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Objectives of journal

1. To encourage and publish knowledge and useful opinions in any field of study
2. To support academicians and teachers in creating work beneficial to the academic community
3. To stimulate and support education at the university level

Policies of the journal :

The Interdisciplinary Research Review (IRR) publishes six issues per year. All submitted articles are subject to peer review, and must be approved by two experts in the relevant field prior to acceptance. Prior to review, all articles must pass a screening process which evaluates the articles' appropriateness for the journal, originality, proper formatting, and English proficiency. All material in each article that is not original must be properly referenced to the published literature. The editors reserve the right to modify articles in the interests of clarity and proper English usage. The opinions and views expressed in the journal are those of the authors of the respective articles and not those of the editors or publisher.

Submission of articles :

Articles should be submitted on-line at <https://www.tci-thaijo.org/index.php/jtir>. The website contains full instructions about how to prepare and submit articles. Please contact the journal or editors for information at irr@npru.ac.th, or by phone at +66 3426 1053, or +66 3410 9300 ext. 3909.

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Editorial Note

The Interdisciplinary Research Review (IRR) was established with academic cooperation by The Royal Society of Thailand Committee of Interdisciplinary Research and Development, Rajabhat University (Western Group). This Issue, Volume 19 Number 1 (January – February 2024). This issue contains of six interesting articles in multidisciplinary fields: (1) The utilization of KineMaster application: Mobile-based digital storytelling to improve English speaking skills of Thai EFL undergraduate students during the COVID-19 pandemic , (2) Ethnobotanical documentation of plants used as traditional therapies by Partido Albulario in the Philippines , (3) Toward a Framework for a Transportation Service Sharing Economy Platform with a Blockchain-based Service Review System , (4) Enhancing Line Chatbot Experiences: Utilizing Thai Question-Answering Systems to Enrich Dialogue with Unpredictable Questions , (5) Modeling Thai Concentrated Latex Sector , (6) Exchange Rate Volatility and Cointegration of ASEAN Member Countries .

The Editorial Board of the IRR encourages anyone to submit articles for evaluation and review. The processes of submission, review and publication of articles are described on the journal's website, <https://www.tci-thaijo.org/index.php/jtir>. The Editorial Board and Committees of the IRR sincerely thank all peer reviewers who have sacrificed their time to help us produce a better journal, and also wish to thank all teachers, researchers and other academicians for submitting their valuable research to this journal. Finally, we thank readers of our journal who help to spread the knowledge and benefits gained to others. With your feedback and suggestions, we will strive to improve the quality and relevance of the IRR.

Yongyudh Vajaradul
Editor
Interdisciplinary Research Review



The utilization of KineMaster application: Mobile-based digital storytelling to improve English speaking skills of Thai EFL undergraduate students during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic has led to a reevaluation of priorities, including education. In Thailand, social distancing measures have prompted the implementation of online learning policies. The study utilized the KineMaster app for mobile-based digital storytelling to improve Thai undergraduates' English-speaking skills during the pandemic. It enhanced online learning through editing and recording features, fostering active learning and student autonomy. The study evaluated the feasibility of combining multimedia applications and online learning and pinpointed the obstacles. In a recent study, 72.6% of students who received clear instructions on KineMaster usage and 64.5% who received regular app instruction from teachers improved their English-speaking skills through mobile-based digital storytelling using KineMaster. The study found that post-test scores (8.94 ± 0.936) of Thai EFL undergraduate students using the KineMaster app for mobile-based digital storytelling significantly improved compared to pre-test scores (7.39 ± 1.18), with a significance level of .05. In the group interview, students preferred English-speaking instruction using KineMaster, finding it engaging and believing it would improve their abilities. Most (98%) agreed it helped practice English skills and appreciated the design options. Integrating technology, specifically KineMaster, is identified as a potentially effective tool for language instruction. The study findings have implications for instructional designers and language instructors, offering insights into technology-based language teaching and curriculum design in the digital era.

Keywords: KineMaster Application, English Speaking Skills, Mobile-based digital storytelling

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1. Introduction

The COVID-19 pandemic has led to a reevaluation of life's meaning, education's purpose, and priorities, emphasizing a shift from competition to prioritizing loved ones and quality of life. In Thailand, the pandemic poses significant challenges, particularly in education. Social distancing measures have prompted the government to implement policies for learning while adhering to health guidelines. The Ministry of Higher Education, Science, Research, and Innovation has allowed online learning, making it essential for sustaining education. However, this creates barriers for students and teachers, including the need for effective teaching materials and students becoming self-directed learners [1].

English plays a crucial role globally, including in the online learning environment during the COVID-19 pandemic. It serves as the lingua franca of the ASEAN Economic Community and

is vital for education, job applications, and career advancement. Efforts are being made to enhance English language education and proficiency across ASEAN, recognizing its significance in regional and global contexts [2]. Thai students have studied English in formal education for several years but need help communicating in English. When they need help to think of a term during an English conversation, they can often infer the meaning of unfamiliar words using context cues but rarely resort to compensatory techniques like gestures [3]. Thai students' English proficiency needs to be revised [4]. The Universal European Framework of Reference for Languages (CEFR) is now the standard that must be adhered to at all educational levels in Thailand to improve students' overall English competence. English proficiency must align with societal changes to help the global creative expression of

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Thai ideas and cultures and adapt to the digital age.

Undergraduate students learning English as a Foreign Language (EFL) in Thailand require assistance developing confidence in speaking the language. Despite English being taught for a significant period, educators and learners face ongoing challenges in teaching and learning. Factors such as the fear of speaking in front of instructors, the fear of making mistakes, and a lack of interest in the subject contribute to the difficulty [5]. Students need to enhance their language proficiency in Thai EFL due to insufficient understanding, limited language usage opportunities, and fear of real-life communication. Teachers are crucial in boosting students' confidence and providing speaking practice opportunities. Designing classroom activities that promote fluent and accurate speech is essential but challenging for teachers.

Nakhon Pathom Rajabhat University (NPRU) in Thailand is a recognized coed institution offering various degree programs. English language skills are crucial for NPRU students, but they face difficulties in speaking. Limited practice opportunities, large classrooms, and teaching methods contribute to the issue. To address this issue, using digital storytelling as a teaching strategy with technology is presented as an effective solution. Incorporating smartphones, widely used by the tech-savvy Z generation, can enhance English learning [6]. Because of this, incorporating digital storytelling into the classroom using smartphones can be an effective tool. There are some digital storytelling applications (.apk) available for smartphones.

The study focused on using the KineMaster application (www.kinemaster.com) for mobile-based digital storytelling to improve the English-speaking abilities of Thai undergraduate students during the COVID-19 pandemic. The KineMaster app offers precision editing, multi-track audio, and multiple layers for text and visuals. It also provides color adjustments and the ability to record voiceovers, among other functions.

Creating an enjoyable online learning experience requires more than just different learning tools. To overcome network limitations and maintain engagement in online learning, teachers can create multimedia learning resources and share them on social networking sites or other online learning platforms. One such tool is Kinemaster, a free Android/iOS app with basic features, suggested by A Haryudin and F. Imanullah (2021) [1], that can be used to create learning materials. As consistent findings show, integrating digital storytelling into the classroom significantly improves students' English-speaking abilities. It helps teachers create lesson plans that promote active and independent learning and enhance student engagement and autonomy. Successful students demonstrate greater learner autonomy than unsuccessful students [7,8].

The specific objectives of this research are: 1) To compare the English-speaking achievement of the students before and after learning through mobile-based digital storytelling using KineMaster; 2) To investigate the students' opinions towards learning through mobile-based digital storytelling using KineMaster.

2. Kinemaster

KineMaster, a mobile software available on Android and iOS platforms, allows users to augment the caliber of their video content. The prestigious multinational NexStreaming, based in Seoul, South Korea, founded this groundbreaking application and has offices worldwide as of 2021 [9].

2.1 Interface

The KineMaster designers have a unique take on user interfaces. Because of this, developers would instead focus on valuable features and tools rather than unnecessary interfaces. Therefore, the students will feel reassured if the KineMaster app opens with a large, seemingly overwhelming image and a straightforward display of four buttons.



Figure 1. Kinemaster Interface

The secret to revealing KineMaster's true "inner beauty" lies in the circular red button. Clicking this button takes students to a website where they may view all the necessary video editing tools and start a new project. The settings, help, and shop buttons are the other three buttons. The final menu comprises numerous supplemental materials, such as audio, that can be downloaded later to supplement the current tasks. When students access the settings panel upon launching KineMaster, the application automatically switches their device to landscape mode.

2.2 KineMaster Features

2.2.1 Project Assistant

In KineMaster, students first experience two distinct project types: Empty Project and Project Assistant. Together, the two tools enable the creation of fresh video editing projects. However, Project Assistant stands out since it helps less experienced users by guiding them through ordered video creation steps. The KineMaster project assistant assists users in selecting movies and themes and adding videos, filters, and text, among other things, so that students may produce stunning finished videos.

2.2.3 Multiple Media Support

KineMaster accepts most videos taken on portable devices while supporting only a few video types. Students cannot select, but

KineMaster simplifies playing material from internal or external memory. One window shows all content in three separate folders - Background, Favorites, and Cloud Storage. The device stores the remaining data in folders within its memory.

2.2.4 Theme

These four theme options, On-Stage, Serene, and Travel-make this function beneficial for new KineMaster users.

2.2.5 Text

Students may also add text to their videos with KineMaster. Students can customize each sentence by selecting the text style and color best suits their preferences. An introduction and a conclusion are already present in the text choices.

2.2.6 Audio

A video editing program like KineMaster needs more than just background music. KineMaster empowers students to find the perfect soundscape for their projects by offering a symphony of options that surpasses the competition. Whether it is accessing recordings, songs from memory, albums, playlists, imported audio files, or even genres directly from their device, students have a treasure trove of audio at their fingertips. With KineMaster, students are not just editors but sonic storytellers crafting unique soundtracks that amplify their vision. Moreover, they can own their audio narratives with precise volume control and the ability to orchestrate the movie's sonic beginnings and endings.

2.2.7 Complete the Editing Tool

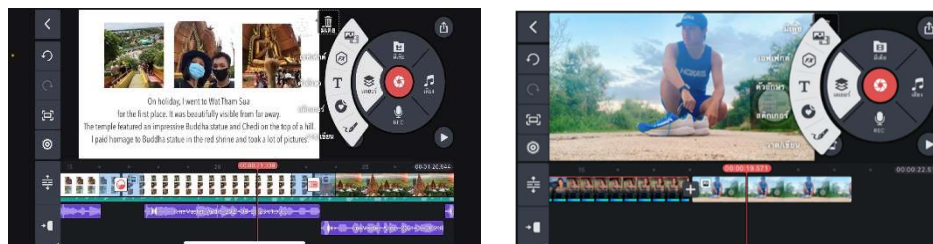


Figure 2. Complete Editing Tool

These elements gather in the main editing window after adding the video, deciding on the music, and typing the text. The window contains several functions, and students may need around 30 minutes to understand and learn the purpose of each button [1]. So, numerous features are present. This only generates an exhaustive list of terms it can comprehend to simplify things. There may be differences in the original language.

1. Multiple-layer support
2. Voice over
3. Playback
4. Sharing
5. Cut, Copy, and Crop
6. Color filters
7. Color adjustment
8. Vignette
9. Trimming
10. Split
11. Rotate
12. Records from cameras and camcorders
13. Drag and Drop
14. Capture frame
15. Duplicate
16. Undo/redo

Teaching resources with a multimedia component

Examples of educational materials include text, music, pictures, videos, and other animations. There are numerous methods to use instructional resources to support students' learning. According to some, teaching materials also function as (1) a guide for instructors to straighten their accomplishments in the educational process, (2) a set of instructions for students to make sure they are on track during the learning process, and (3) a tool for evaluating a student's competency [10]. These include news stories, soap operas, commercials, and snippets from periodicals, newspapers, and television programs. To be a helpful teaching tool, it must incorporate particular learning objectives. There are educational resources available to aid in students' learning. The three main types of instructional resources are materials for individual study, presentation materials, and reference materials. Printed teaching materials, such as handouts and modules, can be utilized to instruct

students alongside audio and video recordings [11].

Multimedia-based educational resources can be created and produced using ICT technologies. These tools can be used in many ways to gather, organize, and store data to provide high-quality information. Similar to the previous ruling, this decision affirms that instructional materials with audiovisual components are the same [12]. ICT-based educational materials have the following qualities: By utilizing electronic and multimedia technologies to connect teachers and students, students and teachers' learning settings can become more appealing: (a) make use of self-contained learning materials available anywhere, at any time; and (b) use interactive data interchange (information sharing) [13]. The use of ICT-based teaching tools has the following advantages. Using educational resources that are dangerous or hard to find encourages students to participate and shows invisible things to the unaided eye. Learning is possible anywhere, at any time. Thus, educators should adopt the KineMaster app, particularly for remote learning

courses, as forcing students to visit virtual classrooms will only leave them bored—especially in light of the current pandemic. There are various strategies to build instrumental pedagogy, and some of them should be based on the current push to incorporate digital literacy into Education 4.0.

3. Materials and Methods

The study utilized a mixed-methods approach, combining quantitative and qualitative methods to collect data. A quasi-experimental research design was employed, incorporating questionnaires, semi-structured interviews, and pre- and post-speaking tests to assess students' linguistic proficiency using the KineMaster app for mobile-based digital storytelling. The quantitative component focused on descriptive statistics of the questionnaire results and statistical analysis to examine the intervention's impact on student's speaking abilities. The qualitative aspect involved semi-structured interviews with students to explore their perspectives on the intervention. Data triangulation was employed to ensure consistency, reduce bias, and increase the reliability of the study findings. Multiple data sources were used to address the research questions, including oral performance tests, assessments, surveys, and interviews. Qualitative theme analysis was conducted to identify difficulties and capture students' opinions on the intervention, alternative evaluation, and student autonomy. The analysis mainly focused on describing the data by examining its mean, median, modal, lowest, and maximum values. Comparisons between pre-and post-test scores were analyzed by independent t-test, as appropriate. All data analysis was conducted using IBM SPSS Statistics 28.0.1.1.

3.1 Sampling and data collection

This study population consisted of 440 second-year undergraduate students at Nakhon Pathom Rajabhat University (NPRU) in Thailand. The population was divided into 20 groups of 22 students each. Following Boonchom Srisa-at's (2010) [14] recommendation, a sample size of 15%, equated to 67 students, was selected for the study. The participants were non-majored English students with varying levels of English proficiency, as determined by "The Gets Placement Test" taken at the beginning of their university studies. Random cluster sampling was used to select three intact groups of students for each research section. The participants' ages ranged from 19 to 21, and they were enrolled in the General English Course 1500104 (English for Professional Purposes) during the first semester of the Academic Year 2022-2023. Pseudonyms were used to protect the participants' identities, and they were informed about the objectives of this study.

Two steps involve gathering data: reviewing and analyzing existing literature and documents. Respondents to online questionnaires provided primary data immediately. The phenomena were then gathered, totaled, and examined to make conclusions and recommendations for further study.

4. Results and Discussion

The researcher collected data from the target group of 62 students using a questionnaire on students' reflections on the KineMaster DST intervention [7, 15], with the following study findings:

Table 1 The number and percentage related to general information of respondents

General information		Number (n=62)	%
Faculty	Faculty of Education	18	29.04
	Faculty of Humanities and Social Sciences	30	48.38
	Faculty of Science and Technology	14	22.58
Majors	Majoring in Physical Education	18	29.04
	Majoring in Social Studies	30	48.38
	Majoring in Mathematics	14	22.58

From the data above, most respondents (48.38%) studied at the Faculty of Humanities, followed by the Faculty of Education (29.04%). The Faculty of Science and Technology had the most minor proportion of respondents. Social studies was the most popular major (48.38%), followed by physical education (29.04%) and mathematics (22.58%).

Table 2 Percentage of the frequency of the development of English-speaking skills, which is essential to the teaching-learning process

English-speaking skills	Always	Very Often	Sometimes	Rarely	Never	Mean $\pm$ SD
The development of English-speaking skills is essential to the teaching-learning process.	64.5	27.4	6.5	-	1.6	12.4 $\pm$ 18.86
Students learning and practicing English: how frequently do students use audio, video, and images that allow them to communicate fluently and meaningfully?	43.5	37.1	19.4	-	-	12.4 $\pm$ 15.58
The teacher performed interactive activities (<i>such as think-pair-share, interactive demonstrations, minute papers, etc.</i>) that allowed students to use the audio, video, and images.	61.3	37.1	1.6	-	-	12.4 $\pm$ 17.35
The teacher employed a mobile-based application, specifically the KineMaster application, to help students improve their English-speaking skills.	64.5	27.4	8.1	-	-	12.4 $\pm$ 16.92
The teacher performed meaningful activities (<i>such as providing engaging videos, leveraging the power of online discussions, providing feedback, increasing learner autonomy, etc.</i>) not suggested by the textbook that helps students improve speaking skills.	58.1	37.1	4.8	-	-	12.4 $\pm$ 16.31
The teacher provided speaking activities (<i>such as short talks, digital storytelling using the KineMaster application, etc.</i>) in English, requiring a mobile-based application and program that allowed students to record and listen to their voices.	62.9	30.6	6.5	-	-	12.4 $\pm$ 16.41
Using a rubric, the teacher gave information about what the students did well or what they could improve after an oral presentation.	61.3	30.6	8.1	-	-	12.4 $\pm$ 16.28
The class activities focus on speaking rather than correctly using English grammar.	61.3	32.3	6.5	-	-	12.4 $\pm$ 16.51
The teacher informed students about the criteria that will be evaluated in an oral presentation using a rubric.	72.6	25.8	1.6	-	-	12.4 $\pm$ 19.44
The teacher clearly explained the process students should follow before giving an oral presentation in English.	72.6	25.8	1.6	-	-	12.4 $\pm$ 19.44

The data presented above indicate that respondents are highly aware of and recognize the importance of developing speaking skills in English language learning and teaching. Of most students, 72.6% stated that their teachers explained how to use the tools effectively, indicating clear instructions on technology usage; 64.5% stated that their teachers regularly instructed them on how to utilize the app for this reason. Since technology is becoming more important in education, more teachers will likely

look for creative ways to use it in their lessons, and 61.3% believed that the teacher regularly used interactive teaching methods to aid in teaching and developing language skills.

Analysis of issues obtained from the semi-structured group interview on students' opinions towards KineMaster DST intervention

The researcher collected data from the target group of 40 students by using a semi-structured group interview about students' opinions towards

the KineMaster DST intervention, which is a focus group discussion. The semi-structured group interview revealed that students preferred English-speaking instruction using KineMaster over teacher-centered instruction without technology. They found it more engaging and believed it would improve their English-speaking abilities. Most (98%) agreed that KineMaster helped them practice English language skills. Students appreciated the range of designs and video editing features, which made learning enjoyable. However, some students needed help with the application (5%). Suggestions were provided to enhance the app's suitability for teaching English storytelling. Overall, technology-assisted learning with KineMaster has potential value in enhancing English language proficiency, but it is vital to address initial challenges and consider student feedback for further improvements.

Pre and post-test results from using KineMaster Application: Mobile-based digital storytelling to improve English Speaking Skills of Thai EFL undergraduate students during the COVID-19 pandemic

The researchers collected data from the target group of 67 students by conducting an online pre- and post-test on "Authentic digital storytelling through informative narratives" [7]. The data were analyzed by a computer program adopting paired samples T-Test). The results of the data analysis were classified into two correlated groups of samples based on the following hypotheses:

H₀: The mean score of the post-test was not different from the mean score of the pre-test.

H₁: The mean post-test score was higher than the mean pre-test score.

Table 3 Comparison of the pre-test and post-test scores for authentic digital storytelling through informative narratives

Mean	S.D.	Mean Difference	SD of mean difference	t	df	Sig.	Mean	S.D.	Mean Difference
7.39	1.18	1.55	1.158	10.968*	66	<0.001	7.39	1.18	1.55
8.94	0.94						8.94	0.94	

*Statistical significance of 0.05 (paired samples T-Test)

Table 16 shows that the mean pre-test score of students was 7.39, and the mean post-test score was 8.94. When the two tests were compared, it was discovered that post-test scores were statistically significantly higher than the pre-test, at a level of .05. According to this, the online course held a focus group discussion based on the semi-structured interview about how students learn English using mobile-based digital storytelling with KineMaster. The results of the semi-structured focus group show that students can learn English with the help of the KineMaster program.

5. Conclusion

The research highlights the importance of prioritizing speaking skills in English language learning and teaching, as it supports students in personal and educational contexts and contributes to global competence. Initiatives like KineMaster should focus on improving speaking skills by providing more opportunities for students to engage in conversation sessions and language exchange programs. Using multimedia resources, such as audio, video, and graphics, is crucial in English language training to offer engaging and dynamic learning opportunities. Table 5 demonstrates that many respondents recognize the value of incorporating multimedia components into language learning and teaching. This approach enables teachers to cater to students' needs and preferences, leading to more effective

language instruction. Traditional passive instruction methods should give way to considering learners' needs and preferences, as teachers already use interactive activities to enhance students' language abilities, increasing their involvement and skills. Most students' favorable opinions of KineMaster as a helpful teaching tool demonstrate their dedication to honing their speaking skills and active participation in language learning. The study emphasizes the importance and benefits of implementing interactive teaching strategies in English language classes. These strategies make learning more exciting and compelling, promoting student interest and learning outcomes. Teachers who still need to incorporate interactive approaches can use the study findings as a roadmap to enhance their lessons and student performance. Implementing conversation sessions, debates, problem-solving exercises, and other interactive techniques can create an engaging and productive learning environment, further increasing student involvement and language skills.

The research demonstrates that teachers play a crucial role in developing students' language skills by offering exciting activities and promoting student ownership of learning. Teachers significantly impact their academic progress by going beyond the textbook requirements and actively engaging students. The study also highlights the potential of technology-based language learning strategies, urging educators to explore innovative ways of using tools like KineMaster in the classroom. Integrating the KineMaster app into language acquisition instruction is a successful tactic, as indicated by a significant percentage of students reporting its frequent use by their teachers. Teachers employ motivating activities, online discussions, feedback, and learner autonomy to assist students in practicing and improving their speaking talents. Technology tools like KineMaster and other digital media tools enable students to practice their language abilities and receive prompt feedback. This suggests that technology integration in language instruction can effectively

enhance student attitudes and performance. Teachers dedicated to their student's success and willing to go beyond traditional methods can positively influence their language development. Even if some students participate occasionally, regular engagement in these exercises demonstrates the teacher's commitment to fostering a supportive and encouraging learning atmosphere through feedback. The study reveals that most students perceive their teachers as encouraging and training them to practice practical speaking skills, highlighting the importance of developing students' confidence in effective English communication. Teachers should not solely focus on grammar rules but also emphasize practical speaking skills to enable confident and assertive communication in English, aligning with students' needs and aspirations.

The findings indicate that digital storytelling with KineMaster has the potential to be an effective teaching tool for English language competency. Compared to traditional teacher-centered instruction, technology-assisted training using KineMaster is more engaging and effective in improving students' English language proficiency. Students' interest in learning noticeably increased when using KineMaster, emphasizing its potential as a valuable teaching tool. English-language video editing techniques contribute to enhanced proficiency. Adapting instructional materials based on initial issues and incorporating student input is essential. The study conclusions have significant implications for instructional designers and language instructors seeking to integrate technology and innovative teaching techniques to enhance language learning outcomes in the digital era. Using digital storytelling to teach language skills can be successful and enjoyable, benefiting language education. The study limitations are that it examined the proficiency of English-speaking skills, focusing on linguistic and pragmatic aspects such as word choice, fluency, and natural speech in daily life. This study focused on 440 second-year undergraduate students at Nakhon Pathom Rajabhat University, ranging from

elementary to pre-intermediate English proficiency. The sample size was 67, with a gender disparity in enrollment. The participants were non-English majors, and the study did not include other levels or majors. The results should be cautiously interpreted when applying them to teaching speaking proficiency to EFL students, as the proportion of male and female students was unequal.

6. Recommendation for Further Research

The present study examines the possible advantages of utilizing technology in language instruction; nevertheless, additional investigation is necessary to ascertain the applicability of these results to diverse demographics and situations. The study findings demonstrate the potential advantages of utilizing technology in language instruction. Further research is required to completely comprehend and utilize digital media technologies for language learning in various circumstances. The study findings demonstrate the potential advantages of utilizing technology in language instruction. Still, more research is needed to fully understand and use digital media tools for learning languages. Based on the research findings and what they mean, the following suggestions and recommendations for future research could help us learn more about how to teach and learn English, especially when it comes to speaking skills:

Although the research results presented in this paper are encouraging, it is essential to keep in mind that they are only applicable to the context of this particular study and that additional research is required to determine whether or not these results can be generalized to other populations and contexts given the numerous unanswered questions. Research examining the connection between speaking abilities and other linguistic skills appears fully justified because future work that builds on these findings may help create more efficient language teaching strategies, educational materials, and treatments that prioritize speaking skill development. This could demonstrate the value of speaking skills in language learning and encourage more teachers and students to support speaking practice sessions. Overall, the research findings highlight how crucial speaking abilities are to the study and instruction of the English language. This could mean looking into task-based learning or

communicative language instruction emphasizing speaking practice. This could make it easier to understand how a person's speaking skills fit into their overall language skills. The study results emphasize how crucial it is to integrate multimedia resources into language training to give students a dynamic and exciting learning environment. This study highlights the value of including multimedia materials in language training to build a more active and engaging learning environment.

Further research into the connection between student motivation and involvement and the usage of multimedia resources in language training is desirable to extend our knowledge of interactive teaching strategies that can be successful in English language classes. Still, more research is required to pinpoint the most successful method. It examines the effects of interactive teaching techniques on various age groups and levels of language proficiency.

Further, combining technology-based methods and interactive teaching strategies into language instruction can improve language acquisition and growth. Teachers prioritize speaking skills while utilizing interactive teaching strategies and multimedia resources to make learning fun and effective for their students. This is a significant finding because it shows that participants in the study were driven to enhance their spoken English to succeed personally and professionally. Interactive teaching techniques and the use of multimedia resources can create dynamic learning environments that are tailored to the requirements and preferences of the students. Technology in language teaching, like the KineMaster app, can improve language learning and proficiency, mainly speaking abilities. The study emphasizes the significance of incorporating cutting-edge and successful teaching techniques to support language learning and development. This presents significant ramifications for the field of language education, particularly in the context of English instruction, where oral communication abilities are prioritized, and instructional techniques involving multimedia and interactive approaches are employed to augment language acquisition. The results highlight the importance of considering students' requirements and interests and incorporating technology into language teaching to create engaging and successful learning experiences. These results emphasize the value of teachers using interactive teaching methods to include students and encourage

language learning and growth. To improve their students' English language skills, teachers should frequently demonstrate how to utilize the KineMaster app to create digital stories on mobile devices. Teachers should provide students with resources to hone their communication skills, such as engaging films, online dialogues, feedback, and learner autonomy. This study has shed light on "The Utilization of KineMaster Application: Mobile-Based Digital Storytelling to Improve English Speaking Skills of Thai EFL Undergraduate Students During the COVID-19 Pandemic." The researcher hopes that it will act as a catalyst for further research and advancement in this field.

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**Ethnobotanical documentation of plants used as traditional therapies
by Partido Albulario in the Philippines**

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Abstract

This study generally aims to study the use of medicinal plants by folk healers in the eastern part of the province of Camarines Sur, the Philippines. Folk healers are identified as the local experts in traditional medicine because of their notable experiences, which have endured over time and are rooted in a body of knowledge that is customarily passed on orally. Thus, collecting their practices and knowledge can preserve the nearly extinct intangible national treasures that may include unstudied plants that can be subjected to pharmacological, botanical, and/or chemical research in the quest to discover new medicines to cure various illnesses. To materialize these, the study conducted a field survey from February to August 2020 and used the informant consensus factor (ICF), use value (UV), and fidelity levels (FI) to determine the level of agreement among informants on the use of plants as remedies. The study found 153 species of plants from 60 families that are used as curative materials for 17 categories of diseases, including various folk illnesses and beliefs about non-corporeal agents. This study confirms that there is still rich cultural knowledge and practices of using plants as a major source of medicine among folk healers. The findings highlight the importance of collecting ethnopharmacological data and conducting pharmacological evaluations of the identified plants, particularly those with higher fidelity levels and use values.

Keywords: Ethnomedicine, Ethnobotany, Folk healing, Hilot, Herbs, Traditional Medicine

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1. Introduction

Medicinal plants and herbs have been used for many centuries as a source of people's drugs for the treatment and prevention of diseases, disorders, and the promotion of good health and continue to provide the first line of primary health care for major segments of the global population [1, 2]. According to the World Health Organization, it is estimated that up to 60% of the population depends exclusively on plants for their health and healing [3]. Information and folk knowledge about the medicinal and therapeutic uses of these indigenous plant materials have been passed down from generation to generation via oral communication [4].

The focus of this study is the documentation of ethnobotanical practices, or the use of plants to cure one's illnesses, by Partido albulario, or the general practitioner of hilot modalities, in the eastern part of the province of Camarines Sur, the Philippines [5]. Similar to other traditional medical practices, Partido Albulario's practices are also threatened with extinction. The rapid disappearance of traditional culture suggests that unrecorded folk knowledge and information may be lost forever [6]. The World Health Organization has a strategy to "integrate TM/CAM with national health care systems, as appropriate, by developing and implementing national TM/Cam policies and programs." Two of its components are the recognition of TM/CAM

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and the protection and preservation of indigenous TM knowledge relating to health. In the Philippines, a law was enacted, known as the "Traditional and Alternative Medicine Act (TAMA) of 1997," to create an institution that will accelerate the development of traditional and alternative healthcare in the country.

Nevertheless, there are still a few systematic studies conducted in the Philippines that deal with recording these significant informational resources. These include, but not limited to, the study in Apayao [7], Bataan [8], Benguet Province [9], Bukidnon [10], Surigao Del Sur [11]; Albay [12]; and Guimaras [13]. Concomitantly, there is no recorded ethnobotanical knowledge and practices in Camarines Sur. This area is rich in diverse flora, which could have played a significant role in effective ethnobotanical practice. The patronization and presence of albularyo in the area provides significant evidence that there is rich ethnobotanical knowledge [14]. With proper documentation and scientific research, traditional medicine can solve many of the basic healthcare service problems in remote communities [15]. This documentation can also contribute to the development of new drugs and therapies based on traditional medicine. Thus, this calls for the urgent conservation and recording of these cultures for the benefit of present and future generations.

2. Methodology

Fieldwork was conducted between February and August 2020. A total of two hundred fifty (250) traditional health practitioners from the eastern side of Camarines Sur – Presentacion, Garchitorena, Caramoan, Logonoy, Tinambac, and Siruma – were interviewed separately on different occasions. The study area is a coastal-mountainous community and is identified with a high incidence of poverty and relatively poor access to quality healthcare facilities. All the informants agreed and signed a consent form, which was then compiled and secured by the researcher. The interview was collected using a voice recorder and analyzed after the interview.

Photo documentation was used to document the herbs and other health practices. Each ethnomedicine, such as herbs, was documented to be assigned a scientific name. The Dictionary of Philippine Plant Names, Volumes I and II, by Madulid, was used to determine the scientific names of the medicinal plants [16]. The study used quantitative ethnobotanical methods such as the informant consensus factor (ICF), Use Value (UV), and Fidelity Levels (FL). The data was analyzed using MS Excel. The data collected were analyzed quantitatively using informant consensus factor [17, 18], fidelity levels [18, 19], and use values [18, 20].

3. Results and Discussion

3.1 The Partido Albularyo

The Partido Albularyo are traditional healers who specialize in treating ailments using plants and herbs. Their actions are inspired by their own experiences, knowledge from close family members, or a sense of divine calling. Folk healing knowledge often spreads via knowledge transfer, and the strong kinship structure in Filipino culture may be seen in how family traditions and rituals are passed down and maintained. The Partido Albularyo is mostly female (76%), married (68%), educated only in elementary school (45%), and poor (98%), with an average of 7 children and a median age of 64. The Partido Albularyo is a group of traditional healers in the Philippines who rely on herbal medicine and spiritual practices to treat illnesses. Despite their lack of formal education, they play an important role in providing healthcare to their communities, especially in rural areas with limited access to modern medicine.

3.2 Characteristics of medicinal plants

There are 153 species of plants identified by the informants as treatments for various illnesses. These species are further classified into 60 families of plants. Fabaceae (legume family) has the most species (15), followed by Euphorbiaceae (spurge family) and Zingiberaceae (ginger family) with 10 each. Other plant families with five or more species

are Rutaceae (citrus family), Moraceae (fig family), Lamiaceae (mint family), Poaceae (grass family), and Asteraceae (daisy family).

The study found that Partido Albuaryos use various parts of the plants, such as leaves (56%), roots (20%), bark (7%), stems (6%), fruits (5%), seeds (2%), flowers (1%), sap (1%), and the whole plant (2%). These plants can either be taken internally (63%), applied or patched externally (32%), or both (5%). They prepare medicinal plants in a variety of ways before administering them. Most of the medicinal plants must undergo pounding or crushing (51.9%), boiling (26.2%), steaming (7.3%), heating (6.4%), or burning (1.3%).

3.3 Informant consensus factor and fidelity level of medicinal plants

The study also calculated the informant consensus factor to identify plants of intercultural relevance and agree on their use. The ICF value ranges between 0.00 and 1.00. High ICF means that only one or few plant species are identified or reported by a high proportion of folk healers to treat a particular category while low ICF values indicate disagreement with the plant to use the disease category [20]. The study used the International Category of Diseases (ICD-11) of the World Health Organization for the category of diseases. It is a scientifically up-to-date global

standard for health data, clinical documentation, and statistical aggregation.

The informants have reported 16 categories of diseases (ICD) or medical conditions and added one category – other culture-bound syndromes (diseases caused by non-corporeal agents and *usog*). Table 1 presents these categories, where traditional medical conditions (ICD11 Chapter 25), symptoms, signs, or clinical findings not elsewhere classified (ICD11 Chapter 21), and certain infectious or parasitic diseases (ICD11 Chapter 1) are the top 3 diseases that comprise the majority (60.8%) of the diseases reported. This finding reflects the subject of traditional therapy among folk healers, which focuses on traditional medicine (common colds, muscle spasms, and other culture-bound syndromes), unclassified illnesses (cough, rheumatism, stomach pain), and diseases caused by infection or parasites (gonorrhea, coronavirus, measles, pox, mumps, fever, influenza, dengue, chikungunya). These three categories of diseases are among the categories with the highest ICF, which means that the folk healers in the study area have higher agreement on the use of certain plant species in treating these disease categories.

Table 1. Informant consensus factor (ICF) and fidelity levels on medicinal plants

ICD-11	Illness Category	Illnesses or Diseases	No. of use report	ICF	Most frequently used species	FL % in this category
1	Certain infectious or parasitic diseases	gonorrhea, corona virus, measles, pox, mumps, fever, influenza, dengue, chikungunya, malaria, diarrhea	311	0.75	<i>Artemisia vulgaris</i>	34.34
2	Neoplasms	cancer, breast cancer	32	0.35	<i>Rauvolfia serpentina</i>	20.00
3	Diseases of the blood or blood-forming organs	Anemia	5	0.25	<i>Caesalpinia sappan</i>	50.00
5	Endocrine, nutritional, or metabolic diseases	Diabetes	14	0.38	<i>Rauvolfia serpentina</i>	20.00
8	Diseases of the nervous system	seizure, migraine, headache	79	0.71	<i>Blumea balsamifera</i>	12.84
9	Diseases of the visual system	conjunctivitis (sore eyes)	2	1	<i>Euphorbia hirta</i>	4.26
11	Diseases of the circulatory system	hypertension, hypotension, heart diseases	102	0.66	<i>Cymbopogon citratus</i>	43.86

ICD-11	Illness Category	Illnesses or Diseases	No. of use report	ICF	Most frequently used species	FL % in this category
12	Diseases of the respiratory system	sinusitis, asthma, pneumonia, lung problem, tonsilitis	29	0.32	<i>Mentha arvensis</i>	9.52
13	Diseases of the digestive system	gastric ulcer, toothache	23	0.14	<i>Psidium guajava</i>	5.88
14	Diseases of the skin	skin diseases, skin allergy, boils	38	0.38	<i>Zingiber zerumbet</i>	40.00
15	Diseases of the musculoskeletal system or connective tissue	arthritis, swelling of muscles	48	0.4	<i>Morinda sp.</i>	60.00
16	Diseases of the genitourinary system	menstrual cycle disorders, kidney problem, liver problem, urinary tract infection	128	0.66	<i>Lagerstroemia speciosa</i>	82.14
18	Pregnancy, childbirth, or the puerperium	<i>baghat</i> (relapse), newly delivered, pregnancy	129	0.74	<i>Cordia dichotoma</i>	67.80
21	Symptoms, signs, or clinical findings, not elsewhere classified	cough, rheumatism, dyspepsia (stomach pain)	319	0.79	<i>Plectranthus amboinicus</i>	38.30
22	Injury, poisoning or certain other consequences of external causes	poison, wounds, animal bite	59	0.41	<i>Psidium guajava</i>	15.69
25	Traditional Medicine Conditions	common cold disorder, muscle spasm disorder, <i>pasma</i> , <i>lipot</i> , <i>nasibogan</i>	473	0.87	<i>Plectranthus amboinicus</i>	60.64
n/a	Other culture bound syndromes	mystical element, <i>sibang</i>	23	0.59	<i>Zingiber officinale</i>	32.26

Further, the study used Fidelity Levels (FI) to determine the ratio between the number of informants who independently suggested the use of a species for the same disease category and the total number of informants who mentioned the plant for any use. Table 1 highlights various plant species as the most frequently used species for each disease category. It shows that *Lagerstroemia speciosa*, a plant used to cure genitourinary system diseases, has the highest fidelity level. This means that informants who identified this plant species have a high agreement to be used in the said category. It can be observed, however, that most of the plant species for each category have low FI. This indicates that folk healers use certain plants in many categories of diseases.

3.4 Use value of medicinal plants

The study employed Use Value (UV) to identify which plant species are mostly used in therapeutics (Table 3). The study revealed that 7 of 10 recommended medicinal plants by the Department of Health in the country were identified as medicinal plants of the albularyos

in the study area [21]. These plants are *Allium sativum*, *Blumea balsamifera*, *Momordica charantia*, *Peperomia pellucida*, *Psidium guajava*, *Quisqualis indica*, and *Vitex negundo*. *Cassia alata*, *Clinopodium douglasii*, and *Ehretia microphylla* were not identified as herbal medicines. *Blumea balsamifera* and *Psidium guajava* are two of the recommended medicinal plants with the highest use values of 0.592 and .204, respectively. Other medicinal plants with high use values are *Artemisia vulgaris* (0.664), *Plectranthus amboinicus* (0.376), *Cordia dichotoma* (0.236), *Cymbopogon ciiratus* (0.228), *Citrus microcarpa* (0.196), *Euphorbia hita* (0.188), *Piper betle* (0.168), and *Moringa oleifera* (0.16). Table 2 shows the identified medicinal plants, their family, scientific name, local name, the illness or type of illness for which the plant is used for medicinal purposes, the plant part used, and preparation and administration. The table also presents the number of use reports and the use value. Out of 153 species identified, Table 2 shows only those with at least a 0.02 use value, or 5 use reports.

Table 2. Medicinal plants, family, scientific name, and their use value.

No.	Family	Scientific Name	No. of use report	Use Value	Local Name	Illness or types of illness	plant parts use	Preparation and administration
1	Verbenaceae	<i>Clerodendrum intermedium</i> Cham.	20	0.008	alibagta/ matang tikling/ Alom	colds, flu	leaf	B Drink decoction and apply the steamed leaf
2	Euphorbiaceae	<i>Melanolepis multiglandulosa</i> (Reinw.) Reichb. F. & Zoll. var <i>multiglandulosa</i>	9	0.036	Alom	asma, fever, colds	leaf	I Drink decoction
3	Boraginaceae	<i>Cordia dichotoma</i> Forst. F.	59	0.236	Anunang	baghat, newly delivered mother, asma, headache, abdominal pain	bark, leaf	I Boil and drink concoction
4	Crassulaceae	<i>kalanhoe pinnata</i> (Lam.) Pers.	10	0.04	Aritana	swelling, boils	leaf	E Patch the crushed leaves
5	Asteraceae	<i>Artemisia vulgaris</i> L.	166	0.664	Artamesa	headache, flu, cough, colds, baghat, asma, wounds, abdominal pain, indigestion, menstrual problem, nasibogan, pneumonia, asthma, high blood pressure, sore eyes	leaf leaf leaf leaf	B Drink or apply decoction or concoction E Patch the crushed leaves I Drink the heated decoction with salt and oil I Drink decoction
6	Lauraceae	<i>Persea americana</i> Mill.	26	0.104	Avocado	body pain, cough, colds, diarrhea, UTI, kidney problem, ulcer, low blood pressure	leaf leaf	E Massage decoction with oil I Boil and drink decoction
7	Poaceae	<i>Eleusine indica</i> (L.) Gaertn.	25	0.1	bag-angan	baghat, high blood pressure, kidney problem, dengue, UTI, cancer, COVID-19, cough	leaf	I Boil and drink decoction
8	Oxalidaceae	<i>Averrhoa carambola</i> L.	11	0.044	balingbing	asma, flu, cough	leaf	B Boil and drink decoction; Boil with other leaves and use the water in a bath
9	Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.	28	0.112	Banaba	kidney stone, UTI, prostate cancer, cough, colds	leaf	I Boil and drink decoction or concoction
10	Musaceae	<i>Musa</i> L.	8	0.032	Batag	diarrhea, muscle spasm	root leaf	I Drink decoction I Patch the steamed leaf with coconut oil
11	Alliaceae	<i>Allium sativum</i> L.	8	0.032	Bawang	abdominal pain, swelling with fever, toothache, culebra, pneumonia, high blood, kabag,	leaf roots	I Patch as cold compress E Drink concoctions and decoction
12	Myrtaceae	<i>Psidium guajava</i> L.	51	0.204	Bayawas	Wounds, baghat, lung problems, kidney problem, UTI, abdominal pain, cough, colds, fever	leaf leaf	E Wash with boiled leaf I Drink decoction or concoction
13	Piperaceae	<i>Piper betle</i> L.	42	0.168	buyo	muscle spasm, boils, culebra, toothache, flu, mystical elements, usog, baklay,	Leaf	E Apply the betel quid, usually with prayers
14	Annonaceae	<i>Annona muricata</i> L.	28	0.112	guyabano	cancer, high blood pressure, diabetes, kidney stone, lung problem, UTI, cough, asma, diarrhea, arthritis	leaf	I Boil and drink decoction
15	Lamiaceae	<i>Mentha arvensis</i> L. var. <i>arvensis</i>	21	0.084	herba buena	baghat, flu, cough, colds, asma	leaf	B Drink or apply decoction
16	Zingiberaceae	<i>Zingiber zerumbet</i> (L.) Sm.	15	0.06	kalawag	sang-ab, boils, culebra, skin diseases	leaf root	E Inhale the crushed leaves E Apply decoction
17	Moringaceae	<i>Moringa oleifera</i> Lam.	40	0.16	kalunggay	wounds, culebra, boils, skin disease, usog, toothache, colds, diabetes, alpersiya, cancer, heart problem, animal bite, high blood pressure, pneumonia	leaf leaf	E Apply decoction I Drink decoction
18	Lamiaceae	<i>Ocimum tenuiflorum</i> L.	7	0.028	kamangkaw	baghat, flu, cough, colds	leaf	B Drink and apply the decoction
19	Fabaceae	<i>Senna alata</i> (L.) Roxb.	5	0.02	kasitas	skin diseases	leaf	E Apply decoction
20	Bombacaceae	<i>Ceibapentandra</i> (L.) Gaertn.	10	0.04	Kayo	nagsuka, nag-udo	bark	I Boil and drink decoction
21	Solanaceae	<i>Capsicum frutescens</i> L.	11	0.044	lada	lapo (muscle spasm), diabetes, anti-bacteria, high blood, alpersiya, fever	leaf fruit	E Patch steamed leaves I Eat the fruit

No.	Family	Scientific Name	No. of use report	Use Value	Local Name	Illness or types of illness	plant parts use	Preparation and administration
22	Verbenaceae	<i>Vitex negundo</i> L.	38	0.152	lagundi	cough, colds, flu, diarrhea, high blood pressure, prostate cancer	leaf	I Boil and drink decoction
23	Asteraceae	<i>Blumea balsamifera</i> (L.) DC.	148	0.592	lakad bulan	flu, headache, colds, cough	leaf	I Drink rice water with soaked leaves and apply the steamed leaves forehead and back neck
						kidney, UTI, lung problem, high blood pressure, diarrhea	leaf	I Boil and drink decoction
						baghat, surip, nasibugan, body ache	leaf	I Boil and drink decoction
24	Zingiberaceae	<i>Zingiber officinale</i> Rosc.	31	0.124	layang gayo	abdominal pain, high blood pressure, flu, pasma, dizziness	root	B Drink as ginger tea
						flu, chest pain, abdominal pain, usog	root	E Patch the crushed root
25	Rutaceae	<i>Citrus microcarpa</i> Bunge	49	0.196	lemonsito	flu, abdominal pain, pasma, nasibugan	fruit, leaf	B Drink and apply decoction
26	Araceae	<i>Acorus calamus</i> L.	13	0.052	lubigan	mystical element	leaf	I Chewing of leaves
						alpersiya, abdominal pain, prostate cancer,	root	I Drink decoction
						snake bite, diarrhea, abdominal pain	root	E Apply pounded roots
27	Rutaceae	<i>Citrus grandis</i> (L.) Osb.	8	0.032	lukban	headache, fever	leaf	E Apply crushed or steamed leaves to the forehead
						pasma, baghat	bark, root	I Drink the crushed and heated decoction
28	Zingiberaceae	<i>Curcuma domestica</i> Valet.	7	0.028	luyang dilaw	cancer, cyst, colds, prostate cancer, diarrhea, fever	root	I Drink as tea
						swelling, culebra	root	E Patch the crushed root
29	Fabaceae	<i>Glicicidia sepium</i> (Jacq.) Kunth ex Walp.	11	0.044	madre kakaw	Wounds, skin diseases	stem	E Patch a pounded stem
30	Poaceae	<i>Zea mays</i> L.	5	0.02	Mais	skin disease, usog	leaf	E Apply decoction
						kidney problem	leaf, hair	I Boil and drink decoction
31	Menispermaceae	<i>Tinospora crispa</i> (L.) Hook. f. & Thoms.	9	0.036	Makabuhay/onong-onong	abdominal pain, toothache, diarrhea, baghat, tonsillitis	leaf, root, bark	I Boil and drink decoction
						swelling, wounds, culebra, boils, cancer, muscle pain	leaf	E Apply the steamed leaf
						skin disease	whole plant	E Apply the crushed plant
32	Malvaceae	<i>Hibiscus tiliaceus</i> L. subsp. <i>tiliaceus</i>	5	0.02	malubago	pasma, fever, cough, colds	leaf	I Drink concoction
33	Anacardiaceae	<i>Mangifera indica</i> L.	12	0.048	mangga	kidney stone, lung problem, cough, high blood pressure, colds, pasma, pneumonia	leaf	I Boil and drink decoction
34	Cucurbitaceae	<i>Mormordica charantia</i> L.	8	0.032	marigoso	colds, cough, alpersiya, low blood pressure	leaf	I Drink the heated decoction
35	Rubiaceae	<i>Morinda</i> sp.	15	0.06	Nino	lapo (muscle spasm), boils, cough, culebra	leaf	E Apply the heated leaves
36	Arecaceae	<i>Cocos nucifera</i> L.	21	0.084	Niyog	pasma, cancer	fruit	I Drink burnt coconut shell
						kidney stone, UTI	fruit	I Drink the coconut water
						COVID -19	fruit	I Drink coconut wine
37	Moraceae	<i>Ficus pseudopalma</i> Blco.	14	0.056	niyog-niyog	kidney stone	leaf, root	I Boil and drink decoction
						high blood pressure	fruit	I Boil and drink decoction
						animal bite (snake, dog)	root, bark	B Drink and apply the decoction
38	Lamiaceae	<i>Plectranthus amboinicus</i> (Lour.) Spreng.	94	0.376	oregano	colds, cough, fever	leaf	I Drink decoction or apply the crushed leaves
39	Pandanaceae	<i>Pandanus</i> spp.	12	0.048	pandan	kidney problem, high blood pressure, prostate cancer, UTI	leaf	I Boil and drink concoction
40	Poaceae	<i>Oryza sativa</i> L.	11	0.044	paroy	Pasma	seeds	I Drink roasted rice as coffee
41	Bromeliaceae	<i>Ananas comosus</i> (L.) Merr.	5	0.02	pinya	nasibugan, pasma	leaf	I Drink decoction or concoction
42	Asteraceae	<i>Chrysanthemum morifolium</i> Ramat	20	0.08	Rosas de hapon/mansanilya	colds, cough, pasma	Leaf	I Drink or apply the heated decoction or concoction
43	Clusiaceae	<i>Cratoxylum sumatranum</i> (Jack) Bl. subsp. <i>Sumatranum</i>	12	0.048	salingogon	colds, cough, fever, pasma	Leaf	I Drink concoction
44	Meliaceae	<i>Sandoricum koetjape</i> (Burm. f.) Merr.	28	0.112	santol	abdominal pain, diarrhea, baghat	roots	I Drink concoction
						diarrhea, prostate cancer, kulatid, kidney stone, lung problem, ulcer	bark	I Boil and drink decoction

No.	Family	Scientific Name	No. of use report	Use Value	Local Name	Illness or types of illness	plant parts use	Preparation and administration
45	Apocynaceae	<i>Rauwolfia serpentina</i> (L.) Benth. ex Kurz	15	0.06	serpentina/esensya	baghat, colds, cough, diarrhea, ulcer, pneumonia, UTI, pasma myomas, diarrhea, abdominal pain, menstrual problem, diabetes, arthritis, baghat, dysmenorrhea, high blood pressure, UTI, rheumatism	leaf leaf	I Boil and drink concoction I Boil and drink decoction
46	Piperaceae	<i>Peperomia pellucida</i> (L.) H.B.K.	36	0.144	suro suro	colds, kidney problem, alpersiya, baghat, fever, cough,	Leaf	I Drink decoction
47	Rutaceae	<i>Swinglea glutinosa</i> (Bloo.) Merr.	5	0.02	tabog	cough, pasma	leaf	I Drink concoction
48	Zingiberaceae	<i>Alpinia brevilabris</i> Presl	7	0.028	tagbak	Bleeding heart problem, pasma	bark stem, leaf	I Boil and drink decoction I Boil and drink decoction or concoction
49	Zingiberaceae	<i>Curcuma zedoaria</i> (Berg.) Rosc.	19	0.076	tamahilan	colds, cough, abdominal pain, fever	root	I Drink decoction
50	Poaceae	<i>Cymbopogon citratus</i> (DC.) Stapf	57	0.228	tanglad	high blood pressure, pasma, nasibugan, baghat, kidney problem, arthritis, UTI	whole plant	I Boil and drink decoction and concoction
51	Caricaceae	<i>Carica papaya</i> L.	8	0.032	tapayas (lalaki)	dengue, fever Gonorrhea Boils	leaf leaf bark	I Drink decoction I Boil and drink decoction E Apply decoction
52	Euphorbiaceae	<i>Euphorbia hita</i> L.	47	0.188	tawa tawa	dengue, fever, colds, pasma	leaf	I Drink decoction
53	Fabaceae	<i>Mimosa pudica</i> L.	10	0.04	turog-turog	kidney stone, bleeding, baghat	root	I Drink decoction
54	Euphorbiaceae	<i>Jatropha gossypifolia</i> L.	14	0.056	tuba-tuba	fever, lapo, mystical element skin disease	leaf leaf	E Patch steamed leaves E Apply decoction
55	Zingiberaceae	<i>Costus speciosus</i> (Koen.) J.E. Sm.	13	0.052	tubong usa	pasma, cough Diabetes	stem leaf	I Boil and drink decoction I Drink decoction

Legend: I- internal; E – external; B – can be internal and/or external

3.5 Plant species based on IUCN Red List

Out of the total 55 species that have been identified, 17 of them have been officially listed on the red list of threatened species by the International Union for Conservation of Nature (IUCN). All of these 17 plant species are listed as 'least concern' in terms of their conservation status. A taxon is classified as 'least concern' (LC) after undergoing evaluation based on the red criteria. This classification is given to taxa that do not meet the criteria for being critically endangered, endangered, vulnerable, or nearly threatened. Among them, *Capsicum frutescens* is the only one identified as decreasing.

4. Conclusion

The findings of this study shed light on the crucial role of traditional healers, specifically the Partido Albularyo, in the eastern part of Camarines Sur, Philippines, and their extensive use of medicinal plants and herbs for treating various ailments. Given the threat of extinction that traditional medical practices face, the study emphasizes the urgent need for documenting and preserving the rich ethnobotanical knowledge that is present in this area. The documented information on medicinal plants and their uses not only contributes to the

preservation of cultural heritage but also opens avenues for scientific research and the development of new drugs and therapies based on traditional knowledge. The study also highlights the importance of integrating traditional medicine into national healthcare systems, as advocated by the World Health Organization. The identified plant species with high-use values aligning with Department of Health recommendations indicate the potential for collaboration between traditional healers and modern healthcare systems. Recognizing and validating the efficacy of certain traditional remedies can lead to a more holistic and culturally sensitive approach to healthcare. The urgent conservation and recording of ethnobotanical knowledge are paramount. This will not only benefit present communities but also contribute to the global understanding of traditional medicine and its potential role in addressing healthcare disparities. The study serves as a call to action for researchers, policymakers, and healthcare practitioners to collaborate in preserving and promoting the valuable heritage of medicinal plant use for the well-being of current and future generations.

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Conflict of Interest

The author has no conflict of interest.

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Toward a Framework for a Transportation Service Sharing Economy Platform with a Blockchain-based Service Review System

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Abstract

Several countries including Thailand currently face a phenomenon of population aging as a consequence of a combination of increasing life expectancy and a low birthrate. As people age, they may require doctor appointments more often to treat illness or for regular health check-up. This is challenging for some families since caregivers need to work and do not have time to take their parents or senior relatives to go to a medical center. In this research, a framework of a sharing economy platform for a senior transportation service, particularly focusing on the service to a medical center, is proposed and evaluated through the prototype system as a proof-of-concept. Decentralized technology in the form of blockchain, smart contract, and interplanetary file system (IPFS) are integrated with the proposed platform to tackle the challenges of transparency and trust with reviews of the provided service. The study results indicate that a hybrid architecture between a centralized and decentralized system is feasible for the proposed sharing economy platform and the emerging technology of decentralized technology has a great potential to drive the future development of a service review system.

Keywords: aging society, sharing economy, blockchain, service review system

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1. Introduction

Average life expectancy in developed countries and some developing countries has increased [1]. This results in a global phenomenon of aging of societies, including in Thailand which is rapidly aging. The percentage of elderly citizens increased from 5% in 1995 to 17.1% in 2017 [2]. According to a report into estimates and projections of the Thai population for the period 2010-2040, it is estimated that Thailand will become a superaged society in 2033 when the proportion of the population aged 60 years or older is predicted to reach 28% [3]. As people age, they may require doctor appointments more often for illness treatment or regular health check-up. It is common in several Asian countries including Thailand that family members have to take care

of the elderly and there is a need for caregivers to take seniors to see doctors. However, this is challenging for some families since caregivers may also need to work and have little time available to take their senior relatives to medical centers. Recently, there has been an increase in the popularity of a sharing economy, an emerging concept for businesses to enable people to share their services or assets via online digital platforms [4]. In 2019, Airbnb, an accommodation-sharing economy platform startup, had a valuation of approximately US\$31 billion, almost as much as the world's largest hotel chain Marriot, valued at US\$44 billion [5]. In the same year, Uber, a transportation company with a ride-sharing application, was valued at (US\$72 billion) which is higher than the market capitalization

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of General Motors, the United States' largest car company (US\$56 billion). These high valuations show that sharing economy platform business models can capture large markets and have significant competitive advantages over traditional platform business models. In addition to economic aspects, because a sharing economy can facilitate people to share and reuse their resources, it could promote sustainability [6]. Many sharing economy service applications are primarily developed for younger people, yet little attention has been paid to a sharing economy platform to specifically provide transportation services for elderly groups [7]. Such services can support aging in place to enable seniors to live independently and more flexibly in order to reduce the burden on their caregivers. The main contribution of this research is to fill this gap by developing a framework of a sharing economy platform for senior transportation services. The platform can help caregivers who need to take their seniors to medical centers to find other elderly who need to visit the same center while sharing transportation costs or earning extra money. Hence, the proposed solution will also help promote sustainability by sharing transport and caregivers when visiting medical centers, while also contributing to social well-being and economic growth. Furthermore, current sharing economy platforms mostly rely on central servers in which administrators can fully control all data manipulation including by reviewing content. To address this issue, the proposed platform is implemented based on a hybrid architecture that combines elements of both centralization and decentralization. The main functions including the management of service request posts are developed based on centralized servers. The service review module which needs to be transparent and trustworthy is implemented based on decentralized technology.

The remainder of the paper is structured as follows. Section 2 provides background and related work on sharing economy and

decentralized technology, namely, blockchain, smart contract, and IPFS. Section 3 describes the research methodology. Section 4 presents system design and implementation. Section 5 introduces a blockchain-based review system. Section 6 provides results and discussion and Section 7 presents the conclusion of the research.

2. Background and related work

This section provides a background and literature review related to the sharing economy and decentralized technology, namely, blockchain, smart contract, and IPFS.

2.1 Sharing economy

According to Hamari et al. [8] the sharing economy is described as “the peer-to-peer-based activity of obtaining, giving, or sharing access to goods and services, coordinated through community-based online services.” A report published by the Australian Competition and Consumer Commission [9] considered a sharing economy platform as a business operating an online platform facilitating peer-to-peer transactions to connect consumers and sellers in the sharing economy and utilizing review mechanisms as a means of regulating quality. According to a PricewaterhouseCoopers report [10], it is estimated that the sharing economy will grow to US\$335 billion by 2025. In [11], the author mentioned that younger people utilize sharing economy platforms more than older people because of the generational and educational gap. As age increases, the use of digital platforms decreases. Therefore, most sharing economy platforms are developed to serve younger people. However, society ages in part as a consequence of increasing lifespans; there is a demand for sharing economy service platforms that focus on elderly people.

In Thailand, the Grab application is one example of the popular sharing economy platforms operating in the country. It connects peer-to-peer users to provide a range of on-demand transport services which include

private cars, taxis, and motorcycles to deliver food, transportation, and packages [12]. Besides Grab, there are other service providers providing services to pick up elderly people to see doctors at hospitals. However, these services are not based on the sharing economy concept and instead operate as a normal business to take care of individual elderly people to see a doctor at medical centers. Furthermore, the advertisements of such services are dispersed across various websites and social media rather than compiled in one place for users to easily find information. Even though sharing economy platforms are gaining broad popularity, there is a crucial barrier in the lack of transparency and trust in the online review system [13]. Therefore, there is a need for the study to tackle this challenge in order to develop transparency and trust towards the online review system in sharing economy platforms.

2.2 Blockchain, smart contract, and IPFS

A blockchain is a specific type of distributed ledger technology (DLT) comprised of a chain of interlinked blocks, with each block having a distinct hash value that serves to identify it uniquely. Each block is interconnected by containing the hash value of each block which is linked to the hash value of its preceding block, forming a continuous chain that constitutes a distributed digital ledger. [14]. A smart contract is a computer program in which the code and state persist as data deployed on a blockchain [15]. It can proactively respond to received or executed transactions according to predefined rules. Solidity is the most popular language for creating Ethereum smart contracts. When a smart contract is deployed, it will be running on an Ethereum Virtual Machine (EVM) and is stored on the blockchain network and it can be executed automatically with high security and speed without intermediation costs. IPFS is a peer-to-peer, open-source, content-addressable, globally distributed file system that enables high throughput storage and shares large volumes of data [16]. It is based on distributed hash table

technology (DHT). Data is fragmented into several small parts and each part is identified with its hash address which is called CID and is distributed among other nodes. IPFS is widely used as an off-chain decentralized storage solution for blockchain-based applications because it can help to store decentralized and immutable data.

The sharing economy and blockchain are emerging concepts and fast-moving phenomena. Some works have been carried out on the sharing economy and blockchain technology. Nevertheless, only a relatively small number of research has been undertaken on the combination of these two fields to develop a sharing economy platform [17]. Mehrwald, et. al. [18] proposed the conceptual model of blockchain-based transparency and trust of online peer-to-peer transactions in the sharing economy. They mentioned that blockchain technology can enable trust at various stages and it has the potential to facilitate disintermediation and solve trust issues in the sharing economy. In [19], the authors presented a blockchain-based circular economy credit rating system to address the challenges of traditional credit checking process that relies on information from another party's credit status, which is time-consuming and results in higher transactional costs.

According to the literature review, numerous studies have focused on developing sharing economy platforms for various purposes, while some attempts have been made to integrate blockchain-based technology into their platforms. Nevertheless, to the best of our knowledge, there have been no studies that combine these two fields to develop a hybrid system architecture of a sharing economy platform providing a transportation service for elderly people to go to medical centers.

3. Research methodology

In this research, the design science research methodology was chosen. According to [20], design science research is a research paradigm

that addresses human problems by building innovative artifacts and contributing new knowledge to the body of scientific evidence. Design science research addresses the design, creation, and evaluation of applicable artifacts, for example, methods, applications, and systems, that could potentially enhance the efficacy of information systems in organizations [21]. In this study, a design science research methodology is applied to develop and evaluate the proposed framework as it provides guidelines and principles to solve problems through the creation of innovative information technology artifacts. Six activities are implemented according to the guidelines of design science research methodology of Peffers et al. [21] as follows.

3.1 Activity 1: Problem identification and motivation

In this activity, an extensive literature review is conducted on the topics related to problems in aging and aged society, particularly focusing on the challenges of getting seniors to their doctor appointments in Thailand's context and existing sharing economy platforms. The analysis of the existing literature helps to identify research gaps and open research issues. A comprehensive study has revealed that there is a lack of a sharing economy platform to provide service for seniors to their doctor appointments in which some resources such as transportation or carers can be shared. In addition, because transparency and trust in the quality of service providers are important, particularly in the peer-to-peer sharing economy platform, the proposed platform should be integrated with an effective mechanism to provide transparency and trust with a service review system.

3.2 Activity 2: Objectives of the solution

According to the problem identification and motivation previously identified in Activity 1, in this step, the primary objective of this research is defined. It seeks to develop a framework for a sharing economy platform for senior transportation services to medical

centers. The research objective can be segmented into the following sub-objectives:

Sub-objective 1: To develop a system architecture of a sharing economy platform focusing on senior transportation services to medical centers.

Sub-objective 2: To develop an approach to provide transparency and trust through service reviews.

Sub-objective 3: To develop and evaluate a system prototype as a proof-of-concept experiment of the proposed framework.

3.3 Activity 3: Design of the solution

To address the abovementioned problems in Activity 1, the objective of the proposed solution is transformed into the software artifact's functionality and its system architecture. The proposed sharing economy platform framework for senior transportation services to medical centers (hereinafter referred to as GoMed) is designed as a hybrid system between a centralized and decentralized architecture. The main function of the platform which is a host for service providers and clients to meet and match the service relies on a centralized architecture. However, since a user review of the service quality is vulnerable to data manipulation by the host, the service review module is designed based on a decentralized architecture. The detail of the design activity is described in Section 4.

3.4 Activity 4: Development of the solution

Once the software solution was designed in the previous activity, in this step, a proof-of-concept system prototype is developed. As previously mentioned, the GoMed platform does not just rely on a centralized software solution, but also integrates both centralized and decentralized technologies. The main function of the platform to be a host for service providers and client to meet relies on a centralized technology. However, a service review module is built upon a decentralized technology, specifically blockchain and smart contract, to handle system's state and logic. Furthermore, in this research, IPFS is also used to store user service review content. More

details of the development activity are described in Section 5.

3.5 Activity 5: Evaluation

Once the system prototype is implemented as a proof-of-concept experiment, it is used to evaluate technological feasibility and functionality of the proposed sharing economy platform and to enable trust and transparency in reviewing the service. The developed software artifacts' functionality is compared with the solution objectives. The proposed solution is evaluated in accordance with a framework for evaluation in design science research addressed by Veneble et al. [22]. The simulation technique, which is considered an artificial evaluation approach by executing a prototype with artificial data, would be used to evaluate the system prototype. The detail of the evaluation activity is described in Section 6.

3.6 Activity 6: Research communication

This activity involves the dissemination of the research objective, methodology, and research findings to relevant audiences such as the academic community through this publication.

4. GoMed: A sharing economy platform for senior transportation services to medical centers

In this section, the system analysis of the proposed platform is discussed, followed by the system design and implementation.

4.1. System analysis

In this study, a use case diagram was chosen to explain and document the interaction required between the users and the system to accomplish the user's task as well as to provide the functionalities of the proposed platform as shown in Figure 1. There are five types of actors as follows.

1) User – This actor is kind of an actor generalization to represent the inheritance relationship meaning that the descendant actor can have all the use cases that have been defined for its ancestor. For instance, a general user and a client have some common behaviors, namely, “Browse post” and “View service review”; therefore, an actor type “User” is used to capture those common functionalities and

then the descendant actors which are “General user” and “Client” can be specialized to identify the individual needs of each actor.

2) General user – This actor can browse posts regarding service offerings and service requests and view service reviews. Then if he wants to post his available service on the platform, he has to register to the platform.

3) Client – When the general user successfully registers to the platform, his role will be changed to be a client. He can then manage his post by adding, updating, or deleting the post to request a transportation service to take a senior to the doctor for a scheduled appointment. In addition, this actor can view service reviews of a specific service provider written by previous clients to make a service purchase decision. He can also add a service review after the job has been completed. In addition, he can view service request reports and manage his user profile.

4) Service provider – This actor needs to register to the platform. He can manage his posts to offer a transportation service for seniors to go to medical appointments. He can view service reviews and service-related reports as well as manage his profile.

5) Administrator – This actor has rights over several services including managing the system configuration, managing user profiles, and viewing service-related reports.

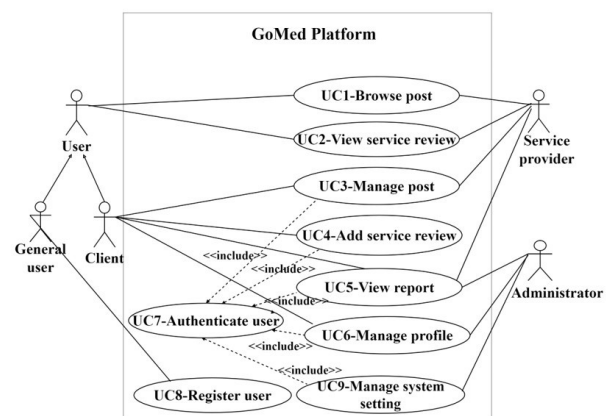


Figure 1. A use case diagram

Table 1 presents available use cases and their functionalities for the proposed platform.

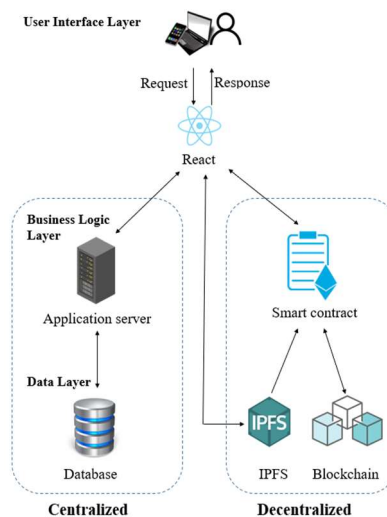
Table 1. Detail of GoMed platform use cases

Use case#	Use case name	Use case functionalities
UC 1	Browse post	To allow users to browse service posts
UC 2	View service review	To allow users to view service reviews
UC 3	Manage post	To allow service providers and clients to add/update/delete their posts
UC 4	Add service review	To allow clients to add service reviews regarding the quality of service received
UC 5	View report	To allow authorized users to view service post reports
UC 6	Manage profile	To allow authorized users to manage their profiles
UC 7	Authenticate user	To authenticate user identity
UC 8	Register user	To allow general users to register to the GoMed platform

4.2 System design

The GoMed platform is designed as a hybrid system between a centralized and decentralized architecture as depicted in Figure 2. The system

architecture can be divided into three layers. The first layer is a user interface layer interacting with a user by sending a user request to the next adjacent layer, receiving a response and displaying a result to the user. The second layer is a business logic layer, an intermediate tier between a user interface layer and a data layer. It is responsible for logical processes and calculations. A request is also processed based on predefined logic in the application to yield meaningful information for communicating to the data layer which is the third layer. The main function of the platform which is a host for service providers and clients to make service-related posts to share transportation services for medical appointments relies on a centralized manner. However, the review of the quality of the service received is based on decentralized technologies, namely, blockchain and smart contract used to provide decentralized management of the logic and state of the system. In addition, IPFS is used to store service review content to enable off-chain decentralized file storage and provide immutable permanent links which use content addressing in a blockchain.

**Figure 2.** Overview of the GoMed architecture.

4.3 Prototype implementation

The GoMed prototype is implemented as a proof-of-concept based on the following criteria.

4.3.1) Authentication

Even though general users can access and view public posts, they cannot make a new post or modify or delete a post. Only registered

users, i.e., clients, service providers, and administrators can log in and do those operations.

4.3.2) Transparency and trust of review content

In the sharing economy platform, consumers are likely to make their purchase decisions based on previous service quality reviews. Therefore, with the centralized system, reviews are subject to compromise or tampering by the administrator in order to manipulate consumer purchase decisions. Concerning the transparency and trust of service review content, blockchain technology, smart contract, and IPFS are utilized in the proposed platform. As a consequence, reviews can be verified that they are genuine, historically consistent, as well as untampered.

4.3.3) Human-computer interaction

The main functions of the GoMed platform prototyping to allow clients and service providers to manage their posts and to communicate to each other are developed with a combination of various technologies, namely, HTML5, CSS, JavaScript, Bootstrap, and React JavaScript library. The design of the interface follows the principles of being simple and easy to use so a new user can learn to use the platform easily.

The current state-of-the-art online review system of sharing economy platforms is inefficient as they lack transparency and trust in review content. This is because those platforms rely on central servers with full control of the platforms' authorities such as administrators. Therefore, all service review content is prone to be modified, removed, or manipulated by the central authorities. In this paper, a novel blockchain-based review system approach is presented to solve the abovementioned issues in sharing economy platforms. A blockchain is selected to be an underlying infrastructure to provide transparency and trust in service review content. Smart contract which is a deterministic program that runs on a blockchain is also used to automatically execute when it is triggered by an on-chain transaction without human intervention. The platform also uses IPFS as off-chain storage to solve the scalability problem that arises due to the increasing number of transactions and nodes on the blockchain by carrying out transactions outside of the blockchain. IPFS is widely used as an off-chain decentralized storage solution for blockchain-based applications because it can help to store decentralized and immutable data. A workflow of the blockchain-based service review module in the GoMed platform is presented in Figure 3.

5. Toward a blockchain-based service review system

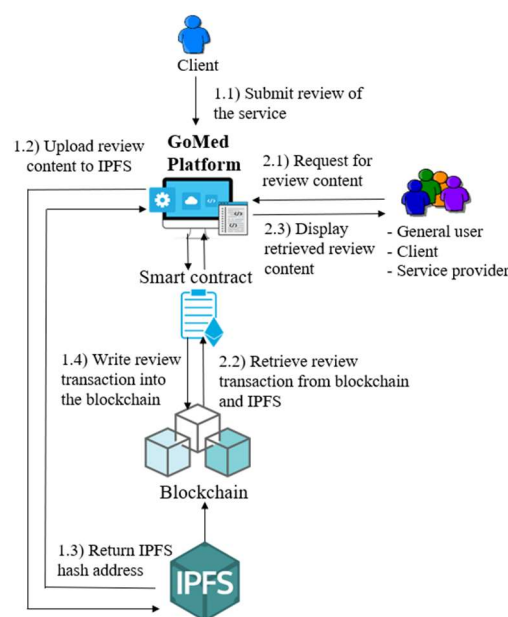


Figure 3. A workflow of the service review module

As shown in Figure 3, the blockchain-based service review module consists of three main components, namely, blockchain, smart contract, and IPFS. During the development phase, the smart contract written in Solidity programming language is compiled and executed on a development network. Then it is deployed to the Sepolia blockchain which is a testing network for Ethereum blockchain. The transaction is time-stamped depending on the block that it is accepted and cannot be altered or removed later. When a user submits a review regarding the quality of a service previously received, the review content is uploaded to the IPFS network which is used to store service review content in an open distributed storage system. Therefore, although the host node is disconnected, there will be other nodes in the IPFS network that have a cache and can provide the requested review content. Once the review is uploaded, the IPFS hash address which is a unique identifier of the document is returned to the platform. Next, the GoMed platform submits the service review information and IPFS hash address of review content to the Sepolia blockchain network by interacting with a smart contract through Web3.js, the JavaScript Application Programming Interface library to connect the web application to a blockchain.

In case a user would like to view the review content of a particular service provider to make a service purchase decision, they can make a request to receive review content through the GoMed Platform. The smart contract function to get service review information is activated. It retrieves the review information stored on the blockchain as well as the real review content from the IPFS. The review information is sent to be displayed to the user. After the client received the service from the provider, they are eligible to review the quality of the service. Once, the client submits the review, the review content is uploaded to the IPFS network and then a hash address linked to the uploaded review content is returned. Service review information along with the IPFS hash address is subsequently saved within the blockchain by the smart contract.

Some key variables used in the implementation of the service review smart

contract are shown in Table 2 and an algorithm of the process of service review submission to the blockchain is described in Algorithm 1.

Table 2. Some key variables used in the implementation of the smart contract.

Name	Type	Description
Reviewer-Address	address	The address of a reviewer who submits a review regarding service quality
Service-ProviderID	string	The identification of a service provider
serviceID	string	The identification of a service received
reviewTime-Stamp	uint	Timestamp of the review submission
rating	uint	The rating score of the service quality received
IPFSReview-Content	string	The hash address of review contents in IPFS network
Service-Reviews	mapping	A mapping type that stores a mapping relationship between the service provider and information on the review content
totalReview	uint	The number of total service reviews for a service provider

Algorithm 1. A process of service review submission to the blockchain

Input: serviceProviderID, serviceID, rating, IPFSReviewContent, reviewerAddress
If the rating is between 1 and 5 and the IPFSReviewContent is not empty
Add review information (i.e., reviewerAddress, serviceProviderID, serviceID, reviewTimeStamp, rating and IPFSReviewContent to the blockchain)
Trigger event ReviewAddedEvent
Notify with a message "Submit review successfully"
Else
Revert the smart contract state and display an error message
end if

6. Result and discussion

In this section, the system prototype is used as a proof-of-concept experiment to evaluate the technical feasibility and functionality of the proposed platform framework. Therefore, in this study, the developed system prototype is

evaluated in terms of functional testing against the identified objectives in Section 3.2. The evaluation is carried out in accordance with a framework for evaluation in design science research addressed by Veneble et al. [22]. It is to be noted that the artificial evaluation technique is chosen to evaluate the platform because of its benefits of having stronger scientific reliability in regard to repeatability and falsifiability as well as the possibility to control potential confounding variables more carefully [22].

6.1 Experiment Setup

The proof-of-concept system prototype of the GoMed platform was developed to demonstrate some use cases and evaluate its performance. The proposed smart contract was developed in the remix IDE using Solidity programming language and deployed to the Sepolia blockchain network which allows for development testing and verifying before deployment on the main network. In this research, the black box testing technique was selected, which is a design science evaluation method to evaluate functional testing by executing artifact interfaces to uncover failures and detect defects [20]. The following use case scenarios are simulated examples for the experiment to evaluate the technological feasibility and functionality of the proposed platform. Details of these use case scenarios are as follows.

Use case scenario 1: A client is looking for a service provider

In the experiment, we assume that Alice has the go med username in the platform. Alice, a bank teller with a sixty-year-old father, would like to find someone to take her father to the medical center for an annual health check-up. She logged in to the GoMed platform and browsed for available services. Unfortunately, there was no service offered on that day. Therefore, Alice created a new post to request a service on the GoMed platform. In the post, there was information, namely, the original address to pick up her father, their name, address, and map of the medical center, the date and time of the requested service, the service fee offered, as well as additional details in case that Alice would like to communicate with the service provider. Alice confirmed that the above information was correct and then this information was uploaded to the GoMed

platform as shown in Figure 4. We also assume that Bob, a man who is a registered service provider of the GoMed platform, was going to take his father to see a doctor at the same medical center as Alice's father on that day. He would like to have someone to go with him in order to share the transportation expenses as well as to earn extra money. He thus visited the GoMed platform and browsed through the available service request posts. He found Alice's post and wanted to accept the job. He could send a direct message to Alice in case he had any questions according to the service. Once he decided to accept the job, the platform updated the post's status as accepted and the confirmation message was sent to Alice.

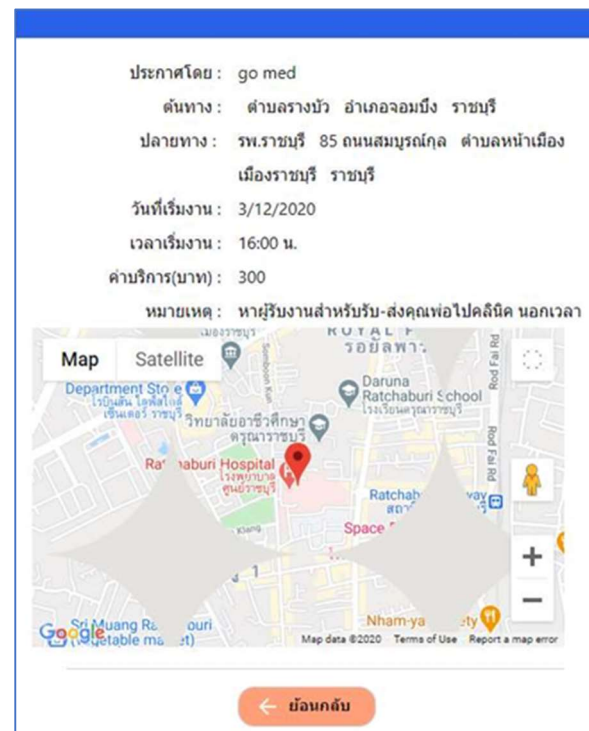


Figure 4. A screenshot of the requested service post

Use case scenario 2: The service has been completed and the client submits the review.

When Bob completed his job and changed the status of the provided service as completed, the GoMed platform allowed Alice to write a review regarding the quality of Bob's service. Alice could submit the review regarding the quality of service provided by Bob through the GoMed platform. There is also a frontend validation for input fields of the service review form to ensure properly formed data is provided (e.g., missing content or incorrect format). The valid service review content was uploaded to

the IPFS network, which then returned the hash address of the uploaded review content to the GoMed platform. The platform would then submit service review information and the hash address of the review content to the smart contract. The smart contract then created a transaction with all the information and submitted it to the blockchain. Figure 5 represents a sequence diagram of submitting a service review process by a client.

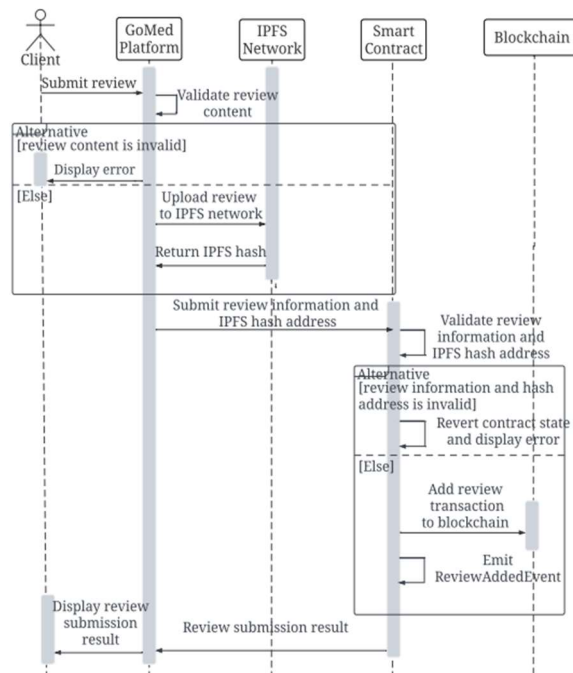


Figure 5. A sequence diagram of review submission

6.2 Result and discussion

According to the design science research, once the proposed solution is developed, it will be evaluated. In this study, the functionality of the proposed system is evaluated through the system prototype by using a black box testing technique. The purpose is to determine whether all functionality of the GoMed platform operates properly according to the use cases that have been analyzed. The result of the evaluation might be either ‘Pass’ for success or ‘Fail’ for failure. The result of the black box testing has shown that all system functionality performed as expected. Specifically, in order to evaluate the blockchain-based review module, a transaction cost is calculated and used to measure the performance of the prototype as a technical-based evaluation. The service review module is implemented on the

Ethereum blockchain; therefore, a transaction fee called ‘gas’ has to be paid for each data manipulation transaction. On the Ethereum network, the gas or transaction fee is paid in Ethereum’s native currency called Ether (ETH). The total cost of fees which is in Ether unit can be calculated by multiplying gas used with gas price [23] as shown in the equation (1).

$$\text{Total cost (Ether)} = \text{Gas used} * \text{Gas Price (Gwei)} \quad (1)$$

Each operation consumes the number of gas used and can be calculated to the amount of transaction cost in Ether as presented in Table 3.

Table 3. The transaction cost of operation in Ether for the developed smart contract

Operation	Gas used (Units)	Gas Price (Gwei)	Total cost (Ether)
contract deployment	1,252,038	2.50000001	0.00313009501
addReview function	366,315	2.50000001	0.00091578750

According to the gas cost evaluation result shown in Table 3, it is seen that the blockchain-based service review system has some costs, but it is rather small and acceptable when compared with the advantage of transparency and trust achieved. It is to be noted that because the proposed system is implemented by using IPFS as a low-cost off-chain storage for the review content, only hash addresses returned from IPFS are stored on the blockchain. The IPFS address is a fixed-size bitstream. As a consequence, the gas cost for processing the hash address data is rather steady no matter the size of the service review content. The experimental result has shown that the integration of decentralized technology, namely, blockchain, smart contract, and IPFS in the GoMed platform can tackle the challenges of transparency and trust in review content which greatly enhances the confidence of users.

In this study, besides the technical-based evaluation to measure the performance of the proposed solution, the comparison of the

developed system prototype to existing solutions is also presented. Table 4 provides a comparison of the conventional review system in existing sharing economy platforms (i.e. Airbnb, Uber, Grab) which do not use blockchain technology, and the proposed blockchain-based review system presented in this study. The comparison result has shown that the integration of blockchain-based technology in the service review process of the GoMed platform can tackle the challenges of transparency and trust in the review process which greatly enhances the confidence of the GoMed platform users.

Table 4. Comparison between conventional review systems and the proposed review system

Characteristics	Conventional review systems	Proposed review system
Architecture	Centralized	Decentralized
Authority	Central authority	No central authority
Single point of failure	Yes. If the central server fails, it may cause the entire system to stop operating.	No. Each node in a blockchain network has a duplicate of the ledger.
Data integrity	Review content can be manipulated.	Review content is immutable.
Data security	Review content is prone to data leaks.	Review content is secure because it is encrypted.
Data manipulation	Support creating, reading, updating, and deleting data operations	Only support reading and writing data operations
Reliability	Less reliable because review content can be deleted or modified	More reliable because review content cannot be deleted or modified
Maintenance	Easy to maintain	Difficult to maintain
Fault tolerant	No	Yes
Anonymity	No	Yes
Transparency	Not transparent	Highly transparent and auditable

7. Conclusion

In this paper, a framework of a sharing economy platform has been proposed and it captures the main operations required for a

peer-to-peer-based activity of providing or sharing senior transportation services to medical centers. Furthermore, a proof-of-concept prototype of the proposed framework is implemented based on a hybrid architecture between a centralized and decentralized system in order to leverage the advantages of both architectures. For instance, the majority of operations such as managing a service post or managing user profiles are designed to operate on a centralized host and traditional database solution because of a need for data modification, cost-effectiveness, and easy maintenance. However, the module for reviewing the quality of service is implemented based on decentralized technology, namely, blockchain, smart contract, and IPFS to provide transparency and trust in the consumer review content to ensure reviews are transparent in the proposed platform since review data is always available at any time to all users. In addition, this service review content can be trusted because it is stored on the distributed file storage platform, namely, IPFS and blockchain in which stored data is immutable.

Overall, the main contributions of this work can be concluded as follows:

1. The development of a framework of sharing economy platform for senior transportation services, particularly focusing on the service to medical centers.
2. A blockchain-based service review approach to provide transparency and trust in consumer review content.
3. A hybrid architecture between centralized and decentralized systems to tackle interoperability challenges according to transparency and trust of consumer reviews within the proposed sharing economy platform.

In spite of a good result from the experiment from a proof-of-concept prototype, this work still has a limitation. It lacks an incentive mechanism to encourage a user to provide a service review previously received. Therefore, in future work, the proposed platform could be enhanced with a business model equipped with an algorithm to incentivize consumers of the

platform to provide their service review through a blockchain-powered incentive mechanism such as loyalty rewards with cryptocurrency tokens. The emerging technology of decentralized technology has great potential to drive the future development of review systems which can influence consumer purchasing decisions for products or services as well as revolutionize the future of sharing economy platforms. When the proposed GoMed platform is deployed for real use, it can facilitate caregivers accompanying their elderly relatives to medical centers. The platform achieves this by connecting caregivers with other seniors who have medical appointments at the same location. This connection enables cost-sharing for transportation or allows caregivers to earn additional income during their visits to the medical center. Consequently, this proposed solution promotes sustainability by fostering the sharing of transportation resources and caregivers during medical appointments. It can play an important role in enhancing social well-being and contributing to economic growth.

Acknowledgments

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Enhancing Line Chatbot Experiences: Utilizing Thai Question-Answering Systems to Enrich Dialogue with Unpredictable Questions

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Abstract

Chatbots have gained popularity in recent years as a means of engaging with people using natural language, especially Line Chatbot, which has 290,000 active chatbots in Thailand. With such a high number of active chatbots in Thailand alone, Line Chatbot has become a prominent player in the chatbot market. The main problem with chatbot construction is processing unpredicted questions. Even if Dialogflow, as a natural language understanding tool, can assist us in finding users' intentions, it is not good enough. In this work, we intend to enhance Line chatbot experiences by utilizing the pre-trained Thai Question Answering model as the NLP service that talks with the chatbot via the RESTful API. The major task is to deal with the message that Dialogflow cannot find the user's intention. With this strategy, we can improve the chatbot's ability to answer unexpected or complex questions, offering more accurate and relevant responses. By incorporating the Thai Question Answering model, the chatbot may exploit its pre-trained expertise to better understand and reply to user queries, boosting the overall user experience. The results show that the system met the specified requirements and consistently provided users with meaningful information.

Keywords: Line Chatbot, Thai Question Answering, Natural Language

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1. Introduction

Chatbots have gained significant popularity in recent years as they provide automated responses and assistance to users in various industries such as customer service, healthcare, e-commerce, and education [1]–[4]. Question-Answering Systems (QAS), on the other hand, are designed to retrieve relevant information from large databases or knowledge bases to answer specific questions. In many universities in Thailand, constantly responding to students' inquiries is the duty that staff must execute on a daily basis. This task can be time-consuming and overwhelming for staff, especially during peak periods. By developing chatbots that are capable of handling complex inquiries, universities can alleviate some of the burden on their staff while still providing timely and personalized support to students. However, the

effectiveness of these chatbots heavily relies on their dialogue capabilities. Most chatbots cannot manage unanticipated queries or sophisticated interactions, generating annoyance for users. As a result, institutions are investing in advanced natural language processing algorithms and machine learning approaches to increase the dialogue capabilities of their chatbots. By training these chatbots on vast datasets and using contextual awareness, universities want to boost their chatbots' capacity to handle a wide range of queries and deliver individualized advice to students, but the training's cost on a large dataset is very high.

This research aims to create a more efficient and cost-effective solution for universities, reducing the need for extensive training and resources for staff members and focusing on enhancing their ability to respond to unpredicted questions within a specific context.

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By studying new techniques and strategies, this research intends to improve the NLP model's capacity to handle complex inquiries and provide appropriate responses. The goal is to enhance the overall chatbot experience and enable universities to offer individualized advice and support to students.

2. Literature Review

2.1 Chatbot

A chatbot [5] refers to a software application that has the capability to imitate a dialogue like that of a human being, either through written text or spoken language. Chatbots can be categorized into three distinct classifications, which encompass rule-based, generative, and retrieval-based models. Rule-based chatbots rely on pre-established rules to decide the appropriate responses to user input, whereas generative chatbots employ neural networks to produce novel responses. Retrieval-based chatbots use a mechanism that selects responses from a pre-existing database of responses in accordance with the user's input.

In the context of university chatbots, in addition to the presence of intelligent chatbots, prioritizing user experience is crucial to fostering a sense of comfort and engagement among students when interacting with the university's digital platforms. The field of user experience design is centered around the enhancement of platform layout, navigation, and functionality in order to provide an intuitive and user-friendly experience. The incorporation of a visually appealing and user-friendly interface enhances the likelihood of student engagement with the chatbot, hence facilitating the acquisition of proactive assistance. Furthermore, the integration of consistent feedback and updates from students can contribute to enhancing the user experience and tailoring it to their specific needs and preferences. The utilization of a chatbot within the Line application is deemed appropriate in this particular context due to its capability to seamlessly integrate into the platform and provide students with a familiar user

experience. The Line Application's chatbot, with 54 million active users in Thailand [6], can be programmed to give individualized advice and help depending on each student's particular progress and goals. In addition, the inclusion of interactive elements such as flex message, quick reply, imagemap, template message, and multimedia support serves to enrich the overall learning experience and adds an element of excitement for students. Incorporating a chatbot into the Line application has the potential to significantly enhance the efficacy and user-friendliness of the platform, particularly for students in search of aid and support.

2.2 NLP & Thai Question Answering System

Natural language processing (NLP) is used in chatbots to make it easier to understand and answer user questions by considering the question's context and the meaning behind the words used. The comprehension of intricate aspects of human language enables chatbots to deliver responses that are both precise and pertinent, enhancing the user experience by ensuring a seamless and gratifying interaction. The Thai language is characterized by complicated tonal distinctions and grammatical structures, posing a significant obstacle for natural language processing (NLP) technology [7]. Thai natural language processing (NLP) has been developed using many methodologies, such as rule-based, statistical, and deep learning techniques [8].

Question answering (QA) and natural language processing (NLP) are two fields within artificial intelligence (AI) that focus on understanding and generating human language. NLP aims to enable computers to understand, interpret, and generate meaningful human language through tasks like text classification, entity recognition, machine translation, text generation, sentiment analysis, and part-of-speech tagging. QA, a specific application of NLP, focuses on extracting answers from textual or structured data in response to user queries. QA systems can range from simple

keyword-based searches to advanced models using deep learning techniques. Recent advancements in NLP have improved the performance of QA systems, making them well-suited for various NLP tasks.

The Thai Question answering system [9] is a cutting-edge technology that uses artificial intelligence to generate accurate, relevant answers to various Thai language inquiries. Thai language faces challenges in natural language processing due to its grammatical structures. Despite this, Thai question-answering systems use various methodologies, including rule-based systems, statistical models, and deep learning architectures, to provide precise responses. However, their precision and scalability are limited by the availability of training data [9]–[12].

2.3 Dialogflow

Dialogflow [13] is a service provided by Google that facilitates the advancement of natural language processing and serves as a foundation for constructing chat interfaces for websites, mobile applications, widely-used messaging platforms, and Internet of Things (IoT) devices. Dialogflow has the capability to establish connections with many platforms such as Alexa, Facebook, Twitter, Slack, Cortana, and Line. Through this integration, Dialogflow is able to receive messages from users and afterwards employ its translation functionality to analyze the content of these messages. The primary objective of this analysis is to discern the intentions of the users and subsequently categorize them into distinct intents. Developers will possess the capability to formulate suitable solutions for users. The aforementioned solutions encompass both static and dynamic responses, facilitating developers in the creation of a program that supports their job by utilizing their preferred programming language and establishing connections with their own database. Moreover, different segments that are implemented within a secure Hypertext Transfer Protocol Secure (HTTPS) are subjected to encryption measures, thereby

guaranteeing the prevention of unauthorized data theft. A potential security threat known as a "man-in-the-middle attack" is being discussed.

2.4 Related Works

Balderas et al. [1] proposed using a chatbot to provide initial support and facilitate communication between students and the university during the COVID-19 pandemic. They create the chatbot using DialogFlow and connect it to Google AppScript as a webhook to retrieve more information. The results of the testing, which involved over 160 students and staff members from student services, are in favor of chatbots as a potential tool for communication in developing emergency situations.

Illescas-Manzano et al. [3] implemented a chatbot via Facebook Messenger and the ManyChat platform, demonstrating that a chatbot on the platform positively impacts lead capture. The study concludes that incorporating a chatbot can be a powerful tool for obtaining consumer information, facilitating two-way communication, and facilitating sales for companies.

Chandra et al. [4] developed a chatbot for university admission using a question-answering system based on the sequence-to-sequence model. They train this model using a dataset of conversations from university admissions. Their approach is to combine sequence-to-sequence with an attention mechanism to give a response to the given question. The model achieves a high BLEU score of 41.04, but an attention mechanism technique using reversed sentences improves it to 44.68.

3. Design and Development

Line Chatbot is an AI program that uses natural language processing and machine learning to provide personalized assistance and information. It can be developed using the Line messaging platform and Dialogflow, a cloud-based platform that integrates AI technologies for intelligent chatbot applications. One

limitation of chatbots is their ability to accurately understand and respond to complex or ambiguous questions. Additionally, chatbots may struggle with providing relevant and contextually appropriate answers, especially when faced with a wide range of diverse questions.

This section aims to elucidate the process involved in the creation of an application that integrates a Thai chatbot with a question-answering system. The NPRU Smart Campus Chatbot system combines chatbot and question-answering technology to provide students with natural language responses. The system consists of three actors: high school students, university staff, and university students as described in Figure 1. Students can inquire about admission requirements, programs, and

deadlines, while university staff can assist with administrative tasks. University students can access course schedules, grades, and campus events. The Line Messaging API offers various message types, making it user-friendly and interactive. The system also integrates with other apps and services, allowing students to access relevant information and resources. This prototype aims to provide students with precise, succinct responses in a natural language format.

Additionally, the API allows for easy communication between students and faculty members, enabling them to schedule appointments or seek academic guidance conveniently. With its versatile features and user-friendly interface, the Line Messaging API enhances the overall efficiency and effectiveness of university operations.

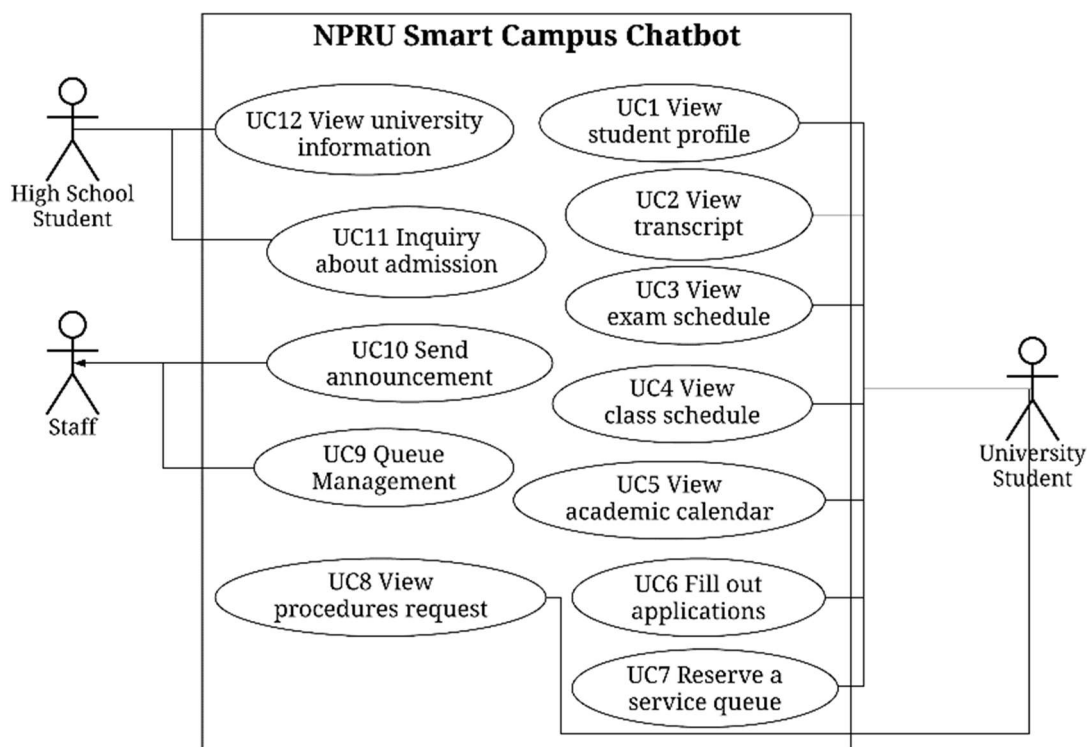


Figure 1. Use case Diagram of NPRU Smart Campus Chatbot

3.1 System Architecture & Implementation

The adoption of a multi-tier architecture design pattern was chosen for the implementation of the NPRU Smart Campus Chatbot. Multi-Tier Architecture [14], alternatively referred to as N-Tier Architecture, is a prevalent design pattern in software development. Its purpose is to partition the many components of an application into independent levels, or tiers. Each layer within the organizational structure is assigned distinct duties and possesses a clearly delineated set of responsibilities. This architectural methodology contributes to the enhancement of scalability, maintainability, and flexibility in intricate software systems. The quantity of tiers may exhibit variability, while the prevailing multi-tier systems often encompass three tiers: presentation, application (business logic), and data tiers.

The system is divided as shown in figure 2: 1) The Presentation Tier, which uses the Line chatbot as a channel to engage with the user, can send messages through the chat room, and when the processing system is completed, the results are sent through the Line application. 2) The Application Logic Tier, constructed using Node.js, operates as a Webhook or Application Gateway that coordinates with the Presentation Tier and Resource Manager Tier. For example, when the user requests their grade, the chatbot will send a service request to the webhook. The system then connects to the database to search for information from the Resources Manager Tier level, then generates the results that are appropriately prepared, thereby distributing the results to users via the online application, etc. In the application logic tier, there is another component, the Dialogflow API, which shifts the natural language processing function (NLP) to the application, so the user is directed back to a webhook processor in order to complete the processing process. 3) The Resource Manager Tier is created utilizing the CodeIgniter framework, a PHP framework that serves as a REST API. Webhook can access the database by using this API. The Resource Manager layer

includes the integration of the NLP service with two additional services. The two technologies under discussion encompass the Dialogflow API and Thai QAS. The implementation of the Thai Question Answering System (QAS) utilizes FastAPI, a Python framework that facilitates the transmission of unforeseen queries and their corresponding context via a RESTful API. The primary objective of this function is to acquire the suitable response from the Dialogflow API, then utilized for generating a reply to the user.

The incorporation of the Natural Language Processing (NLP) service with the Dialogflow Application Programming Interface (API) and Thai Question Answering System (QAS) facilitates enhanced language processing and comprehension with improved efficacy and precision. By leveraging the Dialogflow API, the system demonstrates the ability to perform an analysis and interpretation of the user's queries, afterwards providing relevant responses. The functioning of the Thai Question Answering System (QAS) is greatly enhanced since it allows for effective handling of unanticipated queries and the provision of contextually appropriate responses. In aggregate, these technologies enhance the system's capacity to generate solutions that are both significant and advantageous in resolving user enquiries. Moreover, the partitioning of the system into these three tiers provides improved structuring, expandability, and manageability of the software. The independent development and upkeep of each layer enable the smooth integration of novel functionalities or error corrections without causing disturbances to the overarching system.

3.2 User Interaction with Dialogflow API

Dialogflow is a Natural Language Understanding (NLU) engine to enable users to develop intelligent chatbots effortlessly. It provides developers with an API to interact with the chatbot and retrieve user inputs. This allows users to have a conversational interaction with the chatbot, asking questions or issuing commands. The Dialogflow API

analyzes these inputs and returns suitable replies depending on the stated intents and entities. This enables a more human-like and intuitive user experience. In our scenario, students can submit messages to the chatroom to inquire about any information described in Figure 1. The chatbot may seek more information to grasp the context, and then Dialogflow will determine the genuine intention of the student and transfer it to the API gateway to build an automatic answer in case it cannot fulfill the replies by itself and give it back to the student.

One of the challenges that chatbot developers have to address is that we cannot foresee every user query as it is a chat and users can send any text to the chatroom. In order to emulate people, chatbots have to deal with unpredicted questions. To address this difficulty, developers can utilize machine learning methods to train the chatbot on a wide range of probable user queries. By regularly feeding it with new data and analyzing its performance, the chatbot can learn to recognize

patterns and create acceptable responses, even for unexpected requests. Additionally, developers can also include natural language processing techniques to help the chatbot grasp the underlying meaning and context of user queries, enabling it to offer more accurate and relevant answers. In order to accomplish this, we need a supercomputer with great performance, a huge dataset to feed and train the model, and additional time to train the model. Each of these costs a lot, which a tiny firm such as a government agency cannot offer. In order to address this issue, we proposed an alternative solution. Our approach entails developing Thai Question Answering System APIs based on pre-trained models that offer sophisticated machine learning capabilities while minimizing the work and time required for training. By employing these APIs, we can reduce the need for a supercomputer on-premises. This approach helps small companies like government agencies harness the benefits of NLP without paying extravagant fees.

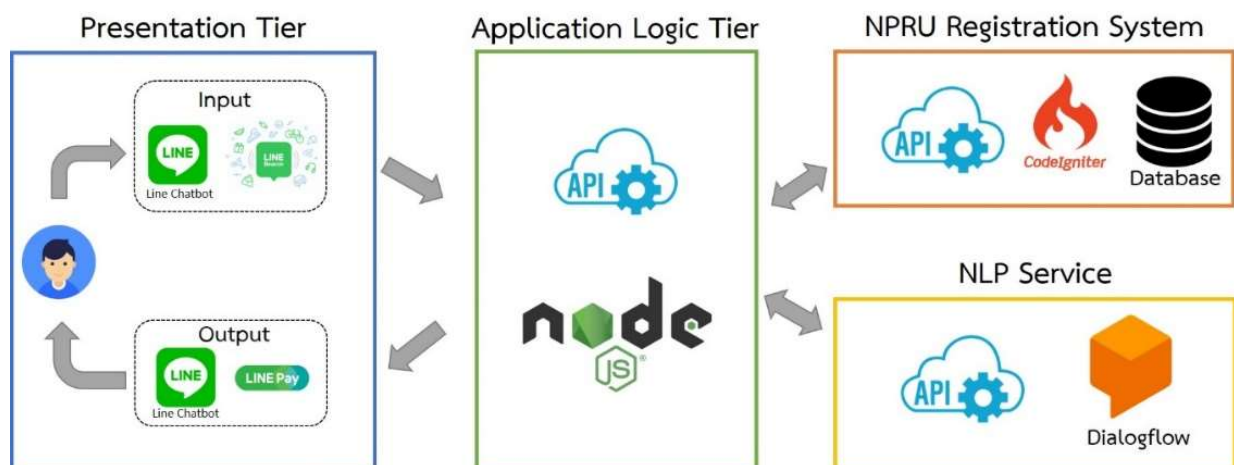


Figure 2. NPRU Smart Campus Chatbot's System Architecture

3.3 NLP Service Combination

As mentioned before, NLP services are developed using a pre-trained Thai question-answering model. According to Thammarak's advice [15], the development of a RESTful API included the use of the WangchanBERTa-QA-

Thaiqa_Squad pre-trained model. WangchanBERTa [16], one of the top BERT-based [17] models for Thai NLP, specializes in a variety of NLP tasks and has been tailored especially for comprehending Thai. In the areas of named entity recognition, text

categorization, and question answering, it has produced cutting-edge results. WangchanBERTa's robust features have greatly increased Thai NLP and made it a useful tool for developers and researchers working with Thai. The utilized model in this study is the Wangchanberta-base-att-spm-uncased model, which is then fine-tuned using the Thaiqa_squad dataset. The Wangchanberta-base-att-spm-uncased model's fine-tuning method uses the Thaiqa_squad dataset to help it do better at answering questions about open-domain themes. The Nvidia DGX-1, consisting of 8 units of a 32GB GPU, was utilized to train this model. It took around 125 days to train the model on a big 78.5GB dataset consisting of 360,000 training steps. There are 4,000 questions in the Thaiqa_squad dataset for training and 74 questions for development, both of which NECTEC generated and PyThaiNLP converted to SQuAD format.

We use FastAPI [16], a Python framework that allows us to easily deploy and serve WangchanBERTa-QA-Thaiqa_Squad for Thai NLP applications. FastAPI is widely recognized for its outstanding performance and scalability, making it a very desirable choice for efficiently handling the significant workload associated with NLP activities. FastAPI offers the functionality to create efficient and reliable APIs for seamless integration of WangchanBERTa-QA-Thaiqa_Squad into various applications. The combination of WangchanBERTa-QA-Thaiqa_Squad and FastAPI offers developers a streamlined and effective method to leverage the sophisticated functionalities of Thai NLP. This methodology enables the creation of NLP services that possess the capability to provide precise responses to inquiries posed in the Thai language. Developers have the ability to leverage pre-trained models and enhance their performance by fine-tuning them with pertinent data, enabling the creation of robust and efficient NLP applications. Not only does this practice result in time and energy conservation, but it also allows enterprises and people to

obtain NLP capabilities at a significantly reduced expense in comparison to the development of their own models.

In summary, students have the ability to submit inquiries to the chatbot through the Line application. Subsequently, our webhook will intercept the text and transmit it to the DialogFlow API for the purpose of ascertaining the student's intention, provided it aligns with the predefined messages outlined in Figure 1. The webhook is responsible for generating responses for students. However, in situations where DialogFlow is unable to identify the true intention of the student (such as an unexpected inquiry), the webhook will transmit this question in a log format together with relevant context to the Thai QA service. The Thai QA service analyzes queries and contexts to provide accurate responses, even if Dialogflow fails to understand them. This integration enhances the effectiveness and reliability of the student support system.

4. Chatbot Evaluation

Software testing is crucial in software engineering to ensure the quality and reliability of a chatbot. Various testing methodologies, such as unit testing, integration testing, and acceptance testing, help identify and rectify potential issues during the development process. Regular evaluations and software testing are essential for creating a resilient and effective chatbot. In this study, two tasks were evaluated: assessing the chatbot's performance in understanding and providing accurate responses to user inquiries and evaluating the accuracy of Thai question-answering responses. This comprehensive evaluation ensures the chatbot's efficacy and reliability before deployment.

Black box testing [17] is a widely used method for assessing software development life cycles, focusing on program functionality without examining its internal architecture. This method ensures chatbot efficacy and compliance with user expectations. It detects potential defects, allowing for modifications

before release. Precision, recall, and F1 score metrics [18] are used to assess the accuracy and comprehensiveness of QA systems, identifying areas for improvement and ensuring the system meets requirements.

5. Result & Discussion

In this research, the output is in the form of a Line chatbot for Nakhon Pathom Rajabhat University's Office of Academic Promotion and Registration. The chatbot can provide information on course registration, academic information, and other relevant topics. The system's performance was evaluated through black box testing techniques and analysis of response accuracy and timeliness. Overall, the Line chatbot proved to be a valuable tool for streamlining administrative processes and improving user satisfaction. Users can learn more about Nakhon Pathom Rajabhat University outside of the provided topics by asking questions regarding the campus facilities, extracurricular activities, and student support services. The chatbot was created with the support of the Thai QA service using data accessed from Nakhon Pathom Rajabhat's websites to provide thorough information on the university's history, goals, and vision, as well as the numerous faculties and departments accessible for students to choose from. Additionally, users can also seek information on admission guidelines, scholarships, and forthcoming events. With the Line chatbot's ability to address a wide range of inquiries, it acts as a comprehensive resource for prospective and present students alike.

We used precision, recall, and F1 score metrics. TP refers to true positives, which are the number of correct answers given by the system. FP refers to false positives, which are the number of incorrect answers given by the system. FN refers to false negatives, which are the number of correct answers not predicted by the system. When calculating recall, divide TP by the sum of TP and FN. When calculating precision, divide TP by the sum of TP and FP.

The F1 score is the harmonic mean of precision and recall, providing a balanced measure of the system's performance. It is formulated as follows:

$$(1) \text{ Precision} = \frac{TP}{(TP + FP)}$$

$$(2) \text{ Recall} = \frac{TP}{(TP + FN)}$$

$$(3) F1 = \frac{2 \times \text{Precision} \times \text{Recall}}{(\text{Precision} + \text{Recall})}$$

Our dataset is composed of 100 questions and their corresponding answers. After evaluating the model, we got: 1) true positives (TP): 65 questions; 2) false positives (FP): 20 questions; and 3) false negatives (FN): 15 questions. Therefore, when evaluating our model, we got the recall score of 0.7647 indicates that our system successfully identified approximately 76.5% of the correct answers in the dataset. This signifies that our model has reasonably good predictive capabilities. The precision score of 0.8125 shows that our system accurately predicted around 81.25% of the correct answers. The F1 score of 0.7879 emphasizes the balance between precision and recall, providing an overall assessment of our system's performance, considering both false positives and false negatives.

During the evaluation of the chatbot, we assessed its performance by considering factors such as response time, user satisfaction, and error rate. We tested the chatbot with a diverse set of user queries and measured its ability to provide accurate and relevant responses. The results showed that the chatbot had high response accuracy, a low error rate, and a quick response time. Users reported high satisfaction levels with the chatbot's performance, indicating that it effectively understood their queries and provided helpful responses. These positive results demonstrate the chatbot's effectiveness in meeting user expectations and its ability to perform well in real-world scenarios.

6. Conclusion

In this research, we provided a Thai chatbot that integrated the Thai Question Answering System as a component of the NLP service to aid the personnel at Nakhon Pathom Rajabhat University's Office of Academic Promotion and Registration. By employing the pretrained Thammarak model that is accessible on huggingface, this strategy may handle unexpected queries and save money on constructing a new Thai question-answering model, which is a good trade-off between accuracy and cost-effectiveness. The chatbot has demonstrated encouraging results in terms of its capacity to offer accurate and fast responses to user queries, therefore boosting the efficiency and effectiveness of the office's operations. Additionally, the integration of the Thai Question Answering System has enabled the chatbot to continuously learn and improve its performance, ensuring that it remains up-to-date and reliable in aiding workers. Overall, this research contributes to the rapid development of NLP technology in the Thai language and establishes an example for future developments in this field. The results showed that the system met the specified requirements and consistently provided users with meaningful information. However, there were a few areas identified that needed improvement, such as the system's response time and the accuracy of certain responses, especially long questions, or long answers. These findings will help guide future enhancements to the system and ensure that it continues to deliver precise and dependable responses.

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Modeling Thai Concentrated Latex Sector

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Abstract

This study aims to identify the factors that influence the dynamics of key variables, particularly output, price, and employment in the concentrated latex sector. To this end, a Dynamic Stochastic General Equilibrium (DSGE) approach is utilized and a Bayesian estimation method is employed using monthly data from the Office of Industrial Economics database, Thailand, for domestic price, demand, and export of concentrated latex from January 2016 to January 2022, with a total of 61 observations. The results suggest that a technological shock increases output and employment while reducing output price. The cost-related shocks, on the other hand, decrease output and employment while increasing output price. Furthermore, external shocks cause a shift in imports and exports and domestic final prices of concentrated latex. Therefore, it is strongly recommended to enhance technology, labor skills, and the domestic concentrated latex industry's capacity.

Keywords: Concentrated Latex, Technology shock, DSGE, Bayesian estimation, Thailand

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1. Introduction

Since 2003, Thailand has been the world's leading producer of natural rubber (NR). Production peaked at 3.4 million tons of fresh latex in 2011, with an average yield of 1.6 tons per hectare. This output is predominantly exported to European countries, China, India, and Malaysia [1]. In comparison to Malaysia, the traditional leader in NR production in the 1980s, Thailand's success in this regard can be attributed to a number of factors, such as decreasing yields in Malaysia due to a decrease in land dedicated to rubber cultivation and an aging population of rubber farmers [2]. It is thus evident that Thailand has been able to effectively capitalize on the opportunities presented by these factors in order to emerge as the world's leading NR producer.

Rubber provides a positive contribution to Thai economy because it generates foreign exchange for the country. Moreover, the rubber industry links other sectors together through a

backward linkage and forward linkage. The groups of backward linkage include, e.g., raw materials, machinery and equipment, business supporters, and infrastructure. In the same way, the groups of forward linkage include, e.g., automotive, housewares, services, transport, and others. Therefore, the rubber industry has a crucial role to play in promoting domestic industry development [3].

Thai rubber production chain has three main components: 1) upstream industries involving the growing and harvesting of rubber on plantations by growers and tappers; 2) intermediate or midstream rubber industries, or rubber processors, taking rubber produced on plantations and convert it into semi-finished products; and 3) downstream producers including manufacturers of automobile tires, latex gloves, condoms, elastics, and so on. Most of Thailand's intermediate rubber goods are sold on overseas markets for processing into downstream products. The most important end-

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use is for the production of tires (60.9 percent of all domestic demand for intermediate rubber products), followed by elastics (16.2 percent) and then other products such as hosing and condoms.

The outlook of Thailand's rubber industry is expected to remain positive throughout 2022, with output levels predicted to rise due to an expansion in the area under cultivation and more favorable climatic conditions. It is projected that the industry will enjoy an average annual growth rate of 4.5-5.5 percent over the next five years [4].

In the empirical study, it was discovered that several key factors drive the growth and development of the Thai rubber industry. These factors, which have been extensively researched, include: 1) Comparative advantage: Thailand possesses a natural comparative advantage in the production of high-quality rubber products for export. This advantage has prompted recommendations to expand the rubber industry into downstream sectors, capitalizing on lucrative export opportunities [6]. 2) Demand from downstream sector: The tire industry, in particular, serves as a major source of demand for Thai rubber. A significant portion of domestically produced Thai rubber is consumed by the tire sector [7]. 3) Foreign investment: Foreign firms play a substantial role in the Thai rubber industry, contributing a significant portion of the industry's income [7]. 4) Upstream strength: The upstream segment of the rubber value chain in Thailand is well-developed and successful. Thailand boasts a significant rubber plantation area and is one of the leading natural rubber producers and exporters globally [8]. 5) Resource endowments: Thailand possesses untapped opportunities for the development of higher value-added activities within the rubber industry, leveraging its existing resource endowments [7]. 6) Government support: Historically, the Thai government has intervened in the rubber industry to support struggling farmers and artificially stabilize rubber prices. As rubber is considered a

politically significant crop, the government aims to ensure a stable supply and provide support to smallholders, who hold considerable political influence [7]. 7) Global demand: Forecasts of increasing global demand for rubber underscore the importance of expanding production in Thailand [7]. These factors collectively contribute to the growth, competitiveness, and sustainability of the Thai rubber industry in the global market.

Concentrated latex is an essential intermediate product in the rubber industry, produced from field latex using high-speed centrifuges. This process separates out water and other impurities, resulting in a concentrated latex that is at least 60 percent rubber and is ready for further processing. In 2021, the total value of concentrated latex distributed by Thai players to the market was estimated at THB 68 billion. Of this, 72.6 percent was exported, with the remaining 27.4 percent consumed domestically. In 2021, concentrated latex exports from Thailand edged up 3.4 percent to 1.19 million tonnes, with revenues from these sales increasing 22.6 percent to USD 1.56 billion. While sales to the primary market of Malaysia declined -0.8 percent to 0.57 million tonnes due to a lockdown imposed in the country, this was offset by increased sales in smaller markets such as Brazil and China [4]. Nonetheless, this concentrated latex industry is anticipated to expand and play a potential role in boosting national income [5].

Motivated by the economic significance of the concentrated latex industry, this study utilizes a Dynamic Stochastic General Equilibrium (DSGE) approach to comprehensively assess the dynamics of this sector and identify potential strategies for enhancing its performance. This work contributes to the existing literature by proposing a novel model for analysis. The subsequent sections are structured as follows: Section 2 presents the variables expected to affect the dynamics of the model formulated in this work. Section 3 outlines the construction of

the models, while Section 4 presents the results, with a brief discussion.

2. Literature Review

This section provides the most pertinent research findings that revealed the factors anticipated to influence the dynamics of the model to be developed in this study.

The influence of government policies on agriculture has been found to significantly impact rubber production, as indicated by previous scholarly studies [9]. One of the most impactful ways in which government policies shape rubber production is through subsidies provided to rubber growers. These subsidies aim to support and incentivize domestic rubber production, enabling growers to expand their plantations and increase output. Government subsidies can take many forms, such as financial assistance, tax incentives, or access to affordable credit. By reducing production costs and increasing profitability, these subsidies play a crucial role in encouraging both small-scale and large-scale rubber farming. For instance, subsidies can help cover the cost of acquiring high-quality rubber seeds, fertilizers, and machinery. This allows farmers to improve efficiency, enhance yield, and compete more effectively in the global rubber market.

For the domestic price of natural rubber, it is affected by the exchange rate, the volume of production, exports [7, 8], input costs, fertilizer subsidies, domestic consumption, the foreign price of natural rubber [9, 10], total domestic natural rubber supply, the total stock of natural rubber in the world, and natural rubber demand [14]. *Exchange rates* play a crucial role in determining the import and export dynamics of a country. For natural rubber-producing nations, this is especially true. When the domestic currency weakens against other currencies, the cost of importing natural rubber increases. This prompts the domestic price of natural rubber to rise, as producers pass on the additional costs to consumers. Conversely, when the domestic currency strengthens, the cost of imports decreases, resulting in a potential decrease in the domestic price of

natural rubber. The relationship between *domestic production* volume and natural rubber prices is rooted in the basic principles of supply and demand. When the volume of domestic production increases, it leads to a surge in supply in the market. This excess supply can exert downward pressure on prices. As the domestic supply increases, it also enhances the competitiveness of domestic producers in the international market. With a larger output, domestic players can leverage economies of scale, potentially enabling them to offer lower prices to capture market share globally. The fluctuations in *export volumes*, therefore, directly impact domestic prices in several ways. Increased exports, reduced domestic supply: As countries export more natural rubber, the domestic supply within their borders decreases. This reduction in supply creates a scarcity effect, driving domestic prices upward. Reduced exports, increased domestic supply: Conversely, when countries restrict their exports, domestic supplies increase, leading to a surplus effect and a subsequent decline in domestic prices. These direct correlations between export volumes and domestic prices form the foundation of the interplay within the rubber market. *Production costs* of natural rubber are subject to various factors, such as labor, energy, and land. Labor plays a crucial role in rubber tapping, latex processing, and overall production. Similarly, energy costs, including electricity and fuel expenses, impact the extraction and processing stages of natural rubber. Additionally, access to suitable land for cultivation and other raw materials further contributes to the overall cost of production. *Fertilizer subsidies* have a profound impact on both production and pricing. Farmers who benefit from these subsidies experience enhanced nutrient availability for their rubber trees, resulting in increased yield per hectare. Moreover, the usage of fertilizers leads to improved quality rubber, contributing to its overall market value. From a supply and demand perspective, fertilizer subsidies lead to an increase in the overall volume of natural

rubber available. With lower production costs due to the reduced expense of fertilizers, farmers are incentivized to cultivate more rubber. Consequently, this increased supply often leads to market saturation and price volatility. Supply-demand imbalances in the rubber market can have significant ramifications on natural rubber prices. When *the domestic demand* for rubber surpasses the available supply, shortages occur, leading to an increase in prices. This shortage can have severe implications for downstream industries that rely on rubber-based products, affecting their production costs and profitability. On the other hand, oversupply, resulting from a decline in domestic demand or an increase in rubber production, can drive prices down. This oversupply is often a consequence of various factors, such as economic slowdowns or unforeseen market disruptions. The correlation between domestic and *foreign natural rubber prices* stems from several factors that intertwine the two markets. Firstly, imports and exports significantly influence domestic rubber markets. Since most countries cannot produce enough natural rubber to meet their demand, they rely on imports to bridge the gap. Consequently, changes in the international price of natural rubber directly affect the cost and availability of imported rubber, thereby impacting domestic pricing levels. In addition to imports, international price benchmarks play a crucial role in determining domestic rubber prices. As a result, fluctuations in foreign rubber prices invariably influence the pricing decisions made within domestic markets. The fluctuations in total domestic supply also play a pivotal role in shaping the dynamics of supply and demand in the natural rubber market. When the supply exceeds demand, a surplus is created, leading to a decrease in the price of natural rubber.

Regarding productivity and efficiency of rubber production, it was found to be influenced by the number of households, years of experience of the farmer, and frequency of the extension agent's visit [15], capital-labor ratios,

wage rates, and firm size [16] and that investing in technology and research is necessary to improve productivity and efficiencies [17]. One of the determining factors in rubber production is the number of households involved in cultivation. Rubber trees require careful nurturing and maintenance, and an increased number of households enables more labor resources for these activities. Additionally, it allows for a more distributed workload, reducing the risk of excessive workloads and potential inefficiencies caused by overburdened farmers. The level of experience farmers possess significantly impacts their knowledge and expertise in rubber cultivation and maintenance. Experienced farmers are more likely to understand the intricacies of rubber tree care, including critical aspects such as tapping for latex extraction, disease prevention, and pest control. Their accumulated knowledge enables them to make informed decisions, leading to increased productivity and efficiency in rubber production. The presence and regular visits from extension agents are critical in ensuring the success of rubber production. These trained professionals provide guidance, support, and expertise to farmers, enabling them to adopt best practices, modern techniques, and remain updated on the latest advancements in the industry. Frequent visits allow for timely interventions, addressing issues such as disease outbreaks or identifying potential challenges before they escalate - contributing to enhanced productivity and improved quality of rubber produced. Achieving the right balance between capital and labor resources is essential for optimizing productivity in rubber production. Adequate investment in machinery, equipment, and infrastructure helps streamline operations, minimize errors, and reduce time-consuming manual tasks. Introducing automated processes and mechanization can significantly minimize labor requirements, allowing workers to focus on more specialized tasks, thus maximizing overall efficiency and output. Setting fair and competitive wage rates is crucial for ensuring a

motivated workforce and high-quality rubber production. When workers are fairly compensated, they are more dedicated, committed, and driven to excel in their tasks. Additionally, fair wages attract skilled workers, contributing to optimal performance, improved yield, and enhanced overall productivity in the rubber industry. The size of the rubber production firm also plays a significant role in determining productivity levels. Larger firms often have access to extensive resources, including finance, technology, and expertise. They can invest in better infrastructure, research, and development initiatives, and adopt advanced technologies. These advantages, combined with economies of scale, contribute to enhanced efficiency, increased output, and improved overall productivity. Investing in technology and innovation is crucial for meeting the growing demands and overcoming challenges. Modern technologies offer improved efficiencies in various aspects of rubber production, including precision tapping, predictive pest and disease management, GPS-assisted mapping for optimal plantation layouts, and real-time crop monitoring systems. By incorporating innovative technologies, rubber farmers can streamline their operations, reduce waste, enhance precision, and maximize productivity. Research and development (R&D) efforts in the rubber industry are vital for continuously improving productivity and developing new techniques and strategies. R&D initiatives help identify and address industry challenges, explore alternative cultivation methods, and develop disease-resistant rubber tree varieties. To create a sustainable and resilient rubber industry, substantial investments in R&D are necessary to advance the understanding of best practices, refine existing techniques, and discover new approaches to rubber production.

In the case of rubber export, it is influenced by financial credit [18], price of domestic natural rubber, volume of domestic rubber production [19], exchange rate, interest rate, and real GDP of the destination country [20].

Financial credit plays a pivotal role in facilitating the growth of rubber export. It serves as a catalyst, allowing rubber exporters to access the capital necessary to expand their operations and explore new markets. Through affordable loans and credit facilities, manufacturers are incentivized to ramp up their production of rubber for international trade. Inadequate availability of financial credit or prohibitively high interest rates, on the other hand, can severely hinder the growth potential of rubber exports. Restrictive financial conditions can limit the ability of exporters to invest in infrastructure, research and development, and other crucial aspects necessary for expanding their market presence. The price of domestic natural rubber is a key determinant of the success and profitability of rubber exports. A competitive and stable price stimulates rubber exporters to increase their production and explore international trade opportunities. When domestic natural rubber prices are favorable, businesses are encouraged to invest in expanding their production capabilities and to satisfy the growing global demand for rubber. However, fluctuations in the price of domestic natural rubber can have a substantial impact on the profitability of exporting businesses and ultimately influence export volumes. The volume of domestic rubber production undoubtedly plays a central role in determining the availability of rubber for export. An increase in domestic production can open up significant opportunities for rubber exporters, as it enhances the supply of rubber for international trade.

The above knowledge provides a comprehensive understanding of the key processes and variables involved in concentrated latex manufacturing. Through this analysis, it is possible to gain insight into the interdependent relationships between variables, forming the basis for the formulation of a model in the subsequent section.

3. Model Formulation

This work applies the Dynamic Stochastic General Equilibrium (DSGE) approach, a widely-used framework in economic modeling, to analyze the dynamics of the concentrated latex industry. By utilizing a set of equations and mathematical relationships, the DSGE approach captures the macroeconomic dynamics, incorporating the element of time and uncertainty. This makes it a valuable tool for policy analysis and forecasting. A distinguishing feature of the DSGE approach is its focus on general equilibrium. It considers all markets in the economy simultaneously, taking into account the interactions between different sectors and agents. This comprehensive approach provides a more realistic understanding of the economic system. In addition, Bayesian estimation is employed in

this research. Bayesian estimation is a statistical technique that allows economists to estimate the parameters of a model using Bayesian inference principles. Unlike traditional maximum likelihood estimation, which relies on a single point estimate, Bayesian estimation assigns probabilities to different parameter values. This approach is particularly useful when dealing with complex models that have multiple parameters and limited data.

The formulated model presented herein is based on the works of Mesike et al. (2008), Oktora & Firdani (2019), and Mulyani et al. (2021) [18- 20]. It involves three principles agents in the production of concentrated latex: a competitive final concentrated latex producer, a farmer, and a domestic concentrated latex manufacturer. The respective production specifications for each of them are as follows:

The competitive final concentrated latex producer combines domestic and foreign intermediate concentrated latex using the following CES technology:

$$X_{H,t} = \left(\varpi_{HD}^{\frac{1}{\eta_H}} X_{D,t}^{\frac{\eta_H-1}{\eta_H}} + (1-\varpi_{HD})^{\frac{1}{\eta_H}} X_{M,t}^{\frac{\eta_H-1}{\eta_H}} \right)^{\frac{\eta_H}{\eta_H-1}}, \quad (1)$$

where ϖ_{HD} denotes the proportion of the domestically manufactured concentrated latex in the final concentrated latex product. η_H is the elasticity of substitution between the domestically manufactured concentrated latex and the imported concentrated latex in the final concentrated latex product.

The farmer produces the latex, $X_{A,t}$, by using the Cobb-Douglas production technology written by:

$$X_{A,t} = A_{A,t} (F_{A,t})^{\alpha_1} (N_{A,t})^{1-\alpha_1}, \quad (2)$$

where $A_{A,t}$ is a labor productivity specific to the agricultural sector. $F_{A,t}$ and $N_{A,t}$ denote the quantity of fertilizer and the number of workers, respectively. α_1 express the proportion of fertilizer used in the production of latex.

The domestic concentrated latex manufacturer produces its product, $X_{B,t}$, by using the Cobb-Douglas production technology written by:

$$X_{B,t} = A_{B,t} (K_{B,t})^{\alpha_2} (N_{B,t})^{\alpha_3} (X_{A,t})^{1-\alpha_2-\alpha_3}, \quad (3)$$

where $A_{B,t}$ is a technology unique to the concentrated latex manufacturing industry. $K_{B,t}$ and $N_{B,t}$ denote the quantity of capital and labor, respectively. α_2 and α_3 express the proportions of capital and labor used in the production of concentrated latex, respectively.

The export is written by:

$$X_{E,t} = X_{f,t} \varpi_{HD} \frac{eP_{f,t}^{\eta_H}}{P_{D,t}^{\eta_H}}. \quad (4)$$

Assuming that $A_{B,t}$, $W_{B,t}$, $R_{KB,t}$, $W_{A,t}$, $R_{KA,t}$, $P_{F,t}$, $P_{f,t}$, e_t , and $X_{f,t}$ evolve according to AR (1) process. Finally, market clearing condition is specified by $X_{B,t} = X_{D,t} + X_{E,t}$.

The log-linear forms of the solutions from the above equations are as follows:

$$\tilde{X}_{D,t} = \eta_H (\tilde{P}_{H,t} - \tilde{P}_{D,t}) + \tilde{X}_{H,t}, \quad (5)$$

$$\tilde{X}_{M,t} = \eta_H (\tilde{P}_{H,t} - \tilde{P}_{f,t} - \tilde{e}_t) + \tilde{X}_{H,t}, \quad (6)$$

$$\tilde{P}_{H,t} = \frac{(\varpi_{HD} - 1)(\tilde{e}_t + \tilde{P}_{f,t})P_{fss}^{1-\eta_H}e_{ss}^{1-\eta_H} - \varpi_{HD}\tilde{P}_{D,t}P_{Dss}^{1-\eta_H}}{(\varpi_{HD} - 1)P_{fss}^{1-\eta_H}e_{ss}^{1-\eta_H} - \varpi_{HD}P_{Dss}^{1-\eta_H}}, \quad (7)$$

$$\tilde{N}_{A,t} = \tilde{P}_{A,t} + \tilde{X}_{A,t} - \tilde{W}_{A,t}, \quad (8)$$

$$\tilde{F}_{A,t} = \tilde{X}_{A,t} - \tilde{P}_{F,t} + \tilde{P}_{A,t}, \quad (9)$$

$$\tilde{P}_{A,t} = (1 - \alpha_1)\tilde{W}_{A,t} + \alpha_1\tilde{P}_{F,t} - \tilde{A}_{A,t}. \quad (10)$$

$$\tilde{N}_{B,t} = \tilde{P}_{D,t} + \tilde{X}_{B,t} - \tilde{W}_{B,t}, \quad (11)$$

$$\tilde{K}_{B,t} = \tilde{P}_{D,t} + \tilde{X}_{B,t} - \tilde{R}_{KB,t}, \quad (12)$$

$$\tilde{X}_{A,t} = \tilde{X}_{B,t} + \tilde{P}_{D,t} - \tilde{P}_{A,t}, \quad (13)$$

$$\tilde{P}_{D,t} = (1 - \alpha_2 - \alpha_3)\tilde{P}_{A,t} + R_{KB,t}\alpha_2 + \tilde{W}_{B,t}\alpha_3 - \tilde{A}_{B,t}, \quad (14)$$

$$\tilde{X}_{E,t} = \tilde{X}_{f,t} + \eta_H (\tilde{P}_{f,t} + \tilde{e}_t - \tilde{P}_{D,t}), \quad (15)$$

This model will be estimated using a Bayesian estimation method with monthly data from the Office of Industrial Economics database for domestic price, demand, and export of concentrated latex from January 2016 to January 2022, including 61 observations. These data are directly relevant to the variables presented in the formulated model.

4. Result and Discussion

The model is estimated using the initial values of the following parameters: $\eta_H=5.4$, $\varpi_{HD}=0.7$, $\alpha_1=0.6$, $\alpha_2=0.3$, and $\alpha_3=0.3$. The estimation results are as follows:

Table 1. Estimated parameters

Par.	Prior		Posterior		
	Distr.	Mean	Mean	HPD inf	HPD sup
ρ_{AB}	beta	0.5	0.4372	0.1726	0.6758
ρ_{WB}	beta	0.5	0.6377	0.5574	0.7214
ρ_{RKB}	beta	0.5	0.4941	0.1731	0.7505
ρ_e	beta	0.5	0.5345	0.1513	0.9384
ρ_{Pf}	beta	0.5	0.3439	0.2398	0.4534
ρ_{Xf}	beta	0.5	0.3391	0.1143	0.5358
ρ_{XH}	beta	0.5	0.2912	0.1733	0.393
ρ_{AA}	beta	0.5	0.3876	0.0877	0.6603
ρ_{PF}	beta	0.5	0.4235	0.086	0.8007
ρ_{WA}	beta	0.5	0.5486	0.2959	0.8758

In the following, the effects of shocks will be discussed.

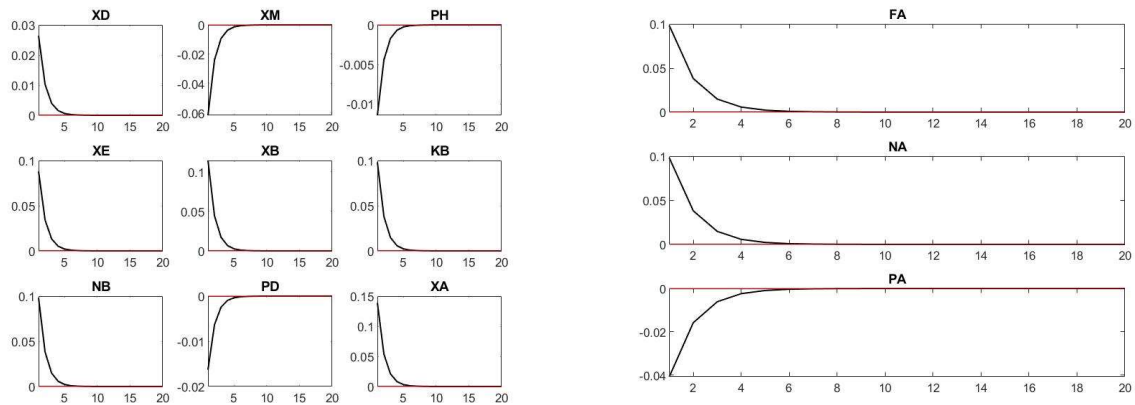


Figure 1. Effect of labour productivity shock in agricultural sector

Figure 1 demonstrates that labor productivity shock in the agriculture sector leads to an increase in agricultural outputs (XA), agricultural employment (NA), fertilizer usage (FA), and manufacturing outputs (XB). However, it decreases the output price (PA) of agriculture and the output price of manufacturing (PD). The explanations are that with the improvement in labor productivity, farmers are able to produce more output with less input. This increased output allows farmers to generate higher profits and create additional employment opportunities (NA). As a result, the agricultural sector has seen an increased demand for labor. The increased fertilizer usage (FA) is a result of the increased output of

agricultural products. Fertilizer is essential for ensuring optimal crop yields, and with the increased output, farmers need to use larger amounts of fertilizer than before. For the increased manufacturing output (XB), it is a result of increased agricultural output. By producing more agricultural products, farmers are able to supply manufacturers with more raw materials. The decreased agriculture output prices (PA) and decreased manufacturing output prices (PD) are a result of increased productivity in the agricultural sector. As farmers are able to produce more output with less input, the prices of agriculture and manufactured goods have decreased.

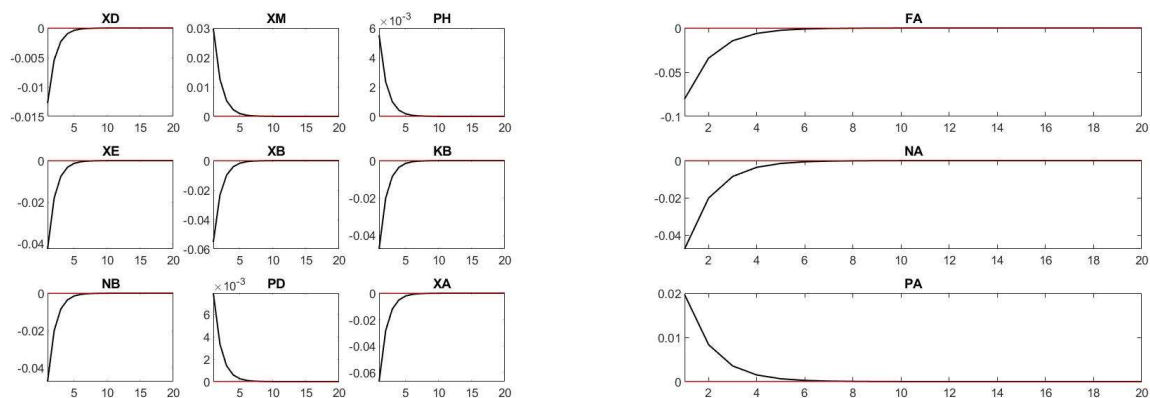


Figure 2. Effect of fertilizer price shock

In Figure 2, it shows that fertilizer price shocks in the agriculture sector lead to a decrease in agricultural outputs (XA), agricultural employment (NA), fertilizer usage (FA), and manufacturing outputs (XB). However, it raises the prices of agricultural (PA) and industrial output (PD). This is due to the fact that a rise in fertilizer prices can cause an increase in production costs, resulting in a decline in agricultural output. In addition, high fertilizer prices can lead to a reduction in the

amount of fertilizer used (FA), thereby reducing agricultural output. Increasing fertilizer costs may also have an effect on manufacturing outputs (XB). Since agricultural production is a significant source of raw materials for manufacturing, a rise in fertilizer prices can reduce the output of manufactured goods. In addition, the rising cost of fertilizer can have a positive effect on the cost and, consequently, the price of agricultural output (PA) and manufacturing output (PD).

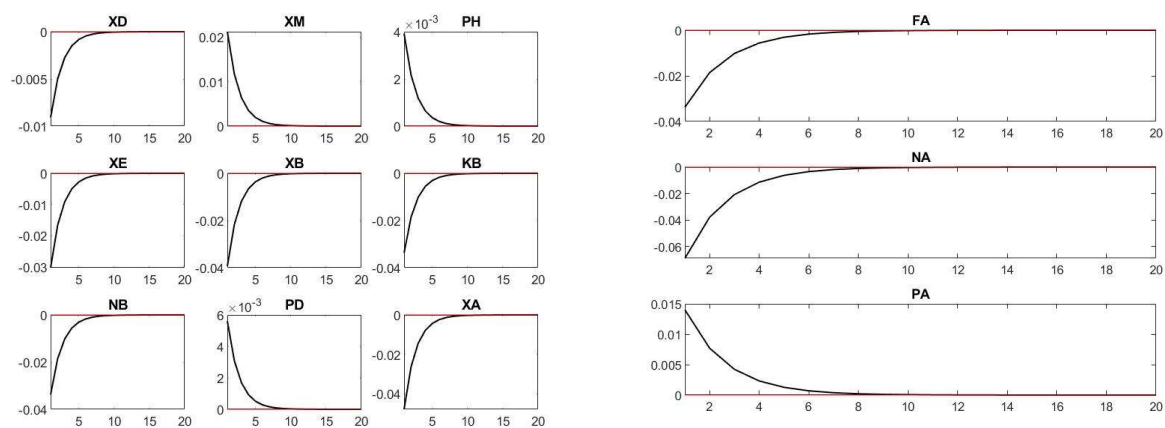


Figure 3. Effect of wage shock in agricultural sector

Figure 3 illustrates that wage shock in the agriculture sector leads to a decline in agriculture outputs (XA), agriculture employment (NA), fertilizer usage (FA), and manufacturing outputs (XB). However, it raises both the agriculture output price (PA) and the manufacturing output price (PD). This is because when wage increases in the agricultural sector, the cost of production rises, making it more expensive to produce agricultural goods. This increased cost of production leads to a decrease in agricultural output (XA), as producers are unable to produce as much as they would have prior to the wage increase. As a result, there is a decrease in agricultural

employment (NA) and fertilizer usage (FA). Moreover, the increased cost of production can lead to an increase in agricultural output prices (PA) and an increase in manufacturing output prices (PB). This is due to a basic economic principle known as the law of supply and demand. As the cost of production of agricultural goods increases, the supply of agricultural goods decreases, driving up the price of agricultural goods. Similarly, as the cost of production of the manufacturing goods increases, the supply of the manufacturing goods decreases (XB) which driving up the price of the manufacturing goods.

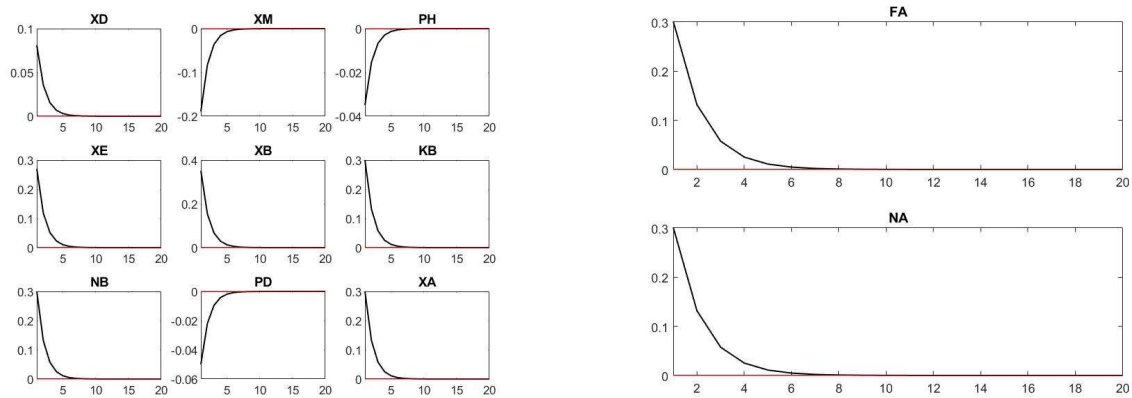


Figure 4. Effect of tech shock in latex manufacturing sector

Figure 4 demonstrates that a manufacturing technology shock increases manufacturing outputs (XB), manufacturing employment (NB), and demand for agricultural outputs (XA) while decreasing manufacturing prices (PD) and the domestic final concentrated latex price (PH). Due to the introduction of efficient methods and machines, technological advancement in the manufacturing sector has resulted in higher outputs (XB). In a short period of time, highly efficient and automated machines can produce vast quantities of goods. This, in turn, leads to greater productivity and output, which can reduce manufacturing prices

(PD). In addition, technological advancements have resulted in an increase in manufacturing sector employment (NB) due to the expansion of manufacturing businesses. Increased technological advancement in the manufacturing sector has also led to an increase in demand for agricultural products (XA), as automated machines enable the production of more manufactured goods, which necessitate an increase in agricultural product consumption. Because there are more manufactured goods on the market, domestic final concentrated latex prices (PH) may decline.

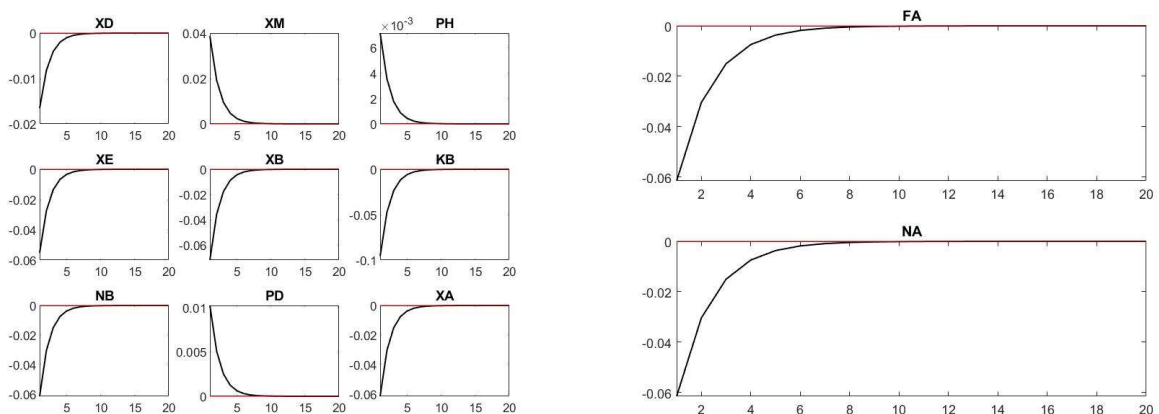


Figure 5. Effect of capital rental rate shock in latex manufacturing sector

Figure 5 depicts that a shock to the capital rental rate in the manufacturing sector reduces manufacturing outputs (XB), manufacturing employment (NB), and demand for agricultural

outputs (XA) while increasing manufacturing prices (PD) and domestic final concentrated latex prices (PH). A rise in the capital rental rate can reduce manufacturing output because firms

are forced to pay more to obtain the necessary capital for production. This is due to the fact that higher capital rental rates result in higher costs that must be passed on to businesses, resulting in lower profits. Consequently, firms are less able to finance their operations, and as a result, they produce less output (XB). Additionally, a rise in the capital rental rate leads to a decline in manufacturing employment (NB), as firms become less likely to hire employees due to the increased costs of capital. Since this product's demand is derived from the manufacturing sector, agricultural outputs (XA)

also experience a decline in demand. A rise in the capital rental rate results in an increase in the manufacturing price (PD), as firms are compelled to pass on the higher capital costs to consumers. This increased cost leads to higher consumer prices for the manufactured goods, resulting in a decline in demand for them as a whole. Simultaneously, the increased cost of capital can lead to an increase in the price of domestic final concentrated latex (PH), as the producer is forced to pay higher prices for manufacturing inputs.

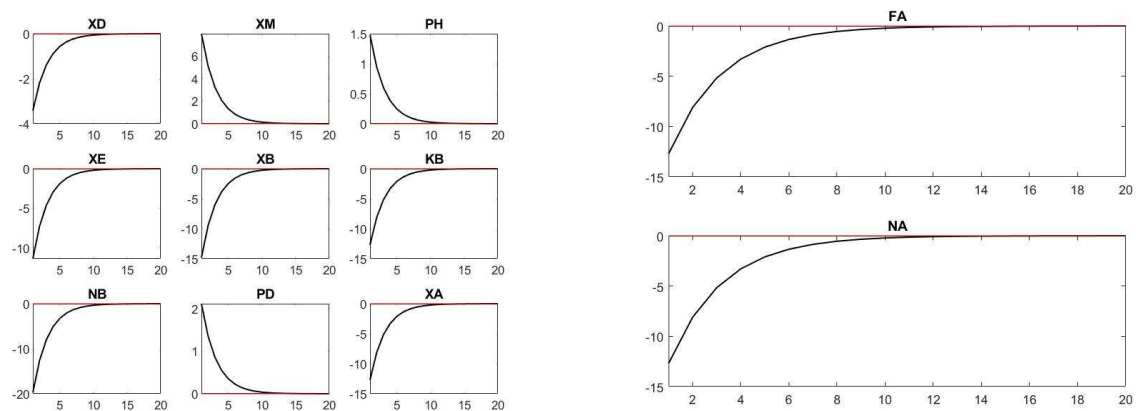


Figure 6. Effect of wage shock in latex manufacturing sector

Figure 6 reveals that a wage shock in the manufacturing sector reduces manufacturing outputs (XB), manufacturing employment (NB), and demand for agricultural outputs (XA) while increasing manufacturing prices (PD) and the domestic final concentrated latex price (PH). This is primarily due to the substitution effect. In order to reduce labour costs, firms in the manufacturing sector are likely to substitute labour (NB) with capital when wages increase. This increase in the cost of labour results in an increase in the price of manufactured goods (PD), as firms are now able to pass along the cost of capital equipment to consumers.

Additionally, the increase in the price of manufactured goods reduces the demand for agricultural outputs (XA). This is because, as the price of manufactured goods rises, consumers are less likely to buy them (XB) because they can no longer afford them. This decrease in manufacturing output demand results in a decline in agricultural input demand (XA). Due to the fact that the price of manufactured goods has an effect on this price, the domestic final concentrated latex price increase is a result of rising wages in the manufacturing sector.

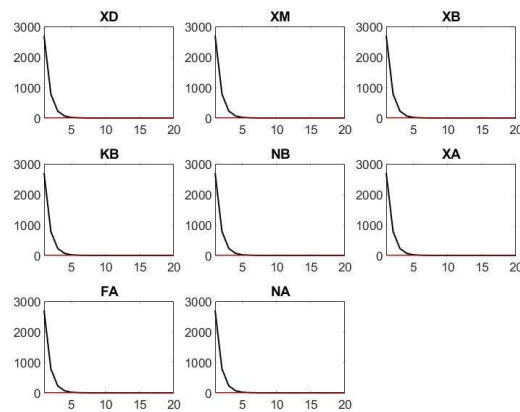


Figure 7. Effect of domestic demand shock

Figure 7 indicates that the domestic demand shock for final concentrated latex increases agricultural output, manufacturing output, and concentrated latex imports (XM). Since domestic final concentrated latex originates

from the manufacturing sector and is imported, the increase in demand will lead to an increase in agricultural production, manufacturing output, and concentrated latex imports.

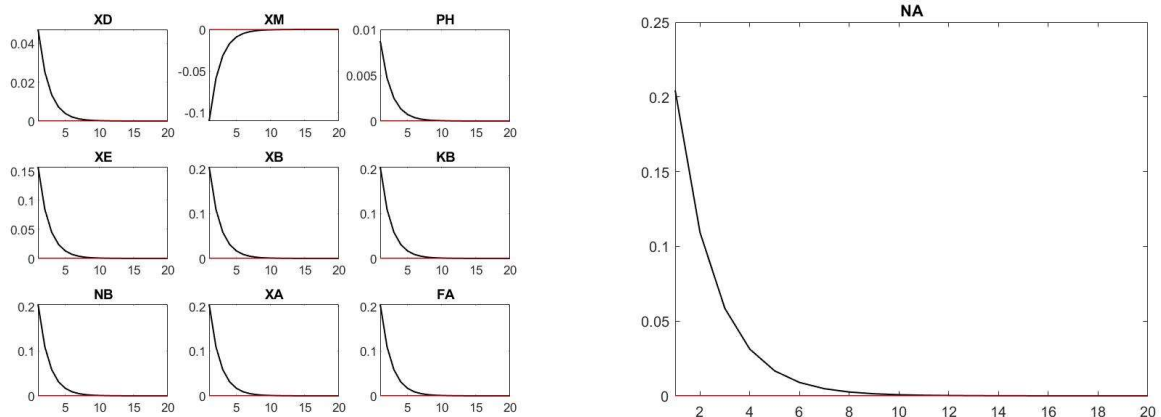


Figure 8. Effect of exchange rate shock

Figure 8 demonstrates that an exchange rate shock or baht depreciation increases concentrated latex export (XE), but decreases concentrated latex import (XM). As exchange rates change significantly, so do the relative costs of exporting and importing goods, leading to proportional changes in the volume of international trade. When the exchange rate increases or the baht depreciates, purchasing concentrated latex from abroad becomes more expensive. Consequently, the price of

importing concentrated latex is now greater than it was previously. This causes a decrease in the importation of concentrated latex (XM). However, a rise in the exchange rate or depreciation of the baht results in a reduction in the price of concentrated latex for foreign buyers. Therefore, it is more likely that foreign buyers will purchase concentrated latex from Thai producers. This causes an increase in the export quantity of concentrated latex (XE).

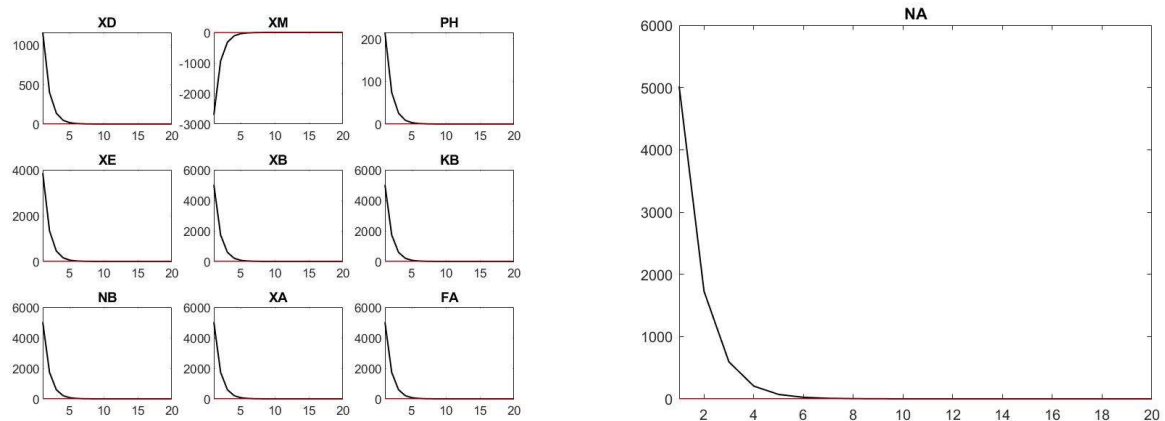


Figure 9. Effect of foreign price shock

Figure 9 shows that the foreign concentrated latex price shock causes an increase in concentrated latex exports (EX), a decrease in concentrated latex imports (XM), and an increase in the domestic price of concentrated latex (PH). A rise in foreign prices increases the relative desirability of exports of Thai concentrated latex. This is due to the fact that, as foreign prices rise, Thai concentrated latex exports (XE) become relatively less expensive for foreign buyers. Therefore, foreign buyers

are more likely to purchase concentrated latex at a lower price from Thailand. However, a rise in foreign prices also reduces imports of concentrated latex (XM). This is due to the likelihood that domestic buyers will purchase concentrated latex within countries with lower prices. As the foreign price of concentrated latex is included in the domestic final price of concentrated latex (PH), when the foreign price increases, so does the domestic final price.

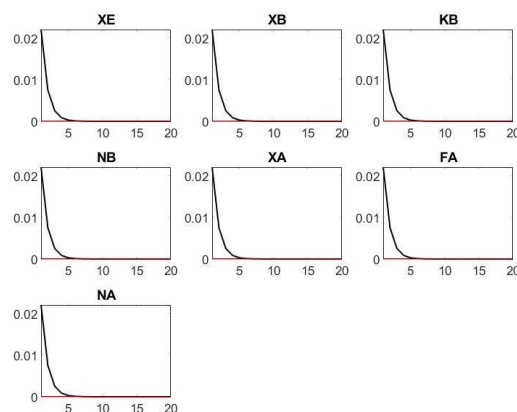


Figure 10. Effect of foreign demand shock

Figure 10 illustrates that foreign concentrated latex demand shocks lead to an increase in concentrated latex exports, which stimulate agricultural and manufacturing outputs. The shock of foreign demand induces exports that must be met by Thailand. This directly results in an increase in the demand for the manufacturing product (XB), which in turn

encourages the demand for the domestic agricultural product (XA).

5. Recommendations

Based on the results of the analysis, the following recommendations are suggested: 1) investing in production technology in the manufacturing sector to improve production efficiency and productivity, e.g. integrating

smart sensors and data analytics into the production process to provide real-time insights into latex quality and production metrics; 2) implementing practices to minimize the negative effects of increasing fertilizer price, wage, and capital rental rate, such as supporting domestic fertilizer production, increasing labor productivity through equipping workers with new knowledge and skills, and utilizing as much of the capital capacity as possible; and 3) encouraging domestic concentrated latex demand by supporting the growth of downstream producers through credit support and building proper infrastructure. Furthermore, the government should leverage external shocks that are out of its control by strengthening the domestic concentrated latex industry, which is less reliant on foreign countries in the event of a concentrated latex global crisis. For a more comprehensive analysis that accurately reflects the dynamics within this industry, it may be beneficial to incorporate other types of shocks or investigate the long-term effects of the identified factors on the concentrated latex sector.

6. Conclusion

Concentrated latex is an intermediate rubber product that serves a unique purpose in the rubber industry as the primary raw material for a variety of rubber manufacturing processes. This industry contributes positively to the economy by facilitating the growth of other industries and generating foreign currency. Due to the economic significance of the concentrated latex industry, this study employs the DSGE method to describe the factors that influence the dynamics of key variables, including output, price, and employment, in the upstream and midstream of the industry. The model is estimated using a Bayesian estimation method with monthly data from the Office of Industrial Economics database for domestic price, demand, and export of concentrated latex from January 2016 to January 2022. The results indicate that a technological shock increases output and employment while reducing output

price. The cost related shocks decrease output and employment while increasing output price. As anticipated, external shocks cause a shift in imports and exports and domestic prices. Therefore, enhancing technology, labour skills, and the domestic concentrated latex sector is strongly recommended.

Acknowledgement

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Exchange Rate Volatility and Cointegration of ASEAN Member Countries

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Abstract

This study investigates the volatility and cointegration of exchange rates in nine selected ASEAN member countries using five forms of the GARCH model. Daily data was sourced from the Bank of Thailand website, as Baht per foreign currency, over the period from October 2, 2018 to October 7, 2022. This data included Malaysia Ringgit, Singapore Dollar, Brunei Darussalam Dollar, Philippines Peso, Indonesia Rupiah, Myanmar Kyat, Cambodia Riel, Laos Kip, and Vietnam Dong. According to the findings of this study, only eight exchange rates were suitable for analysis. The GARCH (1,1), TGARCH (1,1), and PGARCH (1,1) models were determined to be the most applicable, with leverage effects observed in certain exchange rates. The analysis revealed a long-run and short-run relationship between these exchange rates. In order to mitigate the associated risk, investors and governments should carefully monitor news that may affect the value of exchange rates. It is thus essential to pay particular attention to the economic news and its potential impact on exchange rates.

Keywords: exchange rates volatility, cointegration, ARMA, ARCH-type model, ASEAN member countries

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1. Introduction

Since the end of the Bretton Woods system of fixed exchange rates, real and nominal exchange rates have been notoriously volatile due to market forces like supply and demand. This volatility of exchange rates poses a significant threat to the economy [1] and makes it difficult to predict prices, asset values, and currency values [2]. Such uncertainty can have far-reaching effects on businesses and the economy, including effects on stock prices [3], export performance [4], and foreign direct investment [5], all of which are indicators of economic stability and prosperity.

The 1997 Asian financial crisis raised significant concerns regarding the economic interdependence, investment flows, and exchange rate volatility of the Association of Southeast Asian Nations (ASEAN) member countries. In response to these concerns, some

ASEAN member countries shifted from controlled floating regimes with no fixed path for currency rates to stable arrangements, while others moved to floating regimes. However, it was revealed that despite the different exchange rate management regimes in this region, the real exchange rates of the ASEAN currencies follow similar cycles and trends over the long term, indicating the interconnection between countries [6]. Also, it was recognized that the Thai baht served as the primary conduit through which regional currency fluctuations were transmitted [7].

Previous works have highlighted the potential risks associated with exchange rate volatility, which can have a negative impact on countries. For example, Ewubare and Merenini [8] found that countries with higher exchange rate volatility are more likely to experience a

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trade deficit, while Mosbei et al. [9] found that countries with higher exchange rate volatility were more likely to experience a decrease in exports. Similarly, Ekanayake and Dissanayake [10] established that countries with higher exchange rate volatility were more likely to experience a decrease in export performance. In contrast, Yussif et al. [11] could not confirm the impact of exchange rate volatility on import. For the investment, research conducted by Heroja [12] indicated that the effect of exchange rate volatility on foreign direct investment may differ depending on the context. In particular, ASEAN countries have experienced significant impacts of exchange rate volatility on their trade balances [13], foreign direct investment [14], and economic growth rate [15].

In response to the increasing efforts of governments and investors to mitigate exchange rate volatility, there is a growing need for effective measurement of this volatility. This is becoming increasingly pressing as it directly impacts policy and strategy design. By measuring exchange rate volatility and cointegration, policy and strategy designers can identify patterns and formulate more appropriate responses, benefiting both business opportunities and economic growth. This research aims to contribute to this area by extending the investigation of exchange rate volatilities in ASEAN member countries and their cointegration, which have received relatively limited attention in previous studies. The currencies of these countries are of interest mainly because they are recognized to have interconnections between them. To achieve these objectives, this work is organized as follows: Section 2 will present the academic works that support the research framework. Section 3 will outline the research methodology, and Section 4 will provide the results and discussion.

2. Literature Review

For decades, researchers have been fascinated by exchange rate volatility, but the

precise cause of such extreme fluctuations remains elusive. Various explanations have been suggested to account for this phenomenon, with historical information and leverage effect emerging as two of the most prominent potential causes [16]. Regarding the leverage effect, defined as a negative correlation between return and volatility mediated by news and primarily observed in the stock market [17], it is anticipated that the leverage effect can persist in the foreign exchange market, as it has been established that news, particularly negative news, can have a significant impact on the conditional volatility of exchange rates when they are closely intertwined [18].

For the investigation of exchange rate volatility, models of the ARCH type have been widely employed. In order to gain a deeper understanding of the ARCH-type models used in current research, an overview of previous empirical studies employing these models is provided as follows.

Nguyen [19] conducted a research to investigate the nature of exchange rate volatility in the exchange rates of the Vietnamese dong (VND). Using ARMA-GARCH models to capture the mean and volatility process of USD-VND, GBP-VND, JPY-VND, and CAD-VND exchange rate returns, the author found that these models were well-adequate. Mahroowal and Salari [20] also investigated exchange rate volatility, finding that the GARCH model was the best model to explain the volatility of the return on the exchange of Afghanistan's foreign exchange rate with the US dollar. Ponziani [21] conducted a similar investigation into Southeast Asian countries, finding that the PARCH model was appropriate for Malaysian Ringgit (MYR), Vietnam Dong (VND), and Singapore Dollar (SGD), while the GARCH model was appropriate for THB and PHP, and the TARARCH model was appropriate for Indonesia Rupiah (IDR). These findings indicate that different exchange rate volatility models may be better suited for different currencies.

The following academics' works contain evidence for the leverage effect in the exchange

rate: Mohsin et al. [22] studied the Pakistan-US dollar exchange rate volatility and found a negative significance of the EGARCH's leverage value. Atabani [23] examined the volatility of the RMB exchange rate return for both onshore and offshore markets and revealed the presence of leverage effects in both. Abdulhakeem et al. [24] found that the best-fitting model for China, India, Spain, UK, and the USA is GJR-GARCH, followed by GARCH, TGARCH, and EGARCH. Also, Ali [25] modeled the volatility of Somali shilling against US dollar and found that the TCHARCH and EGARCH models were more suitable, with evidence of a leverage effect.

The previous mentioned studies were conducted to gain a better understanding of the effects of historical data and market news, implying a leverage effect, on the foreign exchange market. The most important takeaway from these previous studies is that different exchange rates are fitted with different models that reflect the diverse effects of historical data and market news on the foreign exchange market, which inspired the current investigation, which seeks to make a contribution to this field of research by implementing models utilized in previous work and extending their application to the currencies of ASEAN Member Countries.

3.1. AR Model

An autoregressive model is based on the idea that the current value of the dependent variable can be explained by its past values. This model can be presented by:

$$Y_t = \alpha + \sum_{i=1}^p \rho_i Y_{t-i} + \varepsilon_t, \quad (1)$$

where α is a constant. ρ_i , ρ_i , $i = 1, 2, \dots, p$ is the parameter of the model AR, p is the order of the model, and ε_t represents the error that cannot be explained by the model.

3.2. MA Model

A moving model is based on the idea that the current value of the dependent variable can be explained by past errors. This model can be written by:

$$Y_t = \beta + \sum_{j=1}^q \theta_j \varepsilon_{t-j} + \varepsilon_t, \quad (2)$$

3. Methodology

Volatility is the variation of the observed variable in time series data. This volatility is often forecast instead of the forecast of values conducted by conventional time series models, which are based on the assumption of homoscedasticity, as it allows for heteroscedasticity to exist in the data. This concept of volatility forecasting is reflected in the Autoregressive Conditional Heteroscedasticity (ARCH) model proposed by Engle in 1982 [26]. This model and its extensions, e.g. the GARCH model [27], the exponential GARCH (EGARCH) model [28], the Power GARCH (PGARCH) model [29], Threshold GARCH (TGARCH) model [30], become popular for analysts to forecast volatility.

In this research, various models within the ARCH family model, incorporated with the ARMA model, will be used to forecast the volatility of the selected exchange rates. Additionally, the Johansen Cointegration Test and Granger Causality Test will be employed to identify any long-term and short-term relationships between these exchange rates. Thus, in what follows, the details of the models, the related approaches, and the data used in this research will be presented.

where β is a constant. θ_j , $j = 1, 2, \dots, q$ is the parameter of the model and q is the order of the model.

3.3. ARMA Model

The ARMA (p, q) model is the combination of the above two models. If Y_t is stationary, this model can be represented by:

$$Y_t = \delta + \sum_{i=1}^p \rho_i Y_{t-i} + \sum_{j=1}^q \theta_j \varepsilon_{t-j} + \varepsilon_t, \quad (3)$$

where δ is a constant.

3.4. ARCH-type Models

The autoregressive conditional heteroscedasticity (ARCH) family model can be used to justify the volatility of price and return in the financial market. This model enables the analysts to trace the patterns of market fluctuation. To understand how the model within the ARCH family was formed for this study, this section will provide a brief overview of five models used in this research. The details of each model are as follows.

3.4.1. ARCH model.

The Autoregressive Conditionally Heteroscedastic Model, ARCH (q), is used to describe the variance of the current error term. This model is commonly applied in modeling financial time series that exhibit time-varying volatility and volatility clustering, and it can be stated as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \dots + \alpha_q \varepsilon_{t-q}^2, \quad (4)$$

$$h_t = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2, \quad (5)$$

where h_t is the conditional variances. ε_t denotes the error term. q is the number of lags. $\alpha_0 > 0$ and $\alpha_i \geq 0$, $i = 1, \dots, q$. This implies that the conditional variance depends on previously squared residuals and needs to be non-negative. If $\alpha_i = 0$, h_t will equals to constant and thus conditional variance is homoscedastic.

3.4.2. GARCH Model

Generalized autoregressive conditional heteroscedastic models, GARCH (p, q), permit a longer memory and a more adaptable lag structure. GARCH (p, q) models incorporate the previous conditional variances, whereas ARCH models only consider that the conditional variance is linearly associated with the past variances. The p and q in the model denote the GARCH element and the ARCH element, respectively. The specification of the GARCH (p, q) process is as follows:

$$h_t = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j h_{t-j}, \quad (6)$$

where p is the number of lags. $\beta_j \geq 0$. ε_{t-1} is an ARCH term that represents a previous shock. h_{t-1} is a GARCH term which represents the past forecasted conditional variance.

3.4.3. Threshold GARCH Model

The Threshold Autoregressive Conditionally Heteroscedastic Model (TARCH) employs a piecewise equation for the conditional standard deviation in order to accommodate asymmetry in the conditional variance. Mathematically, the TARCH model is defined as:

$$h_t = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{k=1}^r \gamma_k \varepsilon_{t-k}^2 I_{t-k} + \sum_{j=1}^p \beta_j h_{t-j}, \quad (7)$$

where $I_t = 1$ if $\varepsilon_t < 0$ and 0 otherwise. In this model, good news, $\varepsilon_{t-i} > 0$, and bad news, $\varepsilon_{t-i} < 0$, have differential effects on the conditional variance; good news has an impact of α_i , while bad news has an impact of $\alpha_i + \gamma_i$. If $\gamma_i > 0$, bad news increases volatility and there is a leverage effect for the i -th order. If $\gamma_i \neq 0$, the news impact is asymmetric.

3.4.4. Exponential GARCH Model

EGARCH, the Exponential Generalized Autoregressive Conditionally Heteroscedastic Model, regulates asymmetries in financial data. Even if the estimated coefficients are negative, the logarithmic features of the EGARCH model ensure that the conditional variance will be positive. The conditional variance of an EGARCH model can be expressed as follows:

$$\log h_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \left| \frac{\varepsilon_{t-i}}{h_{t-i}} \right| + \sum_{k=1}^r \gamma_k \frac{\varepsilon_{t-k}}{h_{t-k}} + \sum_{j=1}^p \beta_j \log h_{t-j}^2, \quad (8)$$

The left-hand side is the log of the conditional variance. This implies that the leverage effect is exponential, rather than quadratic, and that forecasts of the conditional variance are guaranteed to be nonnegative. The presence of leverage effects can be tested by the hypothesis that $\gamma_k < 0$. The impact is asymmetric if $\gamma_k \neq 0$.

3.4.5. Power GARCH model

PGARCH is modeled by standard deviation rather than variance. The PARCH model may be specified as follows:

$$h_t^\delta = \alpha_0 + \sum_{i=1}^q \alpha_i (|\varepsilon_{t-i}| + \gamma_i \varepsilon_{t-i}) + \sum_{j=1}^p \beta_j h_{t-j}^\delta, \quad (9)$$

where $\delta > 0$, $|\gamma_i| \leq 1$ for $i = 1, 2, \dots, r$. $\gamma_i = 0$, for all $i > r$ and $r \leq p$. The optional γ_i parameters are added to capture asymmetry of up to order r . If $\delta = 2$ and $\gamma_i = 0$, the PARCH model is simply a GARCH model. The asymmetric effects are present if $\gamma_k \neq 0$.

3.4.6. Cointegration Test

To test the long run relationship, this work employs the Johansen Cointegration Test and Vector Error Correction Model (VECM) [31] [32]. The Johansen cointegration test can be expressed by:

$$\Delta y_t = \alpha_0 + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t, \quad (10)$$

$$\Delta y_t = \alpha_0 + \beta_1 y_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta y_{t-i} + \varepsilon_t, \quad (11)$$

where β_i and δ_i are the coefficient matrices, Δ is the symbol of difference operator and p is the lag order selected. This method employs two likelihood ratio test statistics, the Trace test and the Maximum Eigenvalue test, to determine the number of cointegrating vectors: the Trace test and the Maximum Eigenvalue test, which can be expressed as:

$$T(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\theta}_i), \quad (12)$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\theta}_{r+1}), \quad (13)$$

where $\hat{\theta}_i$ is the expected eigenvalue of the characteristic roots and T is the sample size. r and n are cointegrating vectors. For Vector Error Correction Model (VECM), it can be expressed by:

$$\Delta y_t = \alpha_1 + p_1 ecm1_{t-1} + \sum_{i=0}^n \omega_i \Delta y_{t-i} + \sum_{i=0}^n \gamma_i \Delta x_{t-i} + \varepsilon_{1t}, \quad (14)$$

$$\Delta x_t = \alpha_2 + p_2 ecm2_{t-1} + \sum_{i=0}^n \omega_i \Delta y_{t-i} + \sum_{i=0}^n \gamma_i \Delta x_{t-i} + \varepsilon_{2t}, \quad (15)$$

where ω_i and γ_i are the short-run coefficients. p is the lag order, $ecm1_{t-1}$ and $ecm2_{t-1}$ are the Error Correction Term. ε_{1t} and ε_{2t} are the residuals.

To evaluate the error of the results from the model estimation, root-mean-square error (RMSE) and mean absolute error (MAE) will be used, and they can be written as follows:

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (\hat{e}_i - e_i)^2}, \quad (16)$$

$$MAE = \frac{1}{N} \sum_{i=1}^N |\hat{e}_i - e_i|, \quad (17)$$

where N is the sample number, e is the actual exchange rate return, and $\hat{e}$ is the forecast exchange rate return.

The exchange rate data used for estimating the model was downloaded from the Bank of Thailand website as Baht/Foreign currency. These data are daily basic which include Baht/Malaysia Ringgit (MYR), Baht/Singapore Dollar (SGD), Baht/Brunei Darussalam Dollar (BND), Baht/Philippines Peso (PHP),

Baht/Indonesia Rupiah (1000 Rupiah) (IDR), Baht/Myanmar Kyat (MMK), Baht/Cambodia Riel (100 Riel)(KHR), Baht/Laos Kip (100 Kip)(LAK), and Baht/Vietnam Dong (VND100)(VND). The data covers the time between October 2, 2018 and October 7, 2022, including 1,015 observations.

Table 1. Augmented Dickey-Fuller Unit Root Tests

Var.	t-Stat.	Prob.
LDBND	-27.246	0.000
LDIDR	-28.528	0.000
LDKHR	-31.712	0.000
LDLAK	-29.527	0.000
LDMMK	-30.879	0.000
LDMYR	-28.273	0.000
LDPHP	-26.145	0.000
LDSGD	-26.798	0.000
LDVND	-29.534	0.000

In order to examine the ARCH effect, the ARMA model for exchange rate returns was identified, and the result of analysis reveals that the ARCH effect does not persist in LDMMK, ARMA (2,2), ARCH(1) (F-stat.=0.34, P-value=0.56). Therefore only 8 exchange rates, i.e., LDBND, LDIDR, LDKHR, LDLAK, LDMYR, LDPHP, LDSGD, and LDVND, will be further investigated.

In this study the appropriate models will be selected based on AIC criteria such that the lowest value is the most appropriate one. From the analysis it show the appropriated models for each exchange rate as follows: LDBND ARMA (1,0) TGARCH (1,1) (AIC=-9.08); LDIDR ARMA (2,3) PGARCH (1,1) (AIC=-8.00); LDKHR ARMA (3,3) GARCH (1,1) (AIC=8.20); LDLAK ARMA (3,1) PGARCH

(1,1) (AIC=-8.19); LDMYR ARMA (1,0) PGARCH (1,1) (AIC=-8.75); LDPHP ARMA (1,0) TGARCH (1,1) (AIC=-8.59); LDSGD ARMA (1,0) GARCH (1,1) (AIC=9.10); and LDVND ARMA(1,0) TGARCH (1,1) (AIC=-8.55). The results of model estimations are shown in Table 2.

In Table 2, it was found that the coefficients of the asymmetric parameter, γ , of LDBND, LDLAK, LDMYR, LDPHP, and LDVND were statistically significant, indicating that the leverage effect is present in these exchange rates. This suggests that these exchange rates are more sensitive to bad news than to good news in the specified period.

Table 2. Model estimations

	LDBND TGARCH (1,1)	LDIDR PGARCH (1,1)	LDKHR GARCH (1,1)	LDLAK PGARCH (1,1)
α_0	1.1E-07**	5.4E-06	2.6E-07	3.9E-10
α	0.050***	0.232***	0.038***	0.034***
γ_1	0.100**	0.062	-	-0.197***
γ_2	-0.129***	-	-	-
δ	-	0.431***	-	0.953***
β	0.948***	2.046***	0.946***	2.760***

Table 2. Model estimations (Cont.)

	LDMYR PGARCH (1,1)	LDPHP TGARCH (1,1)	LDSGD GARCH (1,1)	LDVND TGARCH (1,1)
α_0	0.000	1.5E-06**	1.0E-07**	6.5E-08**
α	0.043***	0.097***	0.037***	0.059***
γ_1	-0.583***	0.048		0.074
γ_2		-0.090**		-0.124**
δ	0.947***			
β	0.800**	0.784***	0.947***	0.962***

The properties of the models, i.e., serial correlation, ARCH effect, and normal distribution of residuals, are investigated based on the following hypotheses: H_0 : there is no serial correlation in the residual; H_0 : there is no ARCH; and H_0 : residuals are normally distributed. The results from this investigation reveal that all models present no serial correlation and no ARCH effect. However, the

residuals are not normally distributed, suggesting that these models may not be the most efficient choice.

The volatility estimation results depicted in Figure 1 reveal that among the 8 currencies analyzed, LDLAK, LDMYR, LDSGD, and LDVND not only have high volatility but also a rising trend. Table 3 displays the forecast error.

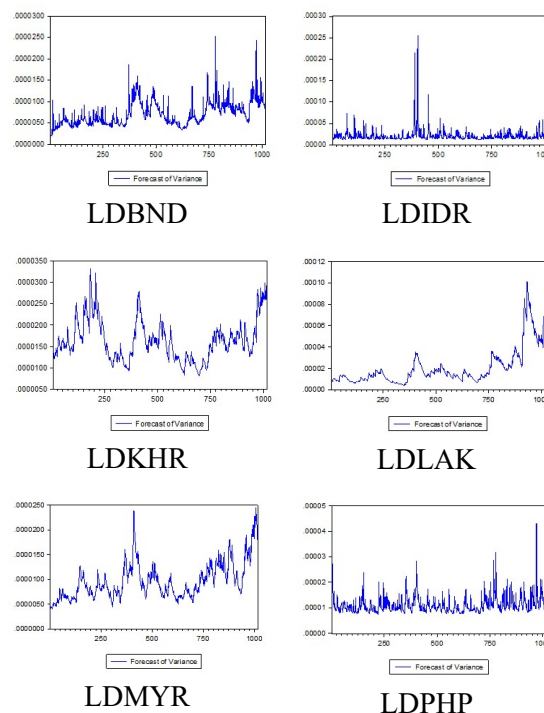
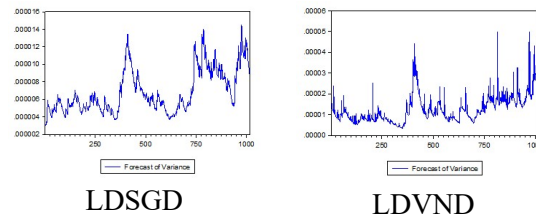


Figure 1. exchange rate volatility estimations**Figure 2.** exchange rate volatility estimations (Cont.)**Table 3.** Errors of exchange rate estimation

Ex. rate	RMSE	MAE
LDBND	0.0026	0.0020
LDIDR	0.0046	0.0035
LDKHR	0.0040	0.0031
LDLAK	0.0045	0.0031
LDMYR	0.0031	0.0024
LDPHP	0.0033	0.0026
LDSGD	0.0026	0.0020
LDVND	0.0036	0.0026

The cointegration test will be described in the following sections. The outcome of the Johansen cointegration test is shown in Tables 4 and 5.

Table 4. Johansen Cointegration Test

Hypothesized	Trace	0.05		
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.261361	1465.374	143.6691	0.0000
At most 1 *	0.234536	1161.822	111.7805	0.0000
At most 2 *	0.183213	894.0138	83.93712	0.0000
At most 3 *	0.161157	691.2321	60.06141	0.0000
At most 4 *	0.157562	515.1494	40.17493	0.0000
At most 5 *	0.125952	343.3516	24.27596	0.0000

At most 6 *	0.110635	208.4627	12.32090	0.0000
At most 7 *	0.086799	90.98063	4.129906	0.0000

Trace test indicates 7 cointegrating eqn(s) at the 0.05 level, * P-value < 0.05

Table 4 indicates that there are at most seven cointegrating equations at a 5 percent level of significance. The significant long-run relationships between normalized variables are shown in Table 5.

Table 5. Normalized Cointegrating coefficients

DGLDBN D	DGLDID R	DGLDK HR	DGLDLA K	DGLDM YR	DGLDP HP	DGLDSG D	DGLDVN D
1.000	-0.664	0.027	0.007	0.907	0.542	-0.647	-0.291
	(0.039)	(0.141)	(0.116)	(0.340)	(0.160)	(0.726)	(0.218)

(.) is standard error

The results presented in Table 5 demonstrate the existence of a long-run relationship between DGLDBND, DGLDIDR, DGLDMYR, and DGLDPHP at the 5 percent level of significance.

Figure 2 is a network representation of the Granger causality test, indicating a short-run relationship between these exchange rates, either unidirectional or bidirectional.

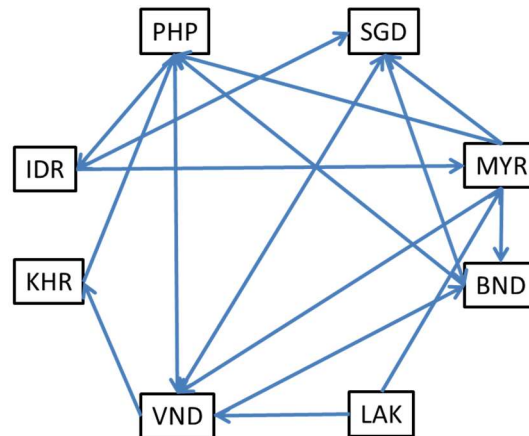


Figure 3. Granger causality network

From the results of the volatility analysis, it appears that market shocks and historical information influence exchange rate volatility. In addition, the significance of the asymmetric parameter can be utilized to divide the exchange rates into two groups: those that are consistent with a symmetric model and those that are consistent with an asymmetric model.

The exchange rates in the symmetric group include LDKHR, LDSGD, and LDIDR. These

exchange rates fit with GARCH models, which have been used in a number of recent studies. For example, Mahroowal & Salari (2019), who used a GARCH model to explain the volatility of the return on the exchange of Afghanistan's foreign exchange rate; Nguyen (2018), who used a GARCH model to explain the volatility of USD-VND, GBP-VND, JPY-VND, and CAD-VND exchange rate returns; and SEKMEN & Ravanoğlu (2020), who used a

GARCH model to explain the volatility of some selected exchange rates.

In the case of the asymmetric group, it consists of LDBND, LDLAK, LDMYR, LDPHP and LDVND. These exchange rates contain the leverage effect expressed by the TGARCH and PGARCH models. Recent studies that used these models to estimate exchange rate volatility include, for instance, the work of Ponziani (2019) and Rehman & Salamat (2021), who indicated the existence of an asymmetric effect of good news and bad news on exchange rate volatility. For investors and governments that deal with exchange rates in this group, they should try to maintain current information and search for news that may affect the volatility of these exchange rates.

The discovery of long- and short-term relationships between exchange rates from cointegration and Granger causality test has important implications for investment and economic policy, as it suggests that shocks to one exchange rate can have an effect on its counterpart.

The above analysis of volatility patterns, cointegration, and leverage effects provides valuable insights into the factors influencing exchange rate volatility. This holistic view enhances the understanding of the underlying attributes that contribute to fluctuations in exchange rates.

5. Managerial Implication

On the basis of this study's findings, it is recommended that investors and government agents alike be prepared to respond to the potential risk posed by exchange rate volatility and co-integration when investing in the foreign currencies under investigation. For investors, they can consider using Hedging Techniques such as Forward Contracts and Options or diversifying their business operations across multiple currencies. Additionally, they may employ Forecasting Methods to obtain information and utilize it before making decisions. For governments, one fundamental

approach to controlling exchange rate volatility is through the implementation of macroeconomic policies. These policies include fiscal and monetary measures aimed at stabilizing currency fluctuations. On the fiscal front, governments can employ strategies such as managing public debt, adopting flexible tax policies, and controlling government spending. By ensuring sound fiscal practices, governments can create an environment of certainty and strengthen investor confidence, thereby mitigating exchange rate volatility. Monetary policies, on the other hand, are orchestrated by central banks to manage exchange rate fluctuations. Actions such as adjusting interest rates, regulating money supply, and engaging in open market operations enable governments to influence the value of their currencies. Due to the results heightened news sensitivity and interdependence, special consideration should be given to LDBND, LDLAK, LDMYR, LDPHP, and LDVND. As a result, investors should use information regarding the expected value of the Baht relative to these currencies, financial market news, and the economic situation as a strategy to mitigate risk arising from trade and investment activities, whereas government agents should use this information to devise interventions to the exchange market to promote exchange rate stability.

6. Limitations and Future Research

This study has only demonstrated the impact of historical data and leverage on the volatility of ASEAN Member Countries' exchange rates. Additionally, only five ARCH-type models were utilized in this study. Consequently, future research may take into account additional alternative time series models to address volatility and utilize various forms of ARCH-type models. External factors such as inflation, interest rates, and international reserves may be considered variables.

7. Conclusion

This study examines the volatility and cointegration of the daily exchange rate for nine selected ASEAN member countries. The 8 forms of the GARCH models, i.e., ARCH (1), ARCH (2), GARCH (1,1), GARCH (1,2), TGARCH (1,1), EGARCH (1,1), and PGARCH (1,1) are used to address the volatility of these exchange rates. The exchange rate data used for estimating the model was downloaded from the Bank of Thailand website as Baht/Foreign currency. These data are daily basic and include Baht/Malaysia Ringgit (MYR), Baht/Singapore Dollar (SGD), Baht/Brunei Darussalam Dollar (BND), Baht/Philippines Peso (PHP), Baht/Indonesia Rupiah (IDR), Baht/Myanmar Kyat (MMK), Baht/Cambodia Riel (KHR), Baht/Laos Kip, and Baht/Vietnam Dong (VND). The data covers the time between October 2, 2018 and October 7, 2022. Before analyzing the volatility, these exchange rates are manipulated by the log of the first difference. The appropriate models are selected based on the AIC criteria. After consideration, it was discovered that BND matched TGARCH (1,1), IDR matched PGARCH (1,1), KHR matched GARCH (1,1), LAK matched PGARCH (1,1), MYR matched PGARCH (1,1), PHP matched TGARCH (1,1), SGD matched GARCH (1,1), and VND matched TGARCH (1,1). The model estimation shows that all models present no serial correlation and no ARCH effect. However, the residuals are not normally distributed. In addition, there are leverage effects in BND, LAK, MYR, PHP, and VND. The results of volatility estimation indicate that the exchange rates of LAK, MYR, SGD, and VND not only display a high degree of volatility but also an increasing trend. Furthermore, the analysis has revealed a long run and short run relationship between these exchange rates. Therefore, investors should search for news relating to these exchange rates to prevent risk from trade and investment activities. Also, government agents need to

search for such news to design actions to intervene in the exchange market to foster exchange rate stability.

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