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Unleashing Competitive Potential: An Intuitive Fuzzy Logic Approach for Assessing Securities Firm Performance

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Abstract

This study presents a mathematical model designed to assess the competitive advantage of securities firms by analyzing eight key factors: service quality, product introduction, product design tailored to user needs, commission fees with and without investment advisors, organizational structure, return on assets (ROA), and return on equity (ROE). Utilizing fuzzy logic and a weighted average approach, the model calculates an overall competitive advantage score for each firm, facilitating a ranking system that highlights the firms with the highest competitive potential. This ranking system not only reflects a firm's strategic and operational strengths but also aligns with external benchmarks from prominent financial websites, offering a comprehensive view of market positioning. The study's conclusions emphasize the model's utility in guiding firms to enhance their strategic planning and improve service offerings, while also serving as a valuable tool for investors and policymakers to understand the competitive landscape within Thailand's securities sector. By providing insights into areas of potential growth and market opportunities, this research aids firms in refining their competitive strategies and bolstering their market presence.

Keywords: competitive advantage value, product design, commission fees, return on assets, return on equity, fuzzy logic, Stock Exchange of Thailand.

1. Introduction

In the Stock Exchange of Thailand (SET), the Securities and Exchange Commission of Thailand (SEC) regulates securities trading. Investors must use a securities company or a broker to facilitate securities trading and receive various services that benefit them, including account opening, settling transactions, advice, and problem resolution. Each securities company offers different services and operates differently based on its size and expertise. As competition increases among securities companies, companies must analyze their strengths, weaknesses, opportunities, and threats to plan, develop, and improve their operations, products, and services to increase their competitive advantage. One interesting question is how management and investors can determine a company's level of competitiveness compared to other securities companies. Securities companies differ in the types of products and services offered, the size of the business, the number of branches, and the expertise of personnel.

Therefore, researchers are interested in studying and analyzing data collected from past securities companies to develop a mathematical model that measures a company's competitive advantage regarding securities trading. The results of this model will provide a score that reflects a company's level of competitiveness in various areas compared to other securities companies. This score will be valuable information for investors and customers when making investment decisions or selecting a securities company for their services. The research objectives:

1) To develop a mathematical model that measures a company's competitive advantage in various areas.

2) To develop a mathematical model that measures a company's overall competitive advantage.

3) To rank securities companies based on their scores of competitive advantages in each area and overall.

This research aims to develop a mathematical model to measure a securities company's competitive advantage in various areas and overall. Registered securities companies in the SET with five years of past data, from 2017 to 2021, will be selected for analysis. From the perspective of both management, investors, and service users, how can they determine the level of competitiveness of a securities company they manage, invest in, or use compared to other companies? This is because each securities company differs in various related variables, such as the size of its business, the expertise of its personnel, and the number of branches. Therefore, the researchers are interested in studying and collecting data from securities companies to analyze and develop a mathematical model that measures a company's competitiveness in various areas. The results of this model will provide a score that reflects the company's level of competitiveness compared to other securities companies. This score will be valuable information for both the investors and customers in making investment decisions and selecting the best securities company for their needs. The conceptual framework of the research is depicted in Figure1.

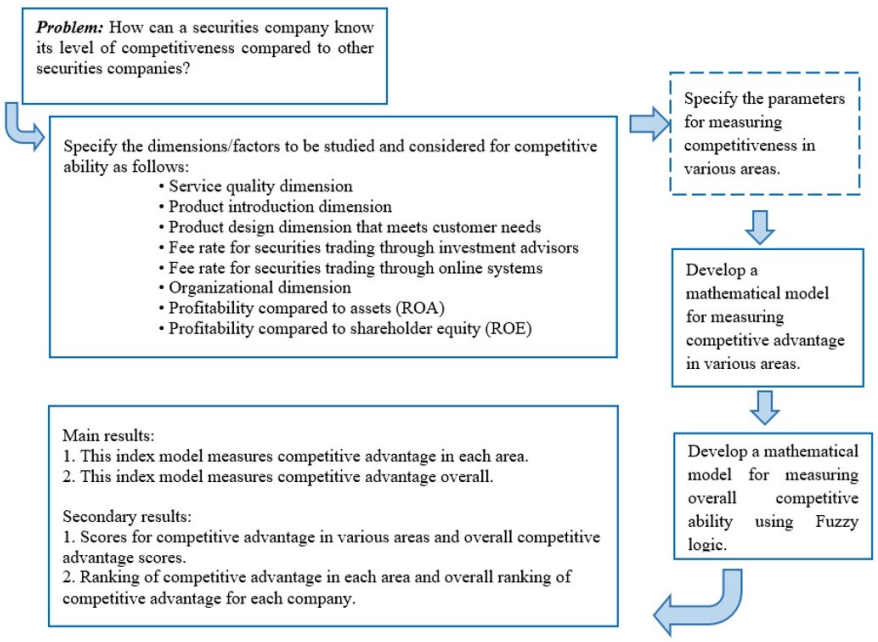

Figure 1 Conceptual Framework of the Research.

2. Literature Review

In our research, we conduct a comprehensive examination of seminal studies that offer a multifaceted understanding of competitive advantage and performance evaluation across various sectors:

1) **Performance Evaluation in Technology Platforms:** El-Gamal et al. (2007) present an insightful comparison between mobile agent platforms and remote method invocation for information retrieval, highlighting the crucial role of performance evaluation in technology platforms. Their work, focusing on developing a mathematical model to assess and compare these platforms, provides a foundational approach for technology evaluation.

2) **Business Models and Strategy:** Massa et al. (2017) delve into the intricate dynamics of business models, exploring three key interpretations: firm attributes, cognitive/linguistic schemas, and formal conceptual representations. Their research critically examines the relationship between business models and strategy, paving the way for future explorations in this field.

3) **Competitive Advantages in SMEs:** This study by Farida and Setiawan (2022) emphasizes the impact of business strategies on the competitive advantages of SMEs. It underlines the significance of performance and innovation as critical mediators in this relationship, offering valuable insights for small and medium business planning and growth.

4) **Global Economic Competitiveness:** Xing et al. (2018) develop a novel analytical framework to understand the competitive advantages of economies from an econophysics perspective. This framework employs bipartite graph theory to analyze global value chain functions and introduces network-based indices for competitive assessment at both industrial and national levels.

5) **Risk Management in Cooperatives:** Sugiyanto and Andriani (2017) focus on Indonesian cooperatives. This study investigates the implementation of risk management and its effects on governance and performance. Utilizing path analysis, the research reveals the indirect impact of risk management through the lens of cooperative governance, emphasizing its necessity for organizational success.

6) **Fuzzy Analysis in Finance:** A series of studies by Yodmun (2016), Witayakiattilerd (2019), Kesamoon (2019) and Boonprasurt (2022) employ fuzzy quantitative analysis and multicriteria decision-making for stock selection. They explore the application of fuzzy logic in finance, offering innovative approaches to portfolio management and stock selection under uncertain market conditions.

By integrating these diverse perspectives, our research constructs a holistic and dynamic framework for understanding and evaluating competitive advantage. This framework not only highlights the importance of performance, innovation, and good governance but also introduces advanced quantitative methods and network-based indices for comprehensive analysis. We developed a mathematical model to rank companies based on these dimensions, guiding them in enhancing service development, strategic planning, and performance for improved efficiency and market competitiveness. This approach not only enriches our theoretical understanding but also provides practical tools for businesses and investors in an increasingly complex and competitive global market.

3. Prelimminaries

3.1. Fuzzy Logic and Inference

Fuzzy logic extends classical logic to handle partial truth, where truth values can range between completely true and false. It is particularly useful in systems where input depends on many uncertain or vague factors.

Fuzzy Sets

A fuzzy set is a class of objects with a continuum of grades of membership, characterized by a

membership function. This function, which ranges between 0 and 1, describes the degree of truth as an extension of valuation. For example, rather than a simple binary setting, where 0 or 1 indicates the absence or presence of a characteristic, fuzzy logic provides a way to deal with intermediate values.

Membership Functions

Membership functions on fuzzy sets are crucial; they define whether an element belongs to a set, and to what extent (a value between 0 and 1). For instance, in a fuzzy set of "tall people," the height can have different degrees of membership ranging from "not tall" to "very tall."

Fuzzy Rules and Inferences

Fuzzy logic rules are typically used in fuzzy inference systems to define relationships between input and output variables. Standard rules are generally structured as follows:

Rule 1: If x_1 is A_{11} and x_2 is A_{12} ... and x_n is A_{1n}, then y is B_1.

Rule 2: If x_1 is A_{21} and x_2 is A_{22} ... and x_n is A_{2n}, then y is B_2.

. . .

Rule m: If x_1 is A_{m1} and x_2 is A_{m2} ... and x_n is A_{mn}, then y is B_m.

In these rules: x_i represents the input variables, A_{ij} represents the fuzzy sets that the input variable x_i must match in rule j, and B_j represents the fuzzy set for the output in rule j. These rules allow fuzzy inference systems to make decisions based on the rules of fuzzy logic. Each rule implies a fuzzy relation and the decision-making process usually involves an aggregation of these fuzzy relations.

Mamdani Inference Method

The Mamdani inference method is a widely used approach in fuzzy logic systems for making decisions. This method uses fuzzy logic to map inputs to outputs using fuzzy rule sets. The output of the Mamdani method is also a fuzzy set.

Defuzzification

The last step in a fuzzy logic system is defuzzification. This process converts the fuzzy output of the inference system into a crisp output. One common method is the center of gravity method, which computes the output as the weighted average of all possible outputs, weighted by their degrees of membership.

Fuzzy logic is extensively applied across various domains including control systems, pattern recognition, and others, owing to its proficiency in reasoning under conditions of uncertainty. This research leverages a fuzzy technique-based model to evaluate and rank the competitive capabilities of securities firms. The adoption of a fuzzy technique-based development model for ranking provides substantial advantages over conventional methods, particularly in its adept management of uncertainty and imprecision. It proficiently handles incremental assessments and integrates both qualitative and quantitative data, effectively mimicking human reasoning within the decision-making process. This approach yields rankings that are more nuanced, flexible, and robust, displaying high resistance to noise and data variations. Fuzzy logic also facilitates the formulation of user-defined, easily interpretable criteria, ensuring that the outcomes closely align with intuitive human judgments. These attributes render fuzzy techniques especially fitting for complex scenarios where data ambiguity is common and qualitative evaluations are critical, thereby offering a practical and versatile solution that excels beyond many traditional ranking methodologies. The effectiveness of this system is further enhanced by tools such as MATLAB's Fuzzy Logic Designer, which provides a comprehensive platform for developing and testing fuzzy inference systems. MATLAB R2020a version was chosen for its robust support for fuzzy logic toolboxes and compatibility with the algorithms employed in this research.

3.2. Basic Knowledge of Securities Companies

Securities companies are crucial in the capital market, providing financial services to investors and various organizations. Their responsibilities include presenting securities to the market, trading securities, and offering financial advice for entering the capital market. Services companies provide include underwriting, selling government securities, raising capital for organizations, and offering

investment advice.

3.2.1 Revenue of securities business

The revenue of a securities business can come from various sources, including:

1) Commissions: Commissions are the primary income for securities companies, derived from trading securities on behalf of investors, such as buying and selling stocks, options, or debt securities.

2) Fees and service charges: Securities companies can collect fees and service charges from investment-related activities, such as portfolio management, investment consulting, or raising funds for business expansion.

3) Annual fees: Securities companies may charge annual fees to customers who use their services, including service fees for investor accounts.

4) Initial Public Offerings (IPOs): Securities companies can earn revenue from offering new securities by coordinating between companies that want to enter the stock market and investors.

5) Shareholding: Securities companies may hold shares in other companies and receive returns from profit-sharing or dividends of the companies in which they hold shares.

6) Investment in debt securities: Securities companies may invest in debt instruments, such as commercial paper, government bonds, or corporate bonds, to generate income from the interest received from these securities.

7) Underwriting fees: Securities companies may act as underwriters in cases where shares or debt securities are offered for sale and receive underwriting fees for offering these securities.

8) Sponsorship fees: Securities companies may offer support for investment activities or propose new investment ideas and charge fees for providing this support.

9) Mutual fund management fees: If a securities company manages mutual funds, they may charge fees for managing the mutual funds to customers who invest in the funds.

10) Savings account management fees: Securities companies may offer savings accounts to customers and charge fees for managing these savings accounts.

When combining revenue from all these sources, securities companies can generate profits and expand their business in the long term. Access to these diverse sources of income helps securities companies achieve financial stability and withstand market competition. At the same time, securities companies must continuously work to develop and improve service quality, offer competitive commission rates, and provide effective investment advice to attract and retain satisfied customers.

3.2.2 Competition among securities businesses

Competition among securities businesses is a significant factor in this industry, and securities companies must consider various factors to compete effectively. The key factors for competition in the securities business include:

1) Service quality: Securities companies should provide high-quality services that cater to customers' needs, such as accurate and helpful advice, swift execution, and comprehensive customer support.

2) Fees and service charges: Setting appropriate and competitive fees and service charges to attract investors, along with transparency in determining fees and charges.

3) Innovation and technology: Offering new services and technologies that benefit customers, such as online services, application transactions, or data analysis tools for investors.

4) Reputation and credibility: A good reputation of a securities company affects investor and customer confidence and trustworthiness. Providing high-quality services, transparency in operations, and compliance with laws and regulations are essential factors in building credibility and a good reputation for the company.

5) Adaptability: Securities companies should be able to adapt to market conditions and customer needs. Improving and developing services based on economic and technological changes can impact a company's competitiveness.

6) Good customer relationships: Building and maintaining good customer relationships is crucial in increasing competitive opportunities. Effective communication, quick responsiveness to customer needs, and excellent after-sales service create customer satisfaction and loyalty toward the company.

Securities companies can boost competitiveness, improve operations, and succeed in the industry by considering key factors. Adapting to economic changes, legal issues, and industry trends helps develop suitable strategies. Establishing lasting relationships and maintaining professionalism ensure long-term advantages and sustainability.

4. Research Procedures

In this study, we will create a mathematical model to measure the competitive advantage values of companies in various aspects. Subsequently, we rank the competitive advantage values in different areas and the overall competitive advantage of companies. The overall competitive advantage can be used to measure a company's service capabilities compared to others, guiding the development, planning, and improvement of company services for enhanced efficiency. The research procedures are structured into 6 steps, which are as follows:

Step 1) **Scope Definition:** Establish the boundaries of the study by clearly defining the data parameters relevant to companies in the securities sector. This includes identifying key performance indicators and operational metrics that will be analyzed.

Step 2) **Data Collection:** Gather comprehensive data on various operational and financial aspects of securities companies. This includes, but is not limited to, the number of branches, available payment channels, market share, fees, Return on Assets (ROA), and Return on Equity (ROE).

Step 3) **Mathematical Model Development:** Construct a mathematical model tailored to assess the competitive advantage of securities companies across diverse dimensions. This model will be the foundation for evaluating different competitive aspects.

Step 4) **Competitive Advantage Assessment:** Utilize the developed model to measure the competitive advantage of companies in several areas. These include service provision efficiency, innovation in product launches, the alignment of product design with user needs, fee structures for stock trading (both with and without investment advisors), organizational effectiveness, ROA, and ROE.

Step 5) **Overall Competitive Advantage Calculation:** Apply Fuzzy Logic techniques within MATLAB software to compute the overall competitive advantage values of these companies. This approach allows for handling uncertainties and subjective assessments inherent in evaluating competitive advantage.

Step 6) **Ranking and Analysis:** Rank the companies based on their competitive advantage in the identified aspects and their overall competitive advantage. This step involves a comparative analysis to understand the positioning of each company within the market.

Each of these steps is crucial for a comprehensive understanding of the competitive landscape in the securities sector and will contribute to the overarching goal of the research.

5. Results

The outcomes derived from executing the procedures outlined in Section 4 are as follows:

Step 1 **Scope Definition.**

In this research, ten companies were selected as case studies, including:

1) Finansia Syrus Securities Co., Ltd. (FSS),
2) KGI Securities (Thailand) Co., Ltd. (KGI),
3) AIRA Securities Co., Ltd. (AIRA),
4) Asia Plus Securities Co., Ltd. (ASPS),
5) Bualuang Securities Co., Ltd. (BLS),
6) Country Group Securities Co., Ltd. (CGS),
7) Maybank Kim Eng Securities (Thailand) Co., Ltd. (MBKET),
8) Phillip Securities (Thailand) Co., Ltd. (PST),
9) Siam Commercial Bank Securities Co., Ltd. (SCBS),
10) UOB Kay Hian Securities (Thailand) Co., Ltd. (UOBKHST).

These companies were chosen based on various criteria, including their innovation in technology, market influence, focus on sustainability, client services, and their strategic role in both local and ASEAN markets. This selection provides a comprehensive analysis of the competitive dynamics within Thailand's securities industry, reflecting the diverse operational strategies and market positioning of each firm.

We define the boundaries of the study by specifying the data parameters relevant to companies in the securities sector. The selection of eight critical factors for evaluating the competitive abilities of securities firms is based on their extensive impact across multiple dimensions of firm performance:

1) Service Provision: Efficient and accessible service is essential for retaining existing customers and attracting new ones. A firm that excels in service provision meets client needs promptly and effectively.
2) Product Launches: The ability to introduce new products and services that meet market demands reflects a firm's innovation and adaptability.
3) Product Design to Meet User Needs: Tailoring products and services to directly address customer needs enhances client satisfaction and loyalty.
4) Fee Rates for Stock Trading Through Investment Advisors: Competitive fee structures for services provided by investment advisors are crucial for attracting and retaining investors.
5) Fee Rates for Stock Trading Without Investment Advisors: Offering trading options without investment advisors appeals to clients preferring direct market access.

6) Organization: An efficient organizational structure facilitates quick and effective decision-making and operations.

7) Ability to Generate Profits Compared to Assets (ROA): ROA is an indicator of how effectively a firm uses its assets to generate earnings.

8) Ability to Generate Profits Compared to Shareholder Equity (ROE): ROE shows how well a firm uses the capital invested by its shareholders to produce income.

These metrics are chosen because they cover a broad range of capabilities and outcomes that collectively determine a securities firm's competitiveness in the industry. They address various aspects of firm performance from client interaction to financial efficiency and strategic market positioning. The study collects relevant data for each aspect over the past 5 years (2017-2021).

Step 2) **Data Collection.**

This research collects data on the 8 different aspects used to compare the competitiveness of each securities company, as shown in Table 1:

Table 1 Data in the 8 different aspects used to compare the competitiveness of each Securities firm.

Aspect	Competitive Advantage Aspect Name	Definition	Quantitative Data for Indicator Calculation
1) Service Provision	Competitive advantage in service provision	Refers to the ability to access customer services, including convenience in using services for customers	1) Number of service branches 2) Number of payment channels
2) Product Launches	Competitive advantage in product launches	Refers to the ability to design products and services with variety to cover all customer groups	1) Number of company products
3) Product design to meet user needs	Competitive advantage in product design to meet user needs	Refers to the ability to design products and services to meet the needs of customers in each target group	1) Market share ratio 2) Number of company products
4) Commission Rates for Stock Trading via Investment Consultants	Competitive advantage in commission rates for stock trading via investment consultants	Refers to the ability to compete in commission rates compared to other companies in the securities market through investment consultants. Lower commission rates attract more customers	1) Commission rates for stock trading via investment consultants at different transaction values, as follows: - Transaction value up to 5 million THB - Transaction value 5-10 million THB - Transaction value 10-20 million THB - Transaction value over 20 million THB
5) Commission rates for stock trading via Online Systems	Competitive advantage in commission rates for stock trading via online systems	Refers to the ability to compete in commission rates compared to other companies in the securities market through online systems for both cash and credit transactions. Lower commission rates attract more customers	1) Commission rates for stock trading via online systems for both cash and credit transactions at different transaction values, as follows: - Transaction value up to 5 million THB - Transaction value 5-10 million THB - Transaction value 10-20 million THB - Transaction value over 20 million THB
6) Organization	Competitive advantage in the organization	Refers to the ability to manage labor skills according to the needs of the company to respond to customers	1) Number of investment analysts 2) Number of investment consultants 3) Number of investment planners
7) Profitability in comparison to assets	Competitive advantage in profitability in comparison to assets	Refers to the ability to generate net profit from current assets. The higher the value, the more efficiently the company can utilize its assets	1) Net profit of the company. 2) Total assets of the company.
8) Profitability in comparison to shareholders' equity	Competitive advantage in profitability in comparison to shareholders' equity	Refers to the ability of the company to generate profit per shareholder's equity. The higher the value, the more profit the company can generate	1) Net profit of the company. 2) Equity (Assets - Liabilities) of the company

Let i represent company i, where $i = 1, 2, 3, \ldots, 10$. Define the variables involved in calculating the competitive capability value of a company as shown in Table 2.

Subsequently, the researchers collected quantitative data for each variable listed in Table 2. The values of this data are presented in Table 3 and Table 4.

Table 2 The variables involved in calculating the competitive capability value of a company.

Variable	Description	Variable	Description
Br_i	Number of branches of company i	C_{1i}	Fee rate for online credit stock trading with transaction amount not exceeding 5 million THB
Ch_i	Number of payment channels of company i	C_{2i}	Fee rate for online credit stock trading with transaction amounts between 5-10 million THB
P_i	Number of products of company i	C_{3i}	Fee rate for online credit stock trading with transaction amounts between 10-20 million THB
Mk_i	Market share of company i	C_{4i}	Fee rate for online credit stock trading with transaction amount exceeding 20 million THB
Fe_{1i}	Fee rate for trading stocks through investment advisors with transaction amount not exceeding 5 million THB	A_i	Number of investment analysts of company i
Fe_{2i}	Fee rate for trading stocks through investment advisors with transaction amounts between 5-10 million THB	B_i	Number of investment advisors of company i
Fe_{3i}	Fee rate for trading stocks through investment advisors with transaction amounts between 10-20 million THB	D_i	Number of investment planners of company i
Fe_{4i}	Fee rate for trading stocks through investment advisors with transaction amounts exceeding 20 million THB	Ne_i	Net profit of company i
M_{1i}	Fee rate for trading stocks through investment advisors with transaction amounts exceeding 20 million THB	To_i	Total assets of the company i
M_{2i}	Fee rate for online cash stock trading with transaction amounts between 5-10 million THB	Eq_i	Equity (Assets - Liabilities) of company i
M_{3i}	Fee rate for online cash stock trading with transaction amounts between 10-20 million THB	e_i^j	Competitive advantage in aspect j of company i when j= 1, 2, 3, . . . , 8
M_{4i}	Fee rate for online cash stock trading with transaction amount exceeding 20 million THB		

Table 3 Collecting quantitative data for the indicator calculation.

Securities Firm	Br_i	Ch_i	P_i	$Fe_{i,1}(\%)$	$Fe_{i,2}(\%)$	$Fe_{i,3}(\%)$	$Fe_{i,4}(\%)$	$M_{i,1}$ (%)	$M_{i,2}(\%)$	$M_{i,3}(\%)$	$M_{i,4}(\%)$
FSS	25	6	7	0.25	0.22	0.18	0.150	0.200	0.180	0.150	0.120
KGI	14	5	10	0.26	0.23	0.19	0.160	0.207	0.187	0.157	0.107
AIRA	14	4	9	0.25	0.22	0.18	0.001	0.200	0.180	0.150	0.100
ASPS	14	5	8	0.25	0.22	0.18	0.150	0.200	0.180	0.150	0.120
BLS	29	7	8	0.25	0.18	0.15	0.001	0.200	0.180	0.150	0.100
CGS	7	5	10	0.26	0.23	0.19	0.160	0.208	0.188	0.158	0.128
MBKET	34	15	12	0.26	0.23	0.19	0.160	0.207	0.187	0.157	0.127
PST	19	4	16	0.25	0.25	0.25	0.250	0.150	0.150	0.150	0.150
SCBS	6	5	15	0.26	0.23	0.19	0.160	0.207	0.187	0.157	0.127
UOBKHST	42	6	9	0.26	0.23	0.19	0.160	0.207	0.187	0.157	0.127
Min	6	4	7	0.25	0.18	0.18	0.001	0.150	0.150	0.150	0.100
Max	42	15	16	0.26	0.25	0.25	0.250	0.208	0.188	0.150	0.128

Table 4 Collecting quantitative data for indicator calculation (Continue).

Securities Firm	$C_{i,1}(\%)$	$C_{i,2}(\%)$	$C_{i,3}(\%)$	$C_{i,4}$ (%)	A_i	B_i	D_i	Ne_i	Te_i	Eq_i
FSS	0.150	0.130	0.110	0.100	7	367	7	-161.24	4,276.95	2,349.25
KGI	0.157	0.137	0.117	0.107	17	320	30	1,079.67	12,438.54	6,239.04
AIRA	0.150	0.130	0.110	0.001	9	128	6	-176.75	9,064.21	4,638.35
ASPS	0.150	0.130	0.110	0.100	21	297	29	271.00	3,985.29	2,221.31
BLS	0.150	0.130	0.110	0.001	41	660	111	1,352.39	3,985.29	8,040.37
CGS	0.158	0.138	0.118	0.108	19	320	11	153.92	10,060.51	7,934.02
MBKET	0.157	0.137	0.117	0.107	19	827	24	316.30	16,137.7	4,277.42
PST	0.150	0.150	0.150	0.150	16	465	15	63.24	3,608.44	1,356.48
SCBS	0.157	0.137	0.117	0.107	29	220	59	309.24	25,770.00	3,123.63
UOBKHST	0.157	0.137	0.117	0.107	24	592	9	19.84	4,723.31	3,447.23
Min	0.150	0.130	0.110	0.001	7	128	6	-176.75	3,608.44	1,356.48
Max	0.158	0.150	0.150	0.150	41	827	111	1,352.39	25,770.00	8,040.37

Step 3) **Mathematical Model Development.**
Create a mathematical model to measure the competitive advantage of securities companies in various aspects. Define the mathematical model for measuring the competitive advantage in each aspect of the company as shown in Table5.

Table 5 Mathematical model for measuring the competitive advantage of securities companies in various aspects.

Aspect	Mathematical model for measuring competitive advantage
1) Service Provision	$e_i^1 = \left(\frac{Br_i}{\max\limits_K Br_K}\right)\left(\frac{Ch_i}{\max\limits_K Ch_K}\right)$
2) Product Launches	$e_i^2 = \frac{P_i - \min\limits_K P_K}{\max\limits_K P_K}$
3) Product Design to Meet User Needs	$e_i^3 = \left(\frac{P_i}{\max\limits_K P_K}\right)\left(\frac{Mk_i}{\max\limits_K Mk_K}\right)$
4) Commission rates for stock trading via investment Consultants	$e_i^4 = \prod\limits_{j=1}^{4}\left(\frac{\min\limits_K Fe_{j,K}}{Fe_{j,i}}\right)$
5) Commission rates for stock trading via online systems	$e_i^5 = \frac{1}{2}\left\{\prod\limits_{j=1}^{4}\left(\frac{\min\limits_K M_{j,K}}{M_{j,i}}\right) + \prod\limits_{j=1}^{4}\left(\frac{\min\limits_K C_{j,K}}{C_{j,i}}\right)\right\}$
6) Organization	$e_i^6 = \left(\frac{1}{3}\right)\left(\frac{A_i}{\max\limits_K A_K}\right)\left(\frac{B_i}{\max\limits_K B_K}\right)\left(\frac{D_i}{\max\limits_K D_K}\right)$
7) Profitability in comparison to assets	$e_i^7 = Ne_i/To_i$
8) Profitability in comparison to shareholders' equity	$e_i^8 = Ne_i/Eq_i$

Table 5 presents a mathematical model designed to measure the competitive advantage of securities companies in various operational aspects. Each aspect is quantified using specific formulas to calculate a competitive advantage score, providing a standardized method for comparing firms across the industry. Here's a detailed explanation of how the competitive advantage for each aspect is modeled:

1) Service Provision: This model measures the competitive advantage by comparing the ratio of the number of branches (B_{ri}) and payment channels (Ch_i) for each company to the highest number observed across all companies. This metric assesses the firm's reach and accessibility to its clients.

2) Product Launches: Competitive advantage is evaluated based on the number of products (P_i) a company offers relative to the highest product count among all firms. This indicates a firm's ability to diversify and innovate.

3) Product Design to Meet User Needs: This measures the firm's market orientation by comparing the number of products (P_i) and market share (Mk_i) against the maximum values in these categories industry-wide. It highlights the company's effectiveness in meeting customer demands and capturing market share.

4) Commission Rates for Stock Trading via Investment Consultants: The advantage is computed through the product of the relative commission rates (Fe_{ij}) for various transaction brackets, promoting firms that offer lower rates as a means to attract more clients through cost competitiveness.

5) Commission Rates for Stock Trading via Online Systems: This metric combines the competitive commission rates (M_j and C_j) offered for online transactions. Lower commission rates are considered advantageous, especially appealing to digitally engaged investors.

6) Organization: This aspect evaluates the staffing density regarding investment analysts, advisors, and planners. It uses the ratio of the number of these professionals in a firm to the maximum found in any company, reflecting the firm's capacity to provide detailed and personalized services.

7) Profitability in Comparison to Assets: The model calculates this ratio by dividing the net profit (Ne_i) by the total assets (To_i) of the company, assessing how efficiently assets are being utilized to generate profit.

8) Profitability in Comparison to Shareholders' Equity: This is determined by the ratio of net profit (Ne_i) to the company's equity (Eq_i), indicating the efficiency with which the firm utilizes shareholders' equity to generate earnings.

Each component of this mathematical model helps in objectively quantifying the elements that contribute to a securities firm's competitive stance in the marketplace, allowing for an apples-to-apples comparison across different companies.

Step 4) **Competitive Advantage Assessment.**

Measure the competitive advantage of companies in areas such as service provision, product launches, product design to meet user needs, fee rates for stock trading through investment advisors, fee rates for stock trading without investment advisors, organization, ROA, and ROE, the measured values as shown as in Table 6.

Table 6 The competitive advantage value of securities companies in various aspects.

Securities Firm	e_i^1	e_i^2	e_i^3	e_i^4	e_i^5	e_i^6	e_i^7	e_i^8
FSS	0.238	0.000	0.223	0.005	0.008	0.230	0.000	0.000
KGI	0.111	0.188	0.250	0.004	0.007	0.357	0.087	0.158
AIRA	0.089	0.125	0.082	0.682	0.813	0.140	0.000	0.000
ASPS	0.111	0.063	0.172	0.005	0.008	0.380	0.068	0.122
BLS	0.322	0.063	0.254	0.001	0.001	0.930	0.123	0.168
CGS	0.056	0.188	0.187	0.004	0.006	0.320	0.015	0.019
MBKET	0.810	0.313	0.750	0.004	0.006	0.560	0.020	0.058
PST	0.121	0.563	0.240	0.002	0.005	0.366	0.018	0.047
SCBS	0.048	0.500	0.320	0.004	0.006	0.500	0.012	0.099
UOBKHST	0.400	0.125	0.139	0.004	0.006	0.460	0.004	0.005
Min	0.048	0.000	0.082	0.001	0.001	0.140	0.000	0.000
Max	0.810	0.563	0.750	0.682	0.813	0.930	0.123	0.168
$\bar{x}$	0.231	0.213	0.262	0.072	0.087	0.424	0.035	0.068
S.D.	0.223	0.179	0.175	0.204	0.242	0.205	0.040	0.062

Step 5) **Overall Competitive Advantage Calculation**

Use Fuzzy Logic to calculate companies' overall competitive advantage values using MATLAB software. In this research, Fuzzy Logic will be applied to calculate the overall competitive capability values of each company. The process begins with designing fuzzy sets for input variables, which are variables used to measure competitive capabilities in 8 different aspects, and fuzzy sets for output variables. The steps and methods are as follows:

Step 5.1) Identify the input variables: Determine the key factors that represent the competitive capabilities in 8 different aspects. These factors will be used as input variables for the fuzzy logic system.

Step 5.2) Define the fuzzy sets for input variables: Assign linguistic terms (e.g., low, medium, high) to the input variables, and determine the corresponding membership functions for each term.

These functions will define the degree to which a specific input value belongs to a particular fuzzy set. For $j = 1, ..., 8$, let e_i^j be a fuzzy set, let x_j be a fuzzy variable of fuzzy set e_i^j, where each fuzzy set e_i^j consists of 2 linguistic terms, namely Le_i^j and He_i^j, defined by $Le_i^j = < 0,\ 0,\ \bar{x}_j - SD_j,\ \bar{x}_j + SD_j >$ and $He_i^j = < \bar{x}_j - SD_j,\ \bar{x}_j + SD_j,\ 1,\ 1 >$. (1) Take the competitive capability values in each aspect, the average value ($\bar{x}$), and standard deviation (S.D.) from Table 6 to construct the fuzzy set of each term of language e_i^j, $j = 1, ..., 8$. The results are shown in Table 7 and the graphs of the membership function of each linguistic term are shown in Figure 2.

Table 7 The fuzzy set of each term of a language e_i^j, $j = 1, ..., 8$.

Aspect	Linguistic	Fuzzy set of the linguistic term, low level Le_i^j	Fuzzy set of the linguistic term, high level He_i^j
1) Service provision	e_i^1	<0, 0, 0.01, 0.45 >	<0.01, 0.45, 1, 1 >
2) Product launches	e_i^2	<0, 0, 0.03, 0.39 >	<0.03, 0.39, 1, 1 >
3) Product design to meet user needs	e_i^3	<0, 0, 0.09, 0.44 >	<0.09, 0.44, 1, 1 >
4) Commission rates for stock trading via investment consultants	e_i^4	<0, 0, 0, 0.28 >	<0, 0.28, 1, 1 >
5) Commission rates for stock trading via online systems	e_i^5	<0, 0, 0, 0.33 >	<0, 0.33, 1, 1 >
6) Organization	e_i^6	<0, 0, 0.22, 0.63 >	<0.22, 0.63, 1, 1 >
7) Profitability in comparison to assets	e_i^7	<0, 0, 0, 0.08 >	<0, 0.08, 1, 1 >
8)Profitability in comparison to shareholders' equity	e_i^8	<0, 0, 0.01, 0.13 >	<0.01, 0.13, 1, 1 >

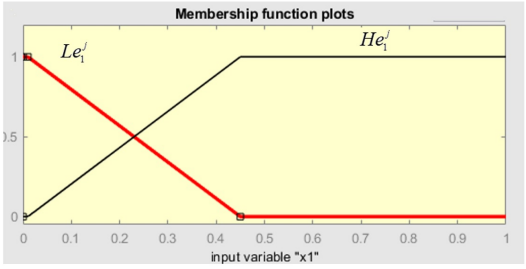

Figure 2 Membership Function Graph of Linguistic Terms Le_1^j and He_1^j.

We note that in practice if the computer used has high processing capabilities, each linguistic variable can be defined by more than two linguistic terms. However, due to processing limitations, each linguistic variable is defined by only two linguistic terms, which will generate a possible number of fuzzy rules, $2^8 = 256$ rules. If each linguistic variable is defined by three linguistic terms, it will generate a possible number of fuzzy rules up to $3^8 = 6,561$ rules, which exceeds the processing capability of the researcher's computer.

Step 5.3) Define the fuzzy sets for output variables: Similarly, assign linguistic terms and membership functions for the output variables, which will represent the overall competitive capability values of the companies. In this study, the output fuzzy set, W, is designed as a total competitive capability score of one 1, using symmetric criteria in designing the fuzzy set of 5 linguistic terms as shown in Table 8.

Step 5.4) Create the fuzzy rules: Develop a set of if-then rules that describe the relationships between the input and output variables, using the linguistic terms defined for each variable. Due to the language variables e_i^j, $j = 1, ..., 8$, each language variable is defined as a 2-level linguistic term, namely Le_i^j and He_i^j. Therefore, a rule consisting of all 8 language variables can be created, all of which are different, $2^8 = 256$. The rules are shown in Table 8. The definition of the linguistic term

Table 8 The fuzzy set of 5 linguistic terms of a language W.

Linguistic Term	Fuzzy Set	Meaning
L	<0, 0, 0.2, 0.4 >	Low level of competitive capability score.
RL	<0.2, 0.4, 0.5 >	A rather low level of competitive capability.
M	<0.4, 0.5, 0.6 >	Moderate level of competitive capability.
RH	<0.5, 0.6, 0.8 >	A rather high level of competitive capability.
H	<0.6, 0.8, 1, 1 >	High level of competitive capability.

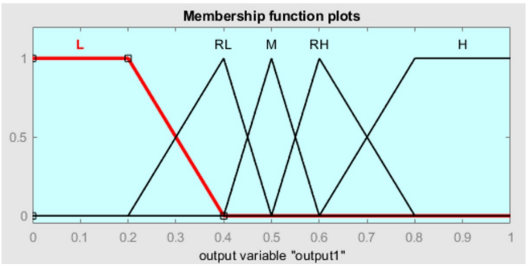

Figure 3 Membership Function Graph of Linguistic Terms of W.

of the output variable W of each rule can be done as follows:

1) Find the average score of the input variables in each rule by assigning a score of 0 for input Le_i^j and assigning a score of 1 for input He_i^j.

2) Assume the level of the output variable W is defined as follows.

Table 9 Illustration of determining the linguistic term of e from the average score of the input language variables.

Average score	[0, 0.2)	[0.2,0.4)	[0.4,0.6)	[0.6,0.8)	[0.8,1]
Level of W	L	RL	M	RH	H

From the criteria for scoring He_1^j,He_2^j,..., He_7^j all have the same score, which is 1 point, and for Le_8^j, the score is 0. The average score is $\frac{1(7)+0}{8} = 0.875 \in [0.8, 1]$. From Table 9, we get ($w$is H). Therefore, Rule 2 is shown in Table 10. In the same way, other rules, are partly shown in Table 11.

Table 10 Example of defining output in Rule-2.

Rule2	if (x_1 is He_1^j)$\wedge$(x_2 is He_2^j) $\wedge$... $\wedge$(x_7 isHe_7^j) $\wedge$(x_8 isLe_8^j) then w is H.

Table 11 The fuzzy rules, if-then rules that describe the relationships between the input and output variables

Rule	Statement
Rule 1	if $(x_1$ is $He_1^j) \wedge (x_2$ is $He_2^j) \wedge \ldots \wedge (x_7$ is$He_7^j) \wedge (x_8$ is$He_8^j)$ then w is H.
Rule 2	if $(x_1$ is $He_1^j) \wedge (x_2$ is $He_2^j) \wedge \ldots \wedge (x_7$ is$He_7^j) \wedge (x_8$ is$Le_8^j)$ then w is H.
Rule 3	if $(x_1$ is $He_1^j) \wedge (x_2$ is $He_2^j) \wedge \ldots \wedge (x_7$ is$Le_7^j) \wedge (x_8$ is$He_8^j)$ then w is H.
Rule 4	if $(x_1$ is $He_1^j) \wedge (x_2$ is $He_2^j) \wedge \ldots \wedge (x_7$ is$Le_7^j) \wedge (x_8$ is$Le_8^j)$ then w is RH.
$\vdots$	$\vdots$
Rule 254	if $(x_1$ is $Le_1^j) \wedge (x_2$ is $Le_2^j) \wedge \ldots \wedge (x_7$ is$He_7^j) \wedge (x_8$ is$He_8^j)$ then w is RL.
Rule 255	if $(x_1$ is $Le_1^j) \wedge (x_2$ is $Le_2^j) \wedge \ldots \wedge (x_7$ is$Le_7^j) \wedge (x_8$ is$He_8^j)$ then w is L.
Rule 256	if $(x_1$ is $Le_1^j) \wedge (x_2$ is $Le_2^j) \wedge \ldots \wedge (x_7$ is$Le_7^j) \wedge (x_8$ is$Le_8^j)$ then w is L.

Step 5.5) Import the fuzzy sets and rules developed in Steps 5.2 to 5.4 into MATLAB's Fuzzy Logic Designer. For this study, the centroid method is selected for defuzzification, and the Mamdani inference method is applied.

Step 5.6) Determine the overall competitive advantage score for each company. This score is a real number output, derived from the fuzzy inference process. It involves inputting the data for each company (denoted as e_i^j, where $j = 1, ..., 8$) from Table 5. An illustrative example of calculating the overall competitive advantage score for KGI using this process is depicted in Figure 4. The final competitive advantage scores for all companies are presented in Table 12.

Figure 4 The overall competitive advantage score of KGI from the inference from the fuzzy process

Step 6 **Ranking and Analysis.**

In this step, we focus on systematically ranking the companies based on their competitive advantage. This process involves two key components:

1) Aspect-Specific Ranking: First, rank the companies according to their competitive advantage values in each specific aspect. These aspects are the individual parameters or criteria established in the earlier steps of the analysis. The ranking in each aspect will provide a detailed view of where each company stands about specific strengths and weaknesses.

2) Overall Competitive Advantage Ranking: After ranking the companies in each aspect, the next step is to rank them based on their overall competitive advantage. This overall ranking is derived from the aggregated scores of all aspects, as calculated in the previous steps. It provides a comprehensive view of each company's competitive position in the market.

The results of these rankings offer valuable insights into the competitive landscape, highlighting both the areas where companies excel and where they may need to improve. This can guide strategic decision-making and help in identifying key areas for growth and development.

Table 12 The overall competitive advantage of companies

Order	Securities Firm	Overall competitive advantage score
1	KGI	0.661
2	MBKET	0.568
3	BLS	0.521
4	SCBS	0.482
5	PST	0.472
6	ASPS	0.434
7	AIRA	0.358
8	UOBKHST	0.296
9	CGS	0.277
10	FSS	0.249

6. Applying Research Findings for Enhanced Performance

Applying research findings involves leveraging the results obtained from research studies to inform decision-making and drive improvements across various areas. This is particularly relevant when it comes to the development of mathematical models and measuring the competitive performance of securities firms. Here are some key ways in which these findings can be applied:

1) Analysis and performance evaluation: Research findings on measuring the competitive performance of securities firms can be used to analyze and evaluate the performance of individual firms. This analysis enables comparisons with competitors in the securities market, such as assessing financial performance, customer service efficiency, fund management, and investment account opening.

2) Strategic development: Research findings on mathematical models and measuring competitive performance can be instrumental in the strategic development of securities firms. By studying and analyzing these results, organizations can identify weaknesses and strengths, allowing them to develop suitable strategies for growth and future preparation.

3) Process improvement: Research findings can be applied to enhance business processes within securities firms. Through careful examination of these findings, areas of improvement and

limitations in competitive performance can be identified. This knowledge facilitates the development of more effective methods to enhance service delivery, operational efficiency, product or service quality, and customer satisfaction.

4) Forecasting and planning: Research findings are valuable for forecasting and planning the future of securities firms. Mathematical models can be utilized to predict future competitive performance, while data from measuring competitive performance aids in strategic planning and process improvement. This enables organizations to prepare for upcoming challenges and capitalize on emerging opportunities proactively. By embracing and implementing research findings, securities firms can gain valuable insights and tools to analyze, strategize, optimize processes, and plan for future growth and competitiveness.

7. Conclusion and Discussion

7.1. Conclusion and Discussion

This study explored the competitive dynamics within Thailand's securities sector, assessing securities firms listed on the Stock Exchange of Thailand. Our investigation was anchored in a multi-dimensional framework, evaluating eight critical aspects of competitiveness: Service Provision, Product Launches, Product Design aligned with User Needs, Commission Rates for Stock Trading (both through Investment Consultants and Online Systems), Organizational Structure, and Profitability Metrics (relative to Assets and Shareholders' Equity).

To quantify these dimensions, we developed an innovative mathematical model. The model's strength lies in its integration of fuzzy logic, executed within the MATLAB environment, to adeptly process and analyze the nuanced competitiveness data of each firm. This approach allowed for a nuanced and accurate assessment of each firm's competitive stance.

The culmination of this analytical journey was the ranking of firms based on their overall competitive capabilities. These rankings are not just numerical placements; they are a reflection of strategic positioning, operational efficiency, and market perception in the eyes of investors and stakeholders. To enhance the robustness of our findings, we juxtaposed our model's rankings with external benchmarks, drawing comparisons with rankings from esteemed financial websites like www.moneyandbanking.co.th, www.mgronline.com, and www.ryt9.com. The congruence or divergence of these rankings, as illustrated in Table 13, offers a unique lens through which the industry's competitive landscape can be viewed and interpreted.

This research doesn't just offer a snapshot of the current competitive landscape; it provides a versatile framework that can guide firms in enhancing their strategic planning, identifying areas of improvement, and seizing new market opportunities. For policymakers and industry analysts, the study serves as a valuable tool for understanding market dynamics and shaping future regulatory and developmental strategies. Overall, the insights gleaned from this study are pivotal for the participating firms and the broader financial sector in Thailand and potentially other emerging markets with similar economic profiles.

Table 13 The rankings obtained from the research model were compared with those from other websites, such as www.moneyandbanking.co.th, www.mgronline.com, and www.ryt9.com (2020, September 28)

Securities Firm	Ranking by the model	www.moneyandbanking.co.th	www.mgronline.com	www.ryt9.com.
KGI	1	4	5	2
MBKET	2	1	1	1
BLS	3	3	3	3
SCBS	4	5	4	4
PST	5	9	8	6
ASPS	6	6	7	9
AIRA	7	10	9	10
UOBKHST	8	8	6	8
CGS	9	7	10	2
FSS	10	2	2	7

The rankings based on the overall competitive capabilities can serve as a decision-making tool for customers when choosing service providers. They also provide valuable information for potential investors interested in securities firms. Additionally, the rankings contribute to decision-making in business planning to enhance the service quality and competitiveness of securities firms, enabling them to compete effectively with other market players and further improve their performance.

7.2. Future research

Building upon the findings of this study, future research should explore the integration of Multi-Criteria Decision-Making (MCDM) methods to refine the evaluation of competitive dynamics within the securities sector. Analytical Hierarchy Process (AHP) could be utilized to determine the relative importance of the competitive factors through expert judgment, focusing on how stakeholder preferences affect firm rankings. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is suggested to rank firms based on their proximity to an ideal solution, considering market fluctuations. VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) could assess the optimal compromise solution under conditions of conflicting criteria, which is common in complex decision-making scenarios. The Complex Proportional Assessment (COPRAS) method can be applied to directly relate the performance of firms to the best performer, adjusting the significance ratios to see how they influence competitive ratings. The Weighted Aggregated Sum Product Assessment (WASPAS) combines weighted sum and product methods to provide a nuanced ranking sensitive to both aggregate and individual criteria impacts. A comparative analysis of these MCDM techniques would also be beneficial to identify which method provides the most consistent results under various scenarios. Additionally, integrating these MCDM methods with traditional financial metrics like ROA and ROE could offer a holistic view of a firm's competitiveness, providing valuable insights for strategic planning and operational improvements. Extending these methods to other sectors or geographic regions could also validate their effectiveness in diverse economic environments, helping to shape future regulatory and development strategies within the broader financial sector.

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