whole study.

2. Literature review

Although our study is the risk budgeting, our model is similar to the model in the asset allocation. We, therefore, will initially talk about the asset allocation. The asset allocation is an investment strategy that attempts to balance risk and reward by apportioning a portfolio's assets according to the investor's goals, risk tolerance and investment horizon. The simple approach is mean-variance analysis introduced by Harry Markowitz (1952). Mean-variance analysis is a mathematical framework for assembling a portfolio of assets such that the expected return is maximized for a given level of risk. It is a formalization and extension of diversification in investing, the idea that owning different kinds of financial assets is less risky than owning only one type. It uses the variance of asset prices as a proxy for risk. Next, we move to new framework which is similar to mean-variance framework. That is excess-return-tracking-error framework. The excess return is defined as the difference between

portfolio return and its benchmark return, and the TE is defined as the standard deviation of the excess return.

To understand better about the asset allocation with the constraint on the TE limit of the portfolio. We first review Roll (1992). His study showed that this allocation may overlook the portfolio's risk which is a risk the investor is also concerned about. He proposed the additional constraint, the portfolio's beta, to limit the portfolio's risk. Based on Roll's model with the additional constraint, Jorion (2003) changed that constraint to the portfolio's variance. His finding was that this constraint made the TE-constrained portfolio closer to the efficient frontier in the mean-variance space. Instead of using the portfolio's variance as the additional constraint, Alexander and Baptista (2008) used the portfolio's value-at-risk (VaR) instead. They said that the portfolio's VaR can make the portfolio closer to the efficient frontier as well. Besides, the fund management industry increasingly used VaR to allocate asset among managers, set risk limit, and monitor asset allocation and managers. Unlike the works that concerned about the portfolio's risk, Bajeux-Besnainou, Belhaj, Maillard and Portait (2011) was about the asset allocation with the constraint on the TE limit of the portfolio and on the assets' weight. They found that in the excess return-TE space, when the weight constraint is not binding, the efficient frontier is linear and hyperbolic otherwise.

The studies in the previous paragraph have only one benchmark. Next, we review the studies about the asset allocation which have multiple benchmarks and still have the constraint on the TE limit of the portfolio. The benefit of the multi-benchmarks portfolio is that the variance of its excess return is less than the variance of the excess return of the single-benchmark portfolio. Chen, Jiang and Zhu (2009) decomposed the TE into two components, namely, the deviation from the benchmark within the style-factor space and the additional risk factors associated with fund alphas. The decomposition helps us to point out managers having active-seeking skill. Xu, Zheng, Natarajan and Teo (2014) defined the TE differ from our work; that is, the standard deviation of the difference between portfolio return and the highest return from the set of benchmarks. New definition makes their solution be less sensitive to estimation errors in the mean and covariance.

Those studies did not set the TE limit on each asset class, so our study will focus on this problem. Although our study is based on Roll's model, the solution that we want to get is different from Roll's study and other studies. We want to find the TE utilized by each asset

class, so that the portfolio achieves maximum expected excess return, not the optimal weight invested in each asset class.

3. Methodology

3.1 Bottom-up model

In the bottom-up model, each asset class return and its own benchmark return is a linear combination of a group of risk factors, and also have exposed to the same risk factors. Each asset class must be chosen how much it should be exposed to each risk factor with the objective of maximizing the expected excess return of the portfolio and satisfy the constraints on the TE limit of the portfolio and the TE limits of the asset classes. The resulting (optimal) beta will determine the optimal TEs of the asset classes.

Let $\tilde{r}_i$ denote the return of the ith asset class's benchmark and suppose that $\tilde{r}_i$ depends on n factors in $f = [f_1 \quad f_2 \quad \dots \quad f_n]'$. The factor f is a set of joint random variables with mean μ and covariance Σ. The return of the ith asset class's benchmark is computed by the linear model as following

$$\tilde{r}_i = \tilde{\beta}_i f, \tag{3.1}$$

where the factor loading of the ith asset class's benchmark return $\tilde{\beta}_i = [\tilde{\beta}_{i,1} \quad \tilde{\beta}_{i,2} \quad \dots \quad \tilde{\beta}_{i,n}]$ is given and constant. The factor f represents the abstract risk factors on which the benchmark return depend, although some risk factors may have macro-economic interpretation such as economic growth, inflationary index, etc. The return of each asset class's benchmark should have exposures to different factors in f (the benefits of diversification) and it is unnecessary to expose to all entries in f. For example, if the return of the first asset class's benchmark has exposed only to the first and second factors, the factor loadings of the first asset class's benchmark return $\tilde{\beta}_1 = [\tilde{\beta}_{1,1} \quad \tilde{\beta}_{1,2} \quad 0 \quad \dots \quad 0]$ where $\tilde{\beta}_{1,1}$ and $\tilde{\beta}_{1,2} \neq 0$.

Let r_i denote the return of the ith asset class and suppose that r_i depends on the same subset of factors in f. The return of the ith asset class is computed by the linear model as following

$$r_i = \beta_i f, \tag{3.2}$$

where the factor loading of the ith asset class's return $\beta_i = [\beta_{i,1} \quad \beta_{i,2} \quad \dots \quad \beta_{i,n}]$ is constant. Both $\tilde{r}_i$ and r_i have exposed to the same factors. In other words, if the return of the first asset class's benchmark has exposed only to the first and second factors, the factor loading of the first asset class's return $\beta_1 = [\beta_{1,1} \quad \beta_{1,2} \quad 0 \quad \dots \quad 0]$ where $\beta_{1,1}$ and $\beta_{1,2} \neq 0$.

Let α_i denote the excess return of the ith asset class which is

$$\alpha_i = r_i - \tilde{r}_i = (\beta_i - \tilde{\beta}_i)f. \tag{3.3}$$

Also, let ε_i^2 (ε^2 is called the TE variance which is the quadratic form of the TE) denote the variance of the excess return of the ith asset class which is

$$\varepsilon_i^2 = \mathrm{Var}(\alpha_i) = (\beta_i - \tilde{\beta}_i)\Sigma(\beta_i - \tilde{\beta}_i)', \tag{3.4}$$

where Σ is the covariance matrix of the factor f.

After we get the equations for an asset class, we can find the equations for the portfolio.

Let $r = [r_1 \quad r_2 \quad \dots \quad r_m]'$ denote the vector of the returns of m asset classes so the return of the portfolio given positive constant weight $w = [w_1 \quad w_2 \quad \dots \quad w_m]'$, where $\sum_{i=1}^{m} w_i = 1$, to m asset classes is

$$r_p = w'r. \tag{3.5}$$

Let $\tilde{r} = [\tilde{r}_1 \quad \tilde{r}_2 \quad \dots \quad \tilde{r}_m]'$ denote the vector of the returns of m asset classes' benchmarks and suppose that the return of portfolio's benchmark has been given the same weight w as the return of the portfolio. The return of portfolio's benchmark is

$$\tilde{r}_p = w'\tilde{r}. \tag{3.6}$$

Let α_p denote the excess return of the portfolio computed as

$$\alpha_p = r_p - \tilde{r}_p = w'(r - \tilde{r}) = w'(\beta - \tilde{\beta})f, \tag{3.7}$$

and let ε_p^2 denote the TE variance of the portfolio which is

$$\varepsilon_p^2 = \mathrm{Var}(\alpha_p) = w'(\beta - \tilde{\beta})\Sigma(\beta - \tilde{\beta})'w, \tag{3.8}$$

where

$$\beta = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_m \end{bmatrix} = \begin{bmatrix} \beta_{1,1} & \beta_{1,2} & \cdots & \beta_{1,n} \\ \beta_{2,1} & \beta_{2,2} & \cdots & \beta_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{m,1} & \beta_{m,2} & \cdots & \beta_{m,n} \end{bmatrix},$$

and

$$\tilde{\beta} = \begin{bmatrix} \tilde{\beta}_1 \\ \tilde{\beta}_2 \\ \vdots \\ \tilde{\beta}_m \end{bmatrix} = \begin{bmatrix} \tilde{\beta}_{1,1} & \tilde{\beta}_{1,2} & \cdots & \tilde{\beta}_{1,n} \\ \tilde{\beta}_{2,1} & \tilde{\beta}_{2,2} & \cdots & \tilde{\beta}_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\beta}_{m,1} & \tilde{\beta}_{m,2} & \cdots & \tilde{\beta}_{m,n} \end{bmatrix}.$$

In this model, the manager seeks the maximum expected excess return of the entire portfolio by determining all the factor loadings for all asset classes in a single optimization problem, subject to constraints on the overall portfolio's TE and the constraints on the asset classes' TEs.

The excess return of the portfolio is $w'(\beta - \tilde{\beta})f$ referring from equation (3.7), so the expected excess return of the portfolio is

$$\mathrm{E}[\alpha_p] = \mathrm{E}[w'(\beta - \tilde{\beta})f] = w'(\beta - \tilde{\beta})\mu = \sum_{i=1}^{m}\sum_{j=1}^{n} w_i(\beta_{i,j} - \tilde{\beta}_{i,j})\mu_j\,, \tag{3.9}$$

where $\mu = [\mu_1 \quad \mu_2 \quad \cdots \quad \mu_n]'$ is the expected values of the factor f. And from equation (3.4), $\varepsilon_i = \sqrt{(\beta_i - \tilde{\beta}_i)\Sigma(\beta_i - \tilde{\beta}_i)'}$, the matrix of asset classes' TEs is given by

$$\begin{aligned} \varepsilon_\beta &= \mathrm{diag}(\varepsilon_1,\ \varepsilon_2,\ \ldots\ ,\ \varepsilon_m) \\ &= \mathrm{diag}\left(\sqrt{(\beta_1 - \tilde{\beta}_1)\Sigma(\beta_1 - \tilde{\beta}_1)'},\ \sqrt{(\beta_2 - \tilde{\beta}_2)\Sigma(\beta_2 - \tilde{\beta}_2)'},\ \ldots\ ,\ \sqrt{(\beta_m - \tilde{\beta}_m)\Sigma(\beta_m - \tilde{\beta}_m)'}\right), \end{aligned} \tag{3.10}$$

which depends on β. Since $\alpha_i = (\beta_i - \tilde{\beta}_i)f$ referring from equation (3.3), it follows that the correlation between α_i and α_j is

$$\frac{\mathrm{Cov}(\alpha_i, \alpha_j)}{\sqrt{\mathrm{Var}(\alpha_i)}\sqrt{\mathrm{Var}(\alpha_j)}} = \frac{\mathrm{Cov}\left((\beta_i - \tilde{\beta}_i)f \ , \ f'(\beta_j - \tilde{\beta}_j)'\right)}{\varepsilon_i \, \varepsilon_j}$$

$$= \frac{(\beta_i - \tilde{\beta}_i)\Sigma(\beta_j - \tilde{\beta}_j)'}{\varepsilon_i \, \varepsilon_j}. \quad (3.11)$$

Therefore, the correlation matrix of the asset classes' excess returns is

$$R_\beta = \begin{bmatrix} 1 & \cdots & \frac{(\beta_m - \tilde{\beta}_m)\Sigma(\beta_1 - \tilde{\beta}_1)'}{\sqrt{(\beta_m - \tilde{\beta}_m)\Sigma(\beta_m - \tilde{\beta}_m)'}\sqrt{(\beta_1 - \tilde{\beta}_1)\Sigma(\beta_1 - \tilde{\beta}_1)'}} \\ \vdots & \ddots & \vdots \\ \frac{(\beta_1 - \tilde{\beta}_1)\Sigma(\beta_m - \tilde{\beta}_m)'}{\sqrt{(\beta_1 - \tilde{\beta}_1)\Sigma(\beta_1 - \tilde{\beta}_1)'}\sqrt{(\beta_m - \tilde{\beta}_m)\Sigma(\beta_m - \tilde{\beta}_m)'}} & \cdots & 1 \end{bmatrix}. \quad (3.12)$$

Equation (3.12) shows that R_β is not the function of ε_β (i.e., ε_β is not sufficient statistics of R_β.) And this correlation matrix R_β can be written in matrix form as

$$R_\beta = \varepsilon_\beta^{-1}(\beta - \tilde{\beta})\Sigma(\beta - \tilde{\beta})'\varepsilon_\beta^{-1}. \quad (3.13)$$

This R_β will be useful for estimating R_ε later. Note that the TE variance of the entire portfolio is $w'\varepsilon_\beta R_\beta \varepsilon_\beta w = w'(\beta - \tilde{\beta})\Sigma(\beta - \tilde{\beta})'w$ which agrees with equation (3.8).

Therefore, the bottom-up model, which is modelled to maximize the expected excess return of the portfolio subjected to the constraints on the TEs of the asset classes $\varepsilon_i = \sqrt{(\beta_i - \tilde{\beta}_i)\Sigma(\beta_i - \tilde{\beta}_i)'}$ and the TE of the portfolio $\varepsilon_p = \sqrt{w'\varepsilon_\beta R_\beta \varepsilon_\beta w}$, is expressed as

$$\max_{\beta} \quad \sum_{i=1}^{m}\sum_{j=1}^{n} w_i(\beta_{i,j} - \tilde{\beta}_{i,j})\mu_j \quad (3.14)$$

$$\text{s.t.} \quad w'\varepsilon_\beta R_\beta \varepsilon_\beta w \le T_p^2$$

$$(\beta_1 - \tilde{\beta}_1)\Sigma(\beta_1 - \tilde{\beta}_1)' \le T_1^2$$

$$\vdots$$

$$(\beta_m - \tilde{\beta}_m)\Sigma(\beta_m - \tilde{\beta}_m)' \le T_m^2.$$

There is no the closed-form solution to this problem, so we have to use a numerical searching approach. Then, the resulting β will be used to compute ε which is the final result we want.

3.2 Top-down model

As mentioned in the previous sub section, the bottom-up model is straightforward to solve the problem of the TE utilization. However, the disadvantage of that model is the computational time for optimization depending on the number of the decision variables which are more than the number of the results we want (the number of asset classes). Therefore, we propose the other model called the top-down model to solve the problem instead and this model also give us the same results as the bottom-up model.

In the top-down model, each asset class is determined its factor loadings independently of other asset classes to maximize its expected excess return, subject to a given TE constraint. The manager's job is to assign the TE utilization to each asset class to make sure that both the TE limit of the overall portfolio and the TE limit of each asset class are not violated.

Let subscript (i) be the partition of a variable which the return of the ith asset class's benchmark has exposed to the factor f. For example, if the return of the first asset class's benchmark has exposures only to the first and second factors, $f_{(1)} = [f_1 \quad f_2]'$, $\tilde{\beta}_{(1)} = [\tilde{\beta}_{1,1} \quad \tilde{\beta}_{1,2}]$ and $\beta_{(1)} = [\beta_{1,1} \quad \beta_{1,2}]$.

The excess return of the ith asset class is computed as

$$\alpha_i = r_i - \tilde{r}_i = (\beta_{(i)} - \tilde{\beta}_{(i)}) f_{(i)}, \tag{3.15}$$

and the TE variance of the ith asset class is computed as

$$\varepsilon_i^2 = \mathrm{Var}(\alpha_i) = (\beta_{(i)} - \tilde{\beta}_{(i)}) \Sigma_{(i)} (\beta_{(i)} - \tilde{\beta}_{(i)})', \tag{3.16}$$

where $\Sigma_{(i)}$ is the covariance matrix of $f_{(i)}$.

The top-down model is the 2-stage optimization. The first stage is to maximize the expected excess return of each asset class under the constraint that the TE of the ith asset class ε_i is freely chosen by the manager. The decision variable of this stage is $\beta_{(i)}$. After solving the problem in this stage, we find that $\beta_{(i)}$ is a function of the ith asset class's TE ε_i. In the second stage, we maximize the expected excess return of the portfolio under the constraint on

the TE limits of the asset classes T_is and TE limit of the portfolio T_p. The decision variable of the second stage is ε_i.

The expected excess return of the ith asset class is $\mathrm{E}[\alpha_i] = \beta_{(i)}\mu_{(i)} - \tilde{\beta}_{(i)}\mu_{(i)}$ where $\mu_{(i)}$ is the expected values of $f_{(i)}$. Since the term $\tilde{\beta}_{(i)}\mu_{(i)}$ is constant and independent of the decision variable $\beta_{(i)}$, the top-down model in the first stage is expressed as

$$\max_{\beta_{(i)}} \ \beta_{(i)}\mu_{(i)} \tag{3.17}$$

$$\text{s.t.} \quad (\beta_{(i)} - \tilde{\beta}_{(i)})\Sigma_{(i)}(\beta_{(i)} - \tilde{\beta}_{(i)})' = \varepsilon_i^2.$$

Optimization problem (3.11) can be solved by an analytical approach as following.

Setting up the Lagrangian function L using the multiplier λ

$$\begin{aligned} L \ &= \beta_{(i)}\mu_{(i)} + 0.5\lambda\left((\beta_{(i)} - \tilde{\beta}_{(i)})\Sigma_{(i)}(\beta'_{(i)} - \tilde{\beta}'_{(i)}) - \varepsilon_i^2\right) \\ &= \beta_{(i)}\mu_{(i)} + 0.5\lambda(\beta_{(i)}\Sigma_{(i)}\beta'_{(i)} - 2\beta_{(i)}\Sigma_{(i)}\tilde{\beta}'_{(i)} + \tilde{\beta}_{(i)}\Sigma_{(i)}\tilde{\beta}'_{(i)} - \varepsilon_i^2). \end{aligned} \tag{3.18}$$

Taking partial derivatives with respect to $\beta'_{(i)}$ and setting it to zero

$$\frac{\partial L}{\partial \beta'_{(i)}} = \mu_{(i)} + \lambda(\Sigma_{(i)}\beta'_{(i)} - \Sigma_{(i)}\tilde{\beta}'_{(i)}) = 0. \tag{3.19}$$

Taking partial derivatives with respect to λ and setting it to zero

$$\frac{\partial L}{\partial \lambda} = 0.5(\beta_{(i)}\Sigma_{(i)}\beta'_{(i)} - 2\beta_{(i)}\Sigma_{(i)}\tilde{\beta}'_{(i)} + \tilde{\beta}_{(i)}\Sigma_{(i)}\tilde{\beta}'_{(i)} - \varepsilon_i^2) = 0. \tag{3.20}$$

Solving equations (3.19) and (3.20) simultaneously, we get

$$\beta_{(i)} = \tilde{\beta}_{(i)} - \frac{1}{\lambda}\mu'_{(i)}\Sigma_{(i)}^{-1}, \tag{3.21}$$

$$\lambda = \pm\sqrt{\frac{\mu'_{(i)}\Sigma_{(i)}^{-1}\mu_{(i)}}{\varepsilon_i^2}}. \tag{3.22}$$

Choosing λ that maximize the objective value, the solution is

$$\begin{aligned}\beta_{(i)} &= \tilde{\beta}_{(i)} + \varepsilon_i \sqrt{\frac{1}{\mu'_{(i)}\Sigma^{-1}_{(i)}\mu_{(i)}}}\,\mu'_{(i)}\Sigma^{-1}_{(i)} \\ &= \tilde{\beta}_{(i)} + \varepsilon_i c_{(i)}, \end{aligned} \tag{3.23}$$

where $c_{(i)} = \sqrt{\frac{1}{\mu'_{(i)}\Sigma^{-1}_{(i)}\mu_{(i)}}}\,\mu'_{(i)}\Sigma^{-1}_{(i)}$ is just the coefficients of ε_i for equations (3.23). Before moving to the second stage, we compute the objective function of optimization problem (3.17); that is

$$\begin{aligned}\beta_{(i)}\mu_{(i)} &= \tilde{\beta}_{(i)}\mu_{(i)} + \varepsilon_i \sqrt{\frac{1}{\mu'_{(i)}\Sigma^{-1}_{(i)}\mu_{(i)}}}\,\mu'_{(i)}\Sigma^{-1}_{(i)}\mu_{(i)} \\ &= \tilde{\beta}_{(i)}\mu_{(i)} + \varepsilon_i \sqrt{\mu'_{(i)}\Sigma^{-1}_{(i)}\mu_{(i)}} \end{aligned} \tag{3.24}$$

Since $\mathrm{E}[r_i] = \beta_{(i)}\mu_{(i)}$ and $\mathrm{E}[\tilde{r}_i] = \tilde{\beta}_{(i)}\mu_{(i)}$, equation (3.24) implies that the expected excess return $\mathrm{E}[\alpha_i] = \mathrm{E}[r_i] - \mathrm{E}[\tilde{r}_i]$ of the ith asset class is

$$\mathrm{E}[\alpha_i] = \varepsilon_i \sqrt{\mu'_{(i)}\Sigma^{-1}_{(i)}\mu_{(i)}}. \tag{3.25}$$

Next, we move to the second stage. We first have to change $\beta_{(i)}$ back into β_i by setting $\beta_{i,j}$ which the return of the ith asset class's benchmark does not have exposures to the factor f to be zero. For example, if the return of the first asset class's benchmark has exposures to the first and second factors, $\tilde{\beta}_{(1)} = \begin{bmatrix}\tilde{\beta}_{1,1} & \tilde{\beta}_{1,2}\end{bmatrix}$. Thus, $\tilde{\beta}_1 = \begin{bmatrix}\tilde{\beta}_{1,1} & \tilde{\beta}_{1,2} & \tilde{\beta}_{1,3} & \dots & \tilde{\beta}_{1,n}\end{bmatrix} = \begin{bmatrix}\tilde{\beta}_{1,1} & \tilde{\beta}_{1,2} & 0 & \dots & 0\end{bmatrix}$ where $\tilde{\beta}_{1,1}$ and $\tilde{\beta}_{1,2} \neq 0$. For changing $\beta_{(i)}$ and $c_{(i)}$ back into β_i and c_i respectively, we can do the same way as $\tilde{\beta}_{(i)}$ so the matrices β, $\tilde{\beta}$ and C are

$$\beta = \begin{bmatrix}\beta_1 \\ \beta_2 \\ \vdots \\ \beta_m\end{bmatrix} = \begin{bmatrix}\beta_{1,1} & \beta_{1,2} & \cdots & \beta_{1,n} \\ \beta_{2,1} & \beta_{2,2} & \cdots & \beta_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{m,1} & \beta_{m,2} & \cdots & \beta_{m,n}\end{bmatrix}, \tag{3.26}$$

$$\tilde{\beta} = \begin{bmatrix}\tilde{\beta}_1 \\ \tilde{\beta}_2 \\ \vdots \\ \tilde{\beta}_m\end{bmatrix} = \begin{bmatrix}\tilde{\beta}_{1,1} & \tilde{\beta}_{1,2} & \cdots & \tilde{\beta}_{1,n} \\ \tilde{\beta}_{2,1} & \tilde{\beta}_{2,2} & \cdots & \tilde{\beta}_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\beta}_{m,1} & \tilde{\beta}_{m,2} & \cdots & \tilde{\beta}_{m,n}\end{bmatrix}, \tag{3.27}$$

$$C = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_m \end{bmatrix} = \begin{bmatrix} c_{1,1} & c_{1,2} & \cdots & c_{1,n} \\ c_{2,1} & c_{2,2} & \cdots & c_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ c_{m,1} & c_{m,2} & \cdots & c_{m,n} \end{bmatrix}. \tag{3.28}$$

The expected excess return of the portfolio in this model is

$$\mathrm{E}[\alpha_p] = \sum_{i=1}^{m} w_i \, \mathrm{E}[\alpha_i] = \sum_{i=1}^{m} w_i \, \varepsilon_i \sqrt{\mu'_{(i)} \Sigma^{-1}_{(i)} \mu_{(i)}}. \tag{3.29}$$

Note that $\mu_{(i)}$ and $\Sigma_{(i)}$ are a column vector and a matrix respectively.

Also, the TE variance of the portfolio in this model is

$$\varepsilon_p^2 = \mathrm{Var}(\alpha_p) = \mathrm{Var}\left(w'\left(\beta - \tilde{\beta}\right) f\right) = w' \varepsilon C \Sigma C' \varepsilon w, \tag{3.30}$$

where $\varepsilon = \mathrm{diag}(\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_m)$ is the diagonal matrix containing the TEs of the asset classes.

Thus, the problem of maximizing the expected excess return of the portfolio subjected to the constraints on the TE limits of the asset classes T_is and TE limit of the portfolio T_p can be written as

$$\max_{\varepsilon} \quad \sum_{i=1}^{m} w_i \varepsilon_i \sqrt{\mu'_{(i)} \Sigma^{-1}_{(i)} \mu_{(i)}} \tag{3.31}$$

$$\text{s.t.} \quad w' \varepsilon C \Sigma C' \varepsilon w \leq T_p^2$$

$$\varepsilon_i \leq T_i \qquad \forall i \in \{1, 2, \ldots, m\}$$

$$\varepsilon_i \geq 0 \qquad \forall i \in \{1, 2, \ldots, m\}.$$

The top-down has no the closed-form solution as well. However, the computational time of this model is dramatically less than the computational time of the bottom-up model. We will show the result in the following section.

4. Result

We set the values of the parameter $\Sigma, \mu, \tilde{\beta}$ and w as shown in the following tables.

Table 1: The covariance matrix of risk factors Σ

Factor	1	2	3	4	5	6	7	8
1	1.21%	0.30%	0.32%	1.55%	0.07%	-0.13%	-0.90%	0.20%
2	0.30%	1.96%	1.06%	0.06%	0.17%	-0.06%	0.22%	0.31%
3	0.32%	1.06%	4.49%	0.39%	1.39%	0.24%	1.86%	1.57%
4	1.55%	0.06%	0.39%	4.08%	-0.09%	-0.31%	-2.96%	0.16%
5	0.07%	0.17%	1.39%	-0.09%	4.08%	0.26%	2.69%	2.73%
6	-0.13%	-0.06%	0.24%	-0.31%	0.26%	0.36%	0.50%	0.03%
7	-0.90%	0.22%	1.86%	-2.96%	2.69%	0.50%	9.00%	2.46%
8	0.20%	0.31%	1.57%	0.16%	2.73%	0.03%	2.46%	2.92%

Table 2: The expected values of risk factors μ

Factor	μ
1	7.0%
2	7.5%
3	5.5%
4	10.0%
5	10.0%
6	5.5%
7	11.0%
8	9.5%

Table 3: The factor loading of sub-manager's benchmark returns $\tilde{\beta}$

Fund	Factor							
	1	2	3	4	5	6	7	8
1	0.6300	1.6646	0	0	0	0	1.4980	1.5890
2	0	1.2904	0.5227	0	1.2849	1.4390	0	0
3	0	1.1389	0	1.3218	0	1.5809	0	0.6936

Table 4: The weights investing in sub-managers w

Fund	Weight
1	33.33%
2	33.33%
3	33.33%

Also, the results of solving the bottom-up model and top-down model are shown in the table below.

Table 5: The results of solving the bottom-up model and top-down model

Model	T_p	T_1	T_2	T_3	ε_p	ε_1	ε_2	ε_3	$\mathrm{E}[\alpha_p]$	Time
Bottom-up	2.00%	2.90%	1.10%	3.10%	2.00%	2.90%	1.10%	3.10%	2.78%	33.31
Top-down	2.00%	2.90%	1.10%	3.10%	2.00%	2.90%	1.10%	3.10%	2.78%	0.27
Bottom-up	2.00%	1.10%	2.10%	3.60%	2.00%	1.10%	2.10%	3.60%	2.83%	33.24
Top-down	2.00%	1.10%	2.10%	3.60%	2.00%	1.10%	2.10%	3.60%	2.83%	0.28
Bottom-up	2.00%	4.60%	1.00%	1.40%	1.99%	4.60%	1.00%	1.40%	2.48%	31.59
Top-down	2.00%	4.60%	1.00%	1.40%	2.00%	4.60%	1.00%	1.40%	2.48%	0.38
Bottom-up	2.00%	1.80%	3.40%	1.90%	2.00%	1.80%	3.40%	1.90%	2.76%	27.58
Top-down	2.00%	1.80%	3.40%	1.90%	2.00%	1.80%	3.40%	1.90%	2.76%	0.30
Bottom-up	2.00%	2.00%	2.30%	2.80%	2.00%	2.00%	2.30%	2.80%	2.82%	22.61
Top-down	2.00%	2.00%	2.30%	2.80%	2.00%	2.00%	2.30%	2.80%	2.82%	0.35
Bottom-up	2.00%	3.30%	1.50%	2.40%	2.00%	3.30%	1.50%	2.40%	2.73%	25.43
Top-down	2.00%	3.30%	1.50%	2.40%	2.00%	3.30%	1.50%	2.40%	2.73%	0.30
Bottom-up	2.00%	4.00%	2.30%	1.00%	2.00%	4.00%	2.30%	1.00%	2.61%	37.02
Top-down	2.00%	4.00%	2.30%	1.00%	2.00%	4.00%	2.30%	1.00%	2.61%	0.34
Bottom-up	2.00%	1.50%	1.10%	4.20%	2.00%	1.50%	1.10%	4.20%	2.85%	26.85
Top-down	2.00%	1.50%	1.10%	4.20%	2.00%	1.50%	1.10%	4.20%	2.85%	0.34
Bottom-up	2.00%	1.30%	4.30%	1.30%	1.99%	1.30%	4.30%	1.30%	2.67%	27.21
Top-down	2.00%	1.30%	4.30%	1.30%	2.00%	1.30%	4.30%	1.30%	2.67%	0.29
Bottom-up	2.00%	3.70%	2.20%	1.40%	2.00%	3.70%	2.20%	1.40%	2.66%	21.20
Top-down	2.00%	3.70%	2.20%	1.40%	2.00%	3.70%	2.20%	1.40%	2.66%	0.33

Table 5 shows that if we can replace ε_i with T_i and it still meets this constraint

$$w'\varepsilon C\Sigma C'\varepsilon w \leq T_p\,,$$

then we can use the top-down model instead of the bottom-up model. The results from both two models are the same. Moreover, the top-down model dramatically reduce the computational time for optimization.

5. Conclusion

In the management of passive funds, the fund manager is given a benchmark index to follow. Sometimes, however, the manager may want to be more active if opportunity arises. But to prevent the manager from being overly active, the manager is given an upper limit of the TE.

In this work, we focus on a multi-asset-class portfolio. The manager's performance on each asset class is usually reported along with the total portfolio's performance. And because each asset class usually has its own widely-accepted benchmark, the manager may be subjected not only to a TE limit on the overall portfolio, but also to a TE limit on each asset class. The manager is allowed to invest in each asset class in a manner that slightly differs from that asset class's benchmark if he sees an opportunity to generate the excess return, as long as he does not violate the TE limit of the asset class or the TE limit of the entire portfolio. Provided that the weights invested in each asset class are fixed, we are interested in finding the TE utilized by each asset class, so that the portfolio achieves the maximum expected excess return, while at the same time satisfying both the TE limit of the portfolio and the TE limits of asset classes.

To solve the problem, we use the top-down model that has less number of decision variables instead of the bottom-up model that is straightforward. These two models are equivalent in the situation that the TEs of asset classes are loose, but the top-down model can dramatically decrease the computational time for optimization. Therefore, we can find the TE utilization of each asset class directly by using the top-down model.

Notation

Symbol	Dimension	Meaning
m	Scalar	Number of asset classes
n	Scalar	Number of risk factors
f	$n \times 1$	Vector of random values of risk factors
μ	$n \times 1$	Vector of expected values of risk factors
Σ	$n \times n$	Covariance matrix of risk factors
β_i	$1 \times n$	Vector of factor loading of the ith asset class return
$\tilde{\beta}_i$	$1 \times n$	Vector of factor loading of the ith asset class's benchmark return
β	$m \times n$	Factor loading matrix of asset class returns
$\tilde{\beta}$	$m \times n$	Factor loading matrix of asset class's benchmark returns
w	$m \times 1$	Vector of weights investing in m asset classes
r	$m \times 1$	Vector of asset class returns

$\tilde{r}$	$m \times 1$	Vector of asset class's benchmark returns
r_p	Scalar	Portfolio return
$\tilde{r}_p$	Scalar	Portfolio's benchmark return
α_p	Scalar	Portfolio excess return
ε_i	Scalar	TE of the ith asset class
ε	$m \times m$	Diagonal matrix of TEs of asset classes
ε_p	Scalar	TE of portfolio
T_i	Scalar	Upper TE limit of the ith asset class
T_p	Scalar	Upper TE limit of portfolio

Reference

Alexander, G.J., and Baptista, A.M. 2008. "Active portfolio management with benchmarking: Adding a value-at-risk constraint." *Journal of Economic Dynamics & Control*, 32(3): 779–820.

Bajeux-Besnainou, I., Belhaj, R., Maillard, D., and Portait, R. 2011. "Portfolio optimization under tracking error and weights constraints." *Journal of Financial Study*, 34(2): 295-330.

Chen, P., Jiang, G.J., and Zhu, K.X. 2009. "Fund of Funds, Portable Alpha, and Portfolio Optimization." *Journal of Portfolio Management*, 35(3): 79-92.

Jorion, P. 2003. "Portfolio Optimization with Tracking-Error Constraints." *Financial Analysts Journal*, 59(5): 70-82.

Markowitz, H.M. 1952. "Portfolio Selection." *Journal of* Finance, 7(1): 77-91.

Roll, R. 1992. "A Mean/Variance Analysis of Tracking Error." *Journal of Portfolio Management*, 18(4): 13-22.

Xu, Y., Zheng, Z., Natarajan, K., and Teo, C. 2014. "Tracking-error models for multiple benchmarks: Theory and empirical performance." Working paper, Study Collection Lee Kong Chian School Of Business.

A Lending Decision Problem for Unfamiliar Loans

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Abstract

In this paper, we consider a lending decision problem of an agent who needs to decide whether to accept or reject a sequence of unfamiliar loan applications based on the characteristics of the loans. The agent is new to this type of loan and hence predicts the risk of default with low accuracy. However, the agent can learn by observing the outcomes of the accepted loans. The agent has a budget which increases every time he accepts a loan that is fully repaid, and decreases every time he accepts a loan that becomes defaulted. The objective of the agent is to maximize the final budget. Using the concept of reinforcement learning, we propose a decision making model that takes the current budget and model accuracy into consideration when making decisions. Based on simulated data, the results show that our model yields a better performance compared to a traditional default prediction model.

1. Introduction

Lending is a core business of most commercial banks. Banks typically have models to classify loan applications into good and bad applications through the probability of default. To develop such models, banks require data to train them. However, building a model to classify loan applications that the bank is not familiar with is difficult as the data are not readily available. This may result in banks deciding not to lend because banks cannot predict default accurately. Unfortunately, the only way to obtain more data is to lend. Lending to non-defaulted borrowers can generate profits. On the contrary, lending to defaulted borrowers generates losses. Prediction accuracy is low at the beginning, therefore, cost of exploring from making mistakes (i.e., lending to the defaulted borrowers) can be high. Furthermore, given that we have limited budget to explore this new group of borrowers, making mistakes too often at the beginning may use up all the budget and hence stop us from making more loans. However, being too conservative and lending to borrowers, who we strongly believe that are low risk borrowers, may take extremely long time to collect enough data and leads to losing competitive advantages. The low accuracy of the prediction model and the budget constraint should be taken into account in the decision making process because each lending decision affects the amount of data that the prediction model can get and causes a change in the budget.

There are many models that can be used to predict default probabilities. For example, Fantazzini and Figini (2009) propose Random Survival Forests (RSF) model for SME credit risk measurement. They use new financial ratios in the RSF model, which is a non-parametric procedure, then compare it with a logistic regression model, which is a parametric procedure. They report that both could predict probability of default for Small and Medium Enterprises, but the logistic regression model could predict better than the RSF model in terms of forecasting performances in the out-of-sample data due to less estimation bias. Credit scoring models are also used to estimate the probability of default. Harris (2015) measures the credit scoring by using clustered support vector machine (CSVM). The author uses the German and Barbados dataset to train the model. He creates a linear regression model, linear support vector machine (SVM) model and radial basis function kernel SVM model. He compares the models in terms of AUC (area under the receiver operating characteristic (ROC) curve), balanced accuracy (BAC), training accuracy, test accuracy and training time. He suggests that CSVM performs better than the nonlinear SVM-based techniques in terms of AUC. However, the classification performance and mean model training time of this model still need to be improved.

As mentioned above, when banks need to make lending decisions for an unfamiliar type of loans, they should account for the model accuracy and the budget constraint. However, the prior models described above do not consider these two important factors. Reinforcement learning (RL) is a type of problems in which actions of agents affect the environments. In our lending situation, actions to reject most of the loans could save the budget, but this makes the model learn slowly. On the other hand, actions to accept too many loans could make the budget drop even though more data could be collected. In this paper, we propose a lending decision model based on the concept of reinforcement learning. Precisely, we use the current budget and the model accuracy to adjust how aggressive we are when we make the lending decisions, in addition to the predicted probability of default. We refer the reader to Leike et al. (2017) for more details about the reinforcement learning concepts. Based on simulated data, we find that the lenders should be less aggressive on the lending decisions when the budget and the accuracy are low. Compared with the typical lending decisions that rely only predicted probability of default, our model significantly outperforms especially when the data available to the lenders contain sufficient information to predict the probability of default.

The rest of this paper is organized as follows: Section 2 states our model formulation. Section 3 describes our model and the benchmark model. Section 4 describes how the data are generated. We report and discuss the results in Section 5. Conclusions are given in Section 6.

2. Problem Formulation

Consider a lending agent (e.g. bank) who needs to make lending decisions for a fixed number of borrowers who request for loans of an unfamiliar type. At each time period, a borrower arrives, and the agent observes the set of features of the borrower, which are the same type of data for all borrowers (e.g. age, gender, employment status, income, financial ratios, etc.). Then the agent uses his decision making model to decide whether to accept or reject the loan application. If he rejects the loan application, the borrower leaves immediately, and the next borrower comes. If he accepts the loan application, he immediately observes the outcome of the loan repayment. If the borrower is able to repay the loan in full (non-defaulted loan), the agent receives a positive reward representing the interest payment of r. However, if the loan defaults (defaulted loan), the agent receives a negative payoff representing the loss of $-L$. Then the new borrower arrivals, and the process is repeated until the last borrower shows up. During this process the agent can update his decision making model based on the new pieces of information. More specifically, when the agent accepts a loan application, he obtains new information as he can observe the borrower's features and the outcome of the loan. However, if he rejects the loan, no useful information can be obtained.

Before the arrival of the first borrower, the agent is provided with a fixed amount of budget for lending. Any positive reward will be added to the budget, while any negative reward will bring the budget down by the loss amount. The agent can continue making the lending decisions only if his budget is above zero. Once the budget becomes zero or negative, the process is terminated. The goal of the agent is to maximize the final budget.

We assume that the agent has an access to a large set of loan data consisting of borrowers' features and their repayment outcomes of one loan type. This could represent the data of loan type that the agent is familiar with. The agent can use this dataset to learn how to make decisions. The agent is then given a small set of loan data for another loan type, the unfamiliar one. The relationships between the borrowers' features and the default probability from these two loan types are different, and hence the agent has to build a new model for predicting the probability of default for the unfamiliar loan type. Once the agent has a

decision model for the unfamiliar loan type, the first borrower from the unfamiliar loan type arrives and the agent start to make his decision.

3. Decision Making Models

We have two decision making models in our study. The first one is the benchmark model that uses a logistic regression model to predict the probability of default based only on the borrower's features. The second model is our reinforcement-learning based model that uses the current budget and the model accuracy, in addition to the borrower's features, to make decisions. We first define some notations. Let $x_{i,t}$ denote the feature i of the borrower t for $i = 1, \dots, N$ and $t = 1, \dots, T$ where N is the number of features and T is the number of borrowers. Let d_t denote the decision made by the agent where $d_t = 1$ if he accepts the loan application of borrower t, and $d_t = 0$ otherwise. Let y_t denote the repayment outcome of t where $y_t = 1$ if loan t defaults, and $y_t = 0$ otherwise. The value of y_t is available to the agent only if he accepts loan application t. Let B_t denote the budget of the agent before the arrival of borrower $t + 1$. Here B_0 is the initial budget. If the agent rejects borrower t, then $B_t = B_{t-1}$. If the agent accepts borrower t, and the loan is fully repaid, then $B_t = B_{t-1} + r$. But if the accepted loan defaults, then $B_t = B_{t-1} - L$. We now describe the two decision models.

3.1 Benchmark model

The benchmark model uses the logistic regression model of the borrower's features to predict the default probability of each borrower t:

$$P(y_t = 1) = \frac{1}{1 + \exp\left(-\left[\beta_0 + \beta_1 x_{1,t} + \cdots + \beta_N x_{N,t}\right]\right)}.$$

The agent then compares the predicted probability, denoted by $\hat{p}_t$, to a time varying threshold θ_t. If $\hat{p}_t < \theta_t$, then the agent accepts the loan application of borrower t, and rejects it otherwise. Before the first arrival, the agent is given a small set of loan data of the unfamiliar type, say m data points. The agent uses these data points to estimate the logistic regression model and determine the initial threshold θ_0. The agent uses this model and the threshold to make decisions for the first n arrivals. Then he updates the model and the threshold again. He consequently uses them to make decisions for the next n arrivals before updating his logistic regression model and the threshold again. This process is repeated until the last arrival.

Let F_t denote the loan data available to the agent before borrower t arrives. This set of data includes the initial m data points given to the agent before the first arrival, and the data of all prior accepted loans. Before the arrival of borrower $t = kn$ for some non-negative integer k, the agent updates the logistic regression model based on F_t using the maximum likelihood estimation. Based on the fitted model, the threshold θ_t is chosen from a set Θ such that the resulting accuracy a_t is maximized:

$$\theta_t = argmax_{\theta \in \Theta}\{a_t | \pi(\theta), F_t\}$$

where $\pi(\theta)$ denotes the decision making rule based on threshold θ. Note that the agent only observes the loan data F_t, and hence only the corresponding borrowers are considered when the value of θ_t is chosen. In our study, we choose the number of borrowers $T = 9{,}900$, the initial set of data has $m = 100$ data points, the model is updated every $n = 100$ decisions, and the set of the threshold choices is

$$\Theta = \{1\%, 2\%, 3\%, \dots 14\%, 15\%, 20\%, 25\%, \dots, 45\%, 50\%\}.$$

Note that this benchmark model does not use the dataset of the familiar loan type as the relationships between the probability of default and the borrower's features for the two loan types are different.

3.2 Reinforcement learning-based model

We propose a decision model that accounts for the budget constraint and the accuracy of the predicted probability of default. This model uses the logistic regression model as in the benchmark model to predict the probability of default. We refer to this logistic regression model as the PD model. To make lending decisions, the model combines the predicted probability of default with the current budget and the current accuracy of the PD model to generate what we call the *adjusted* default probability. Then the adjusted default probability is compared with a threshold to arrive at a lending decision.

To be precise, let $\hat{s}_t$ denote the predicted *riskiness score* of borrower t computed from the PD model defined by

$$\hat{s}_t = \hat{\beta}_0 + \hat{\beta}_1 x_{1,t} + \cdots + \hat{\beta}_N \, x_{N,t} = \ln\left(\frac{\hat{p}_t}{1 - \hat{p}_t}\right)$$

where $\hat{\beta}_i$'s are the estimated parameters in the PD model. Let a_t denote the accuracy of the PD model before the arrival of borrower $t + 1$, and $b_t = \tanh(B_t)$ denote the transformed

budget based on the hyperbolic tangent function. We define the adjusted default probability of borrower t as follows:

$$\tilde{p}_t = \frac{1}{1 + \exp(-[w_0 + w_s \hat{s}_t + w_a a_t + w_b b_t])}.$$

where w_0 is a constant representing an intercept term and w_s, w_b and w_a are weight coefficients associated with the riskiness score, the transformed budget and the accuracy variables, respectively. In this model, the threshold θ is constant but the intercept w_0 is updated from time to time, equivalent to updating the threshold. For borrower t, the agent accepts the loan application if $\tilde{p}_t < \theta$, and he rejects it otherwise. The parameter w_s will be set to 1, while w_a and w_b are updated along with w_0 using the concept of reinforcement learning. The structure of the model is illustrated in Figure 1. We call this model as the RL model.

Unlike the benchmark model, the RL model uses a large set of loan data from a familiar loan type to calibrate the threshold θ, and to find the initial values of w_0, w_a and w_b that will be used to make decisions for the unfamiliar loan type. More specifically, for each fixed $\theta \in \Theta$, the agent is given $m + T$ observations of loan data (features and repayment outcomes) for training the model. The agent first estimates the PD model using the first m observations. He then uses the estimated PD model to compute the riskiness score from the first borrower's features and combines it with the accuracy of the PD model computed from the first m observations or a_0, which is equal to the number of corrected predictions divided by the number of predictions (m in this case), and the transformed initial budget $b_0 = \tanh(B_0)$ to make the lending decision for the first borrower. The initial values of w_0, w_a and w_b are set to 0. If the first loan application is accepted, the accuracy a_1 and the transformed budget b_1 are updated based on the value of y_1. If the loan is rejected, then there is no update and hence $a_1 = a_0$ and $b_1 = b_0$. The agent continues using the PD model and the initial values of w_0, w_a and w_b for the first n arrivals. Then he updates the PD model as in the benchmark model, and uses the reinforcement learning technique to update the values of w_0, w_a and w_b based on the loan data F_t, consisting of the initial m data points of the loan data and the data from the prior accepted loans. The update procedure of the weight coefficients w_0, w_a and w_b is based on the binary cross entropy method with Adam (Adaptive Moment Estimation) optimizer (see, for example, Kingma and Ba (2014) for more details). The agent repeats the process and updates the PD and the values of weight coefficients every

n arrivals until the last borrower. Note that the accuracy and budget variables are updated each time a loan is accepted, while the parameters in the PD model and the weight coefficients are updated once every n arrivals. For $t \geq 0$, the accuracy variable is updated as follows:

$$a_{t+1} = \frac{a_t(m + \eta_t) + e_{t+1}}{m + \eta_t + |e_{t+1}|}$$

where η_t is the number of the accepted loans from the first t arrivals ($\eta_0 = 0$), and $e_t = 1$ if the loan t does not default, $e_t = -1$ if loan t defaults, and $e_t = 0$ if loan t is rejected. So the accuracy increases each time the agent accepts a non-default loan, and decreases when he accepts a defaulted loan.

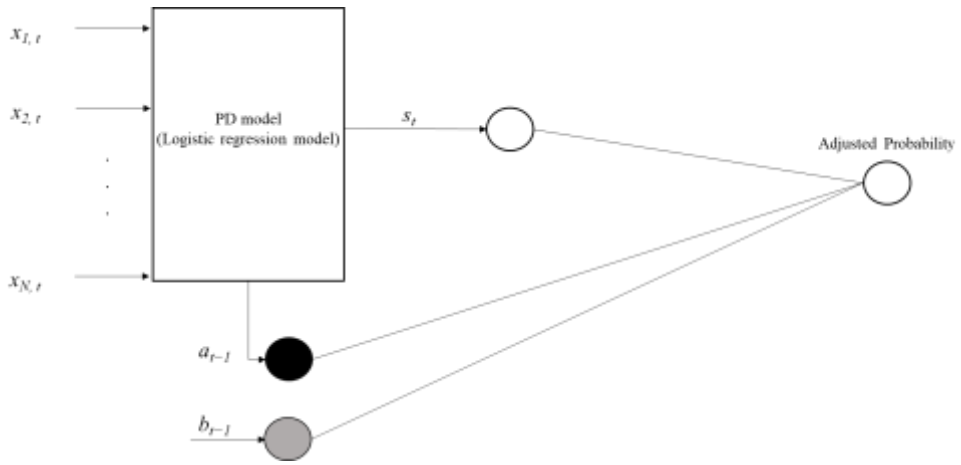

Figure 1: Reinforcement learning-based model

After the last borrower comes, the final budget is kept for each fixed value of θ. The value of θ that yields the highest final budget and its associated weight coefficients w_0, w_a and w_b are chosen. The value of θ is fixed while the values of the weight coefficients are used as the initial values of the coefficients for the unfamiliar loan type.

To test the model with the unfamiliar loan type, the process is the same as in the familiar loan type, except that the initial values of the weight coefficients are set to those obtained from the training data. The values of T, m, n and Θ are the same as those in the benchmark model.

4. Data

Our analysis relies on simulated data so that we can measure the information content available to the lending agent. We assume that the true probability of default of each borrower t or PD_t is given by a logic function of the linear combination of the set of five features

$$PD_t = \frac{1}{1 + \exp\left(-\left[c_1 x_{1,t} + \cdots + c_5 x_{5,t}\right]\right)}$$

where c_i's are constant coefficients. We assume that each feature $x_{i,t}$ is i.i.d. with standard normal distribution and we sample their values according to this assumption. We sample the value of each c_i randomly following the discrete uniform distribution of integers between -10 and 10. The repayment outcome of each borrower t is sampled from the computed PD_t. To make the data imperfect to the lender, we assume that the lending agent can observe only the first three features, namely, $x_{1,t}, x_{2,t}$ and $x_{3,t}$. We also sample two independent uncorrelated features $x_{6,t}$ and $x_{7,t}$ following i.i.d. standard normal distribution and assume that these two features are given to the agent too. That is, the agent observes $x_{1,t}, x_{2,t}, x_{3,t}, x_{6,t}$ and $x_{7.t}$ but he does not know which features in fact have a prediction power for the probability of default and needs to learn from the data. We set the number of borrowers $T = 9{,}900$, and the number of data points for the initial loan data $m = 100$, and simulate the data for six independent samples. The first sample is used as the training data set (familiar loan type) for the RL model, and the other five samples are used as five testing data sets for both benchmark and RL models. To measure the information content available to the agent, we use the ratio of the variance of the linear combination of the true features observed by the agent to the variance of the linear combination of all of the true features. We call this as the variance ratio

$$VR = \frac{c_1^2 + c_2^2 + c_3^2}{c_1^2 + c_2^2 + c_3^2 + c_4^2 + c_5^2}.$$

Note that a high variance ratio indicates that the missing features are not significant to the probability of default prediction. Table 1 reports the true values of the coefficients in each sample, and the corresponding variance ratio. The variance ratio of the training data is the highest, which is 0.822, as it represents a familiar loan type for which the agent knows the main determinants of the probability of default, while the other five scenarios correspond to unfamiliar loan types, and the variance ratio varies from 0.161 to 0.606. The simulated data yields approximately 1:1 ratio between the defaulted loans and non-defaulted loans.

Table 1. True model's coefficients

Scenario	Coefficients					Variance ratio
	c_1	c_2	c_3	c_4	c_5	
Training	2	-10	-4	-1	5	0.822
1	-4	-2	2	-10	5	0.161
2	-2	3	5	9	-8	0.208
3	-8	-2	-6	1	9	0.559
4	-9	1	-6	8	-4	0.596
5	5	-4	4	6	-1	0.606

5. Results

We implement our reinforcement learning-based model (RL model) and the benchmark model based on the five simulated samples. We assume that the initial budget is $B_0 = 600$, the reward from a non-defaulted loan is $r = 15$, and the loss from a defaulted loan is $L = 50$. Table 2 reports the out-of-sample results of each scenario corresponding to each simulated sample.

From Table 2, we can see that our RL model outperforms the benchmark model in every scenario. Given that the information content measured by the variance ratio is very low for scenarios 1 and 2, our RL model manages to survive until the last borrower, while the benchmark model does not. In fact, there are three scenarios (1, 2 and 5) in which the benchmark model runs out of the budget. As the variance ratio increases, the number of accepted loans to the number of rejected loans (accept to reject ratio) of our RL model tends to increase, as well as the final budget. On the other hand, the accept to reject ratio of the benchmark model is very high for scenarios 1 and 2, resulted from the model accepting too many bad loans. This yields a very poor performance for the benchmark model. In summary, we can see that our model achieves what it is designed for. It avoids the negative budget in the low-information content environments (scenarios 1 and 2), and it makes significant long-run profits from learning in the high-information content (scenarios 3, 4 and 5) given that the initial model accuracy is not so reliable.

Table 2. Out-of-sample acceptance and rejection results

Scenario	Variance ratio	Model	No. of good loans accepted	No. of bad loans accepted	No. of loans accepted	No. of loans rejected	Accept to Reject ratio	Final Budget
1	0.161	Benchmark	31	20	51	50	1.02	-28
		RL Model	15	5	20	9,880	0.00	530
2	0.208	Benchmark	75	30	105	94	1.12	0
		RL Model	131	24	155	9,745	0.02	972
3	0.559	Benchmark	1,059	213	1,272	8,628	0.15	2,658
		RL Model	1,670	162	1,832	8,068	0.23	12,540
4	0.596	Benchmark	1,153	221	1,374	8,526	0.16	3,386
		RL Model	1,926	170	2,096	7,804	0.27	15,212
5	0.606	Benchmark	737	189	926	4,314	0.21	-6
		RL Model	1,827	145	1,972	7,928	0.25	15,274

Table 3. Out-of-sample performance measures

Scenario	Model	Accuracy	Recall	Precision	AUC Score
1	Benchmark	0.51	0.03	0.63	0.51
	RL Model	0.50	0.00	0.75	0.50
2	Benchmark	0.51	0.02	0.72	0.50
	RL Model	0.52	0.03	0.85	0.51
3	Benchmark	0.58	0.21	0.83	0.58
	RL Model	0.65	0.33	0.91	0.65
4	Benchmark	0.59	0.23	0.84	0.59
	RL Model	0.68	0.39	0.92	0.68
5	Benchmark	0.59	0.23	0.84	0.59
	RL Model	0.66	0.36	0.93	0.67

Table 3 reports four out-of-sample performance measures of each model in each scenario. The first measure is the accuracy, which is defined by

Accuracy = Number of corrected predictions / Number of predictions.

The second measure is the recall, which is defined by

Recall = Number of accepted non-defaulted loans / Total number of non-defaulted loans.

The third measure is the precision, which is defined by

Precision = Number of accepted non-defaulted loans / Number of accepted loans.

The fourth measure is the AUC score, which is the likelihood that the model assigns a higher probability of default to a defaulted loan than to a non-defaulted loan. From Table 3, we can see that the benchmark model and our RL model have accuracy around 0.5 for scenarios 1 and 2, which means the models only predict correctly 50% of the time. The accuracy increases when the variance ratio increases. In general, our RL model has higher accuracy than the benchmark model. The recalls for both models are quite low for all scenarios which implies the only a small portion of the non-defaulted loans are accepted. However, as the loss is much larger than the reward, a low recall is sensible. Overall, the recall tends to increase as the variance ratio increases, and the RL model has a higher recall for most scenarios. The precision for both models are quite high, particularly when the variance ratio is high. For example, the precision of the RL model is 0.93 in scenario 5 when the variance ratio is 0.606. This implies that given the model accepts a loan, around 93% of them is a non-defaulted loan. This high precision is needed in the lending applications, and both models achieve a good level of precision. The RL model has a higher precision in all scenarios. Finally, the AUC score of both models is around 0.5 for low variance ratio cases (scenarios 1 and 2), and around 0.6 – 0.7 for high variance ratio cases (scenarios 3, 4 and 5). This suggests that both models can somewhat differentiate non-defaulted and defaulted loans in the right direction. The values of AUC score of our RL model are higher than those of the benchmark model when the variance ratio is high.

Table 4. Reinforcement learning's parameters

Scenario	**Budget** (w_b)	**Accuracy** (w_a)	**Intercept** (w_0)
1	-0.00267	-0.00267	-0.00264
2	-0.00266	-0.00266	-0.00264
3	-0.00267	-0.00267	-0.00264
4	-0.00267	-0.00267	-0.00264
5	-0.00267	-0.00267	-0.00264

Table 4 shows the weight coefficients of the RL model at the end of each scenario. As we can see, the weight coefficients are almost the same for all scenarios, suggesting that neither of the variance ratio nor the random data affect the final estimates of the coefficients. The values of the coefficients for the budget and the accuracy variables are negative as we expected. That is, the RL model suggests the agent to be less aggressive in lending when the budget and/or the accuracy is low.

6. Conclusions

We study the lending decision making problems for unfamiliar loan types. In this problem the lending agent initially has a low-accuracy model for predicting the default probability and has to learn about the relationship between the borrower's features and the probability of default though lending. One difficulty is that the agent has a limited budget. We propose a reinforcement learning-based decision making model that accounts for the model accuracy and the budget constraint. We test out model out-of-sample based on simulated data and compare the results with the traditional logistic regression model. The results show that our model outperforms the logistic regression model. Furthermore, our model can avoid losing all the budget when the information content available to the lender is low and hence learning is limited, and our model can generate significant profits from learning through lending when there is sufficient information associated with each borrower.

Reference

Fantazzini, D., and Figini, S. 2009. Random survival forests models for SME credit risk measurement. Methodology and Computing in Applied Probability 11(1), 29–45.

Harris, T. 2015. Credit scoring using the clustered support vector machine. Expert systems with applications 42(2), 741–750.

Kingma, D. P., and Ba, J. 2014. Adam: A method for stochastic optimization. arXiv preprint arXiv:1412.6980.

Leike, J., Martic, M., Krakovna, V., Ortega, P. A., Everitt, T., Lefrancq, A., Orseau, L., and Legg, S. 2017. AI safety grid worlds. arXiv preprint arXiv:1711.09883.