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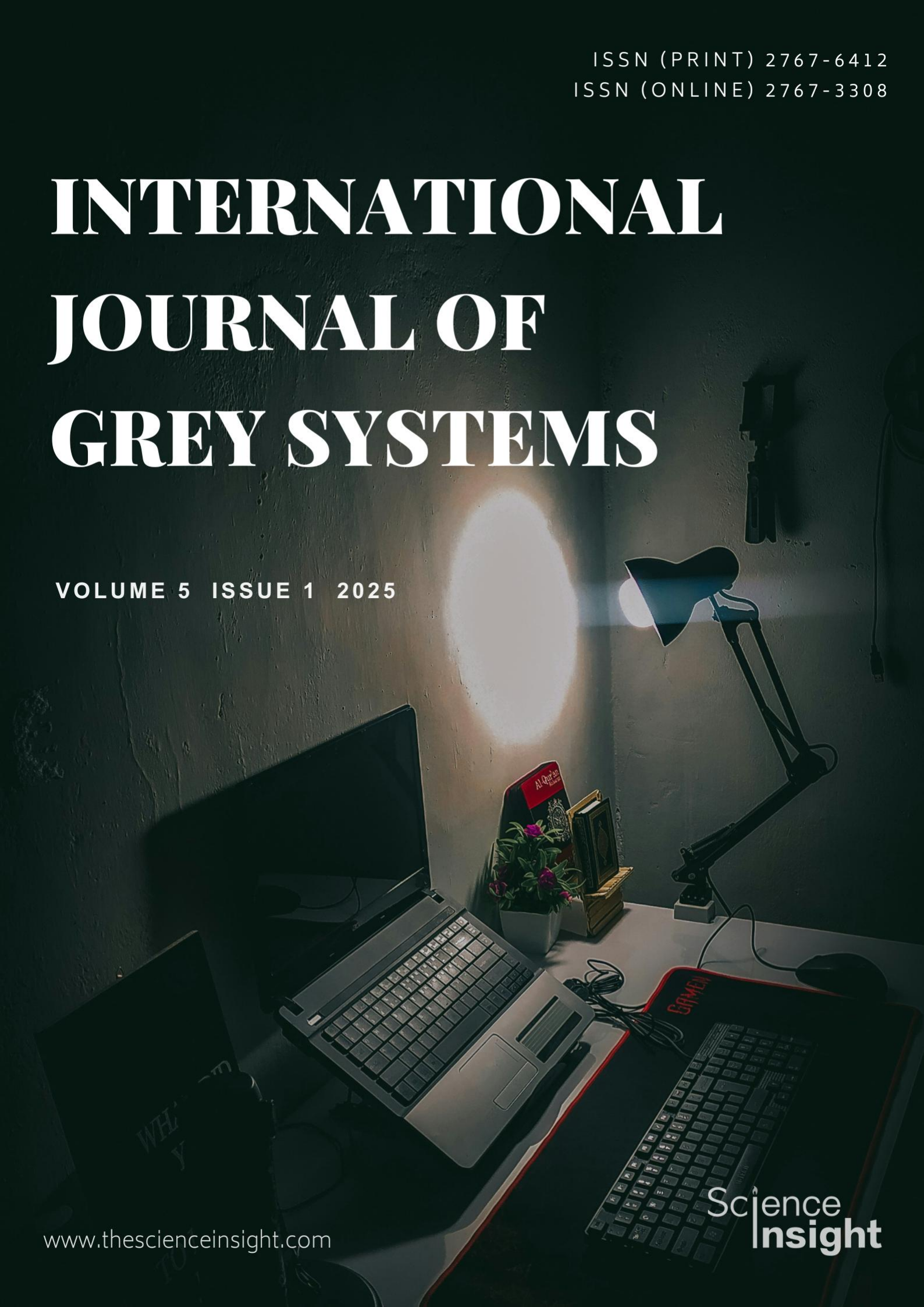

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Research on Loan Market Share Prediction Based on Grey Model and Exponential Smoothing Method

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Abstract: The market share of loans is one of the important indicators in the operation of banking business, representing the market penetration and business operation of commercial banks in a certain region. It largely reflects the competitive position, influence, and profitability of the enterprise. Therefore, predicting the market share of loans is of great significance. This article takes H Bank's loan market share as the research object. Firstly, analyze the loan market data of H Bank over the past decade. Secondly, the relevant knowledge of grey prediction model and exponential smoothing method was introduced. Finally, the grey prediction model and exponential smoothing method are applied to predict the market share of H Bank's loan market. The results show that the market share of H Bank's loan market has been declining year by year, and effective strategies are proposed to increase market share.

Keywords: Commercial banks; market share of loans; grey forecast; exponential smoothing method

1. Introduction

Commercial banks are financial institutions that operate currency and credit businesses, are the mainstay of modern financial industry, and are the hub of national economic operation (Yao, 2008). After experiencing reform and opening up, the market economy has flourished, industrial upgrading, and technological innovation. In this era, the banking industry has been able to develop rapidly. At the same time, with the introduction of various policies, the participating entities in the banking industry have achieved unprecedented development in both quantity and quality. In this industry context, the internal competition in the banking industry is constantly increasing, and commercial banks are more eager for profits. Meanwhile, the market share of loans is the fundamental basis for the development of banks and the foundation for the existence of profits (Wu, 2015). Under controllable risk conditions, the better the loan market share indicator, the greater the profit margin, the stronger the ability to sustain operations, the less operational pressure, and the more promising the future development (Yang, 2024).

The grey prediction model (Wu *et al.*, 2017; Chu, 2017; Liang & Sha, 2014; Wang, 2006) and exponential smoothing method (Cao, 2009) have been applied and studied by scholars both

domestically and internationally in many fields. The market share of loans is an important operational indicator for banks, but there are relatively few research results on the application of grey prediction models and exponential smoothing methods in this area. The grey prediction model is suitable for situations with poor data quality and small sample sizes. It constructs grey differential equations and uses the correlation between known and unknown data for prediction, which can obtain more accurate prediction results in situations with limited data. The exponential smoothing method predicts future trends by weighted averaging historical data, using a smoothing factor to control the importance of past data. It can flexibly adapt to data with different fluctuations and obtain relatively stable prediction results. In predicting the market share of loans, the index smoothing method can assist the grey prediction model, verify and correct the prediction results, and improve the prediction accuracy. The current progress of grey model is shown in *Table 1*.

H Bank is a real bank located in Handan City, Hebei Province, China. H Bank has always been the largest commercial bank in the region. In the past decade, the number of banking operators in the region has gradually increased and stabilized, and the regional business environment is highly competitive. Therefore, this study aims to analyze the market share of H Bank's loans, predict the future loan market share indicators of H Bank, and propose effective strategies to improve market share, providing useful references for the development of commercial bank loan business.

2. Analysis of Local Loan Market Share

Since 2014, the loan balance of H Bank and the region has shown a continuous growth trend, and the market share of H Bank's loans has shown a parabolic shape from low to high and then to low, reaching its peak in the loan market share in 2018. After investigation, it was found that after 2020, due to the conversion of some book loans into debt, equity, write offs, and balance sheets, the loan balance has decreased. In recent years, the loan balance in the region has been increasing year by year, and the relative growth rate of H Bank's loan balance has slowed down. The loan market share has shown an unfavorable development trend. The loan data of H Bank and the region in the past 10 years are shown in *Table 2*.

3. Model Introduction

3.1 Exponential smoothing method

Exponential smoothing, also known as exponential smoothing, is an important time series forecasting method. The exponential smoothing method essentially takes the weighted average of historical data as the prediction result for future time points. The weighting coefficient decays in a

Table 1. The current progress on grey models

Theme	Literature
A novel fractional lag-based mixed-frequency discrete grey model (FMDGM(1,N)).	Gou *et al.* (2025)
To improve prediction accuracy for nonlinear and small-scale data, this study introduces residual learning into grey models, proposing a hybrid model.	Hao *et al.* (2025)
The study proposed a grey model with heterogeneity accumulation operators to predict the future energy consumption in Chinese provinces under the shared socioeconomic pathways.	Zhao and Wu (2025)
This research proposed an innovative hybrid Hausdorff fractional grey model (HfGM) for electricity consumption prediction, weakening buffer operator (WBO) was incorporated to minimize interference of external shocks to original data, the optimal core parameters of HfGM were searched by a newly developed multi-objective enhanced version of slime mould algorithm in two stages, achieving Pareto optimal solutions theoretically.	Qian *et al.* (2025)
This study introduces a novel polynomial-driven discrete grey power model (PFDPGM(1,1)) that includes time perturbation parameters, enabling a flexible representation of complex variation patterns in the data.	Yang *et al.* (2025)
The grey prediction model has been well applied in many fields. This study aims to apply the grey model to the prediction of loan market share.	This study

Table 2. Loan data of H Bank and the local region from 2014 to 2023

Year	H Bank	**Local**	**Proportion**
2014	240.7	2397.6	10.0%
2015	336.6	2803.8	12.0%
2016	406.2	3129.2	13.0%
2017	457.6	3385	13.5%
2018	535.1	3661.4	14.6%
2019	594.3	4167.9	14.3%
2020	601.7	4922.9	12.2%
2021	714.3	5757	12.4%
2022	854.2	6751.9	12.7%
2023	908.3	7768.4	11.7%

Unit: 100 million yuan Data source: Internal data

geometric series, and the closer the time period, the greater the weight, and the sum of weights is equal to 1. Due to the fact that the weighting coefficients follow the exponential law and have the function of exponential smoothing, they are called exponential smoothing (Cao, 2009).

The exponential smoothing model is

$$Q_t{}^{(1)} = \alpha Y_t + (1-\alpha) Q_{t-1}{}^{(1)}.$$

where, α is the smoothing coefficient, with a value range of [0,1]. $Q_t{}^{(1)}$ is the exponential smoothing value at time t, and Y_t represents the actual observation value of the t-th period.

The quadratic exponential smoothing model is

$$Q_t{}^{(2)} = \alpha Q_t{}^{(1)} + (1-\alpha) Q_{t-1}{}^{(2)}.$$

where, $Q_t{}^{(2)}$ is a smoothed value of time t. α is the smoothing coefficient, with a value range of [0,1]. $Q_{t-1}{}^{(2)}$ is the quadratic smoothed value of time $t-1$.

The prediction formula is

$$Y_{t+S} = a_i + b_i S.$$

where, t is the starting point for prediction, and S is the prediction step size.

$$a_i = 2Q_t{}^{(1)} - Q_t{}^{(2)}, b_i = \frac{\alpha}{1-\alpha}\left(Q_t{}^{(1)} - Q_t{}^{(2)}\right)$$

Its basic idea is to preprocess the raw data first, eliminate accidental changes in the time series, and increase the importance of recent data in prediction in the collected data. The processed data is called a 'smoothed value'. Then, based on the smoothed values, a prediction model is constructed through calculation to predict the future target values (Zhang, 2023).

The advantages of exponential smoothing method are: a) it does not require collecting a lot of historical data, considers the importance of each period's data, and uses all historical data. It is an improvement and development of the moving average method and has a wide range of applications. b) It has the advantages of simple calculation, small sample requirements, strong adaptability, and stable results. c) Not only can it be used for short-term forecasting, but it also has better performance for medium and long-term measurement (Cao, 2009).

When using exponential smoothing method for prediction, the value of weight α is also crucial. Generally speaking, if the data fluctuates greatly, the α value should be set larger to increase the influence of recent data on the prediction results. If the data fluctuates steadily, the α value should be taken smaller. Based on the specific time series situation, roughly determine the rated value range, then take several α values for trial calculation, compare the prediction standard error under different α values, and select the α with the smallest prediction standard error (Zhang, 2023).

3.2 Grey prediction model

The grey prediction model establishes a grey differential prediction model based on a small amount of incomplete information, and then makes long-term descriptions of the development laws of things (Tu, 2023). Next, we will analyze the construction and solution process of traditional grey prediction GM(1,1) models (Deng, 2002).

STEP 1: Assuming the original data sequence is

$$X^{(0)} = \left\{x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)\right\}$$

The first-order cumulative sequence is

$$X^{(1)} = \left\{x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)\right\}$$

where

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i)\ (k = 1,2, \cdots, n) \tag{1}$$

STEP 2: $\left\{Z^{(1)}(2), Z^{(1)}(3), \cdots, Z^{(1)}(n)\right\}$ is the adjacent mean sequence of $X^{(1)}$, representing the background values of the entire model, where

$$Z^{(1)}(k) = \frac{x^{(1)}(k) + x^{(1)}(k-1)}{2}(k = 2,3, \cdots, n) \tag{2}$$

Therefore, the classic univariate grey prediction model is

$$x^{(0)}(k) + az^{(1)}(k) = b \tag{3}$$

Among them, a is the development coefficient of the system, and b is the grey action quantity. Parameters a and b are obtained through the least squares method

$$\begin{bmatrix}\hat{a} \\ \hat{b}\end{bmatrix} = (B^T B)^{-1} B^T Y \tag{4}$$

where

$$B = \begin{bmatrix} -Z^{(1)}(2) & 1 \\ -Z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -Z^{(1)}(n) & 1 \end{bmatrix}, Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}$$

STEP 3: Time response equation of GM(1,1) model

$$\hat{x}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{\hat{b}}{\hat{a}}\right)e^{-\hat{a}k} + \frac{\hat{b}}{\hat{a}}(k = 1,2, \cdots, n-1) \tag{5}$$

By substituting the calculated parameters $\hat{a}$ and $\hat{b}$ into the time response equation, the fitting value sequence of the first-order cumulative sequence $X^{(1)}$ of the original sequence can be obtained

$$\hat{X}^{(1)} = \left\{\hat{x}^{(1)}(1), \hat{x}^{(1)}(2), \cdots \hat{x}^{(1)}(n), \hat{x}^{(1)}(n+1), \hat{x}^{(1)}(n+2), \cdots\right\}$$

STEP 4: By reducing and restoring accumulated data, it can be obtained

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k)(k = 1,2, \cdots, n-1) \tag{6}$$

Therefore, the fitting value $\hat{x}^{(0)}(1), \hat{x}^{(0)}(2), \cdots \hat{x}^{(0)}(n)$ of sequence $X^{(0)}$ and the predicted $\hat{x}^{(0)}(n+1), \hat{x}^{(0)}(n+2) \cdots$ can be obtained by formula restoration.

STEP 5: By calculating the Mean Absolute Percentage Error (MAPE), the fitting and prediction performance of the model can be analyzed, and the formula is as follows

$$\text{MAPE} = 100\% \times \frac{1}{n} \sum_{n=1}^{k} \left| \frac{\hat{x}^{(0)}(k) - x^{(0)}(k)}{x^{(0)}(k)} \right|.$$

4. H Bank Loan Market Share Forecast

4.1 Exponential smoothing method

4.1.1 Forecast of H Bank's Loan Market Size. The initial value is the actual average value from 2014 to 2016. After comparison, when α is 0.9, the predicted value is closest to the actual value and the predicted result is optimal. *Table 3* shows the process values for predicting the size of H Bank's loan market. According to the quadratic exponential smoothing prediction model $Y_{t+S} = a_i + b_i S$, $a_i = 909.12$, $b_i = 69.29$ is obtained. Finally, Y=909.12+69.29S was obtained, which can effectively predict the size of the loan market from 2024 to 2030. The predicted loan market size of H Bank in the next 7 years under the index smoothing method is shown in *Table 4*.

4.1.2 Forecast of Loan Market Size in the Region. Using the average value from 2014 to 2016 as the initial value. After comparison, when α is 0.9, the predicted value is closest to the actual value and the predicted result is optimal. *Table 5* shows the predicted process values of the loan market size in the region. According to the quadratic exponential smoothing prediction model $Y_{t+S} = a_i + b_i S$, $a_i = 7767.85$, $b_i = 1007.45$ is obtained. Finally, Y =7767.85+1007.45S was obtained, which can effectively predict the size of the loan market from 2024 to 2030. The predicted loan market size of H Bank in the next 7 years under the index smoothing method is shown in *Table 6*. By using the quadratic exponential smoothing method for prediction, the loan market share of H Bank for the next 7 years is obtained, as shown in *Table 7*.

Table 3. H Bank loan market size prediction process value

Year	H Bank's actual value	Q_1 (Simple exponential smoothing)	Q_2 (Double exponential smoothing)
α		0.9	0.9
2013	Initial value	327.83	325.21
2014	240.7	249.43	257.00
2015	336.6	327.85	320.77
2016	406.2	398.37	390.61
2017	457.6	451.65	445.55
2018	535.1	526.76	518.64
2019	594.3	587.59	580.69
2020	601.7	600.24	598.29
2021	714.3	702.88	692.42
2022	854.2	839.10	824.43
2023	908.3	901.42	893.72

Table 4. Forecast of H Bank's loan market for the next 7 years using exponential smoothing method

Year	2024	2025	2026	2027	2028	2029	2030
Forecast	978.41	1047.7	1116.99	1186.28	1255.57	1324.86	1394.15

Unit: 100 million yuan

Table 5. Process value of predicting the size of the loan market in the region

Year	H Bank's actual value	Q_1 (Simple exponential smoothing)	Q_2 (Double exponential smoothing)
α		0.9	0.9
2013	Initial value	2776.87	2765.16
2014	2397.6	2435.53	2468.49
2015	2803.8	2766.93	2737.09
2016	3129.2	3093.01	3057.42
2017	3385.0	3355.82	3325.98
2018	3661.4	3630.83	3600.35
2019	4167.9	4114.24	4062.85
2020	4922.9	4842.06	4764.14
2021	5757.0	5665.55	5575.41
2022	6751.9	6643.31	6536.52
2023	7768.4	7655.91	7543.97

Table 6. Forecast of loan market in the area for the next 7 years using exponential smoothing method

Year	2024	2025	2026	2027	2028	2029	2030
Predictive value	8775.3	9782.75	10790.2	11797.65	12805.1	13812.55	14820

Table 7. H Bank's loan market share forecast

Year	2024	2025	2026	2027	2028	2029	2030
Loan market share %	11.15	10.71	10.35	10.06	9.81	9.59	9.41

4.2 Grey prediction model

4.2.1 Grey prediction of H Bank's loan market size. The grey prediction model takes small sample data as the research object. This section uses the GM (1,1) prediction model to use the loan market data of H Bank from 2016 to 2023 as the historical data for constructing the model, and obtains the predicted data. The detailed process is as follows.

(1) Initialize the modeling raw sequence

$$X^{(0)} = \{406.2,457.6,535.1,594.3,601.7,714.3,854.2,908.3\}$$

(2) Generation of 1-AGO from the original sequence

$$X^{(1)} = \{406.2,863.8,1398.9,1993.2,2594.9,3309.2,4163.4,5071.7\}$$

(3) Generation of Neighbor Mean for 1-AGO Generated Sequence

$$Z^{(1)}(k) = \{635.0,1131.4,1696.1,2294.1,2952.10,3736.3,4617.6\}$$

(4) Calculate the grey model development coefficient a and grey action quantity b

$$a = -0.115, b = 386.168$$

(5) The fitted predicted values and MAPE values are shown in *Table 8*.

4.2.2 Grey prediction of loan market size in the region. This section uses the GM (1,1) prediction model to use the loan market data of the region from 2016 to 2023 as the historical data for constructing the model, and obtains the predicted data. The detailed process is as follows.

(1) Initialize the modeling raw sequence

$$X^{(0)} = \{3129.2,3385,3661.4,4167.9,4922.9,5757,6751.9,7768.4\}$$

Table 8. Forecast of H Bank's loan market size

Year	Actual value of H Bank loan market	Predictive values
2016	406.2	406.20
2017	457.6	458.76
2018	535.1	514.68
2019	594.3	577.41
2020	601.7	647.78
2021	714.3	726.74
2022	854.2	815.31
2023	908.3	914.69
MAPE		3.081%
2024		1026.17
2025		1151.24
2026		1291.56
2027		1448.98
2028		1625.59
2029		1823.72
2030		2046.00

Unit: 100 million yuan

(2) Generation of 1-AGO from the original sequence

$$X^{(1)} = \{3129.2,6514.2,10175.6,14343.5,19266.4,25023.4,31775.3,39543.7\}$$

(3) Generation of Neighbor Mean for 1-AGO Generated Sequence

$$Z^{(1)}(k) = \{4821.7,8344.9,12259.6,16805.0,22144.9,28399.4,35659.5\}$$

(4) Calculate the grey model development coefficient a and grey action quantity b

$$a = -0.148, b = 2494.974$$

(5) The fitted predicted values and MAPE values are shown in *Table 9*.

4.2.3 Prediction of H Bank's Loan Market Share in the Region. By using the grey model for prediction, the market share of H Bank's loan market for the next 7 years is obtained, as shown in *Table 10*.

Table 9. Forecast of H Bank's Loan Market Size

Year	Actual value of total regional loan market volume	Predictive value
2016	3129.2	3129.2
2017	3385.0	3185.919
2018	3661.4	3692.426
2019	4167.9	4279.461
2020	4922.9	4959.823
2021	5757.0	5748.353
2022	6751.9	6662.245
2023	7768.4	7721.431
MAPE		1.748%
2024		8949.01
2025		10371.75
2026		12020.69
2027		13931.78
2028		16146.70
2029		18713.75
2030		21688.93

Unit: 100 million yuan

Table 10. Prediction of the Market Share of H Bank Loans

Year	2024	2025	2026	2027	2028	2029	2030
Loan market share, %	11.85	11.47	11.10	10.74	10.40	10.07	9.75

4.3 Prediction results

Through the grey prediction model and the quadratic exponential smoothing method, it can be seen that H Bank's loan market share will show a significant downward trend in the next 7 years. If effective measures such as business reform and product innovation are not actively implemented to reverse the current trend, the development prospects of H Bank are not optimistic.

5. Suggestions for increasing the market share of loans

5.1 Increase marketing and promotion

Diversified marketing strategies, in addition to traditional advertising methods, can also utilize social media, short video platforms, content marketing, and other means to attract potential customers by creating interesting and practical financial knowledge content. Brand story dissemination, describing the bank's development history, service philosophy, and successful customer cases, enhancing the brand's appeal and trust. Customer experience activities such as offline customer salons and financial product experience days are held to provide customers with a more intuitive understanding of the bank's products and services.

5.2 Innovative loan products

Gain a deep understanding of customer needs through market research, customer interviews, and other methods to understand their actual needs and pain points, and provide strong basis for product design. Introduce diversified loan products based on the needs of different customer groups, such as low interest loans, flexible repayment plans, etc. Develop specialized financial service solutions for specific industries or enterprises to meet their unique funding needs. Innovative guarantee methods, such as joint guarantee, guarantee company guarantee, accounts receivable pledge, etc., can solve the problem of guarantee for small and micro enterprises. Based on factors such as customers' credit status, repayment records, and industry characteristics, customers are segmented into different groups to provide differentiated loan products for different groups.

5.3 Improving customer service quality

It is suggested that the banks make efforts to enhance employees' professional competence, provide regular professional training to employees, and improve their professional competence and service level. They should also strive to improve customer service system, establish customer follow-up system, timely understand customer feedback, solve customer problems, and improve customer satisfaction. They should also strive to establish a rapid response mechanism, specifically for customer inquiries and complaints, to ensure timely resolution of issues. Meanwhile, efforts should be made to introduce advanced financial technologies, utilize big data, artificial intelligence and other financial technology tools to optimize the loan approval process, while improving approval efficiency and accuracy.

5.4 Optimizing loan structure

For high-risk areas such as real estate and local government financing platforms, it is necessary to strictly control loan disbursement, avoid excessive concentration of risks, and integrate business with local economic development. According to national industrial policies and local economic development needs, we will focus on supporting areas such as energy conservation and environmental protection, technological innovation, and small and micro enterprises. Pay attention

to the small and micro enterprise market and increase credit support for small and micro enterprises. Keeping up with the deployment of technological innovation development, optimizing the customer structure of scientific and technological innovation, and supporting the development of high-tech enterprises. Intensify the expansion of retail consumer credit, business credit and other businesses, and increase the proportion of retail loans in total loans.

5.5 Improve the loan pricing mechanism

Considering cost factors comprehensively, pricing should take into account factors such as capital costs, operating costs, and risk costs to ensure the rationality of pricing. Reflecting market orientation, adjusting loan interest rates in a timely manner based on market interest rates and competitive conditions to maintain market competitiveness. Flexible pricing strategy, based on the characteristics of different customers and loan products, adopts flexible pricing strategies to improve the targeting and effectiveness of pricing. Emphasize the principle of differentiation and establish different interest rates based on factors such as the customer's credit rating and loan purpose.

5.6 Strengthen cooperation with third-party organizations

Establish cooperative relationships with other financial institutions such as banks, insurance companies, and guarantee companies to jointly explore the market. Through cooperation, resource information sharing and complementary advantages can be achieved to improve business processing efficiency and risk prevention and control capabilities. Jointly plan and carry out joint marketing activities to expand market share and brand influence. Utilize the advantages in network, business logic, and basic customer base, and choose third-party companies that match your own strategy and business priorities for cooperation.

5.7 Utilizing financial technology to enhance productivity

Develop credit approval processes and credit evaluation models that adapt to the characteristics of various enterprises, utilize information technologies such as big data, blockchain, artificial intelligence, and big data to enhance credit risk assessment capabilities, and strengthen the deep penetration of emerging technologies in the financial field. Provide a more efficient and orderly business collaboration mechanism, quickly respond to customer and market demands, focus on the shortcomings and weaknesses of financial services, continuously improve full lifecycle, diversified, and relay style financial services, and promote better adaptation to the innovation needs of enterprises in the new era. Utilize emerging financial technology to optimize business processes and operational models, strengthen risk prevention and cost management.

6. Conclusion

There are numerous evaluation indicators for commercial banks, which can be used to evaluate the size, quality, and risk of various assets from different dimensions. The loan market share indicator represents the market penetration and business operations of commercial banks in a certain region, and to a large extent reflects the competitive position, influence, and profitability of enterprises. It is one of the important indicators in banking business operations. The prediction of loan market share plays a crucial role in the development of financial markets and banking industry for financial institutions to formulate strategies, optimize resource allocation, and manage risks.

The current study first analyzed the performance of H Bank's loan market share in the past decade. By applying the grey prediction model and exponential smoothing method, H Bank's loan market share in the region was predicted for the next seven years, which were mutually confirmed. The predicted trend of market share decline was obtained, and relevant suggestions for improving the loan market share were proposed.

The current study validates and compares the effectiveness of the two forecasting methods by constructing them and applying them on H Bank’s loan market share. However, existing research

still has some shortcomings. Although grey prediction models and exponential smoothing methods have their own advantages, they also have limitations. For example, grey prediction models perform well with limited data, but may have some errors in long-term forecasting. The exponential smoothing rule focuses more on predicting short-term trends and may not be accurate enough in grasping long-term trends. Therefore, in practical applications, it is necessary to coordinate the various influencing factors of commercial bank market share according to specific situations, analyze and judge from multiple aspects and dimensions, and lay a solid foundation for the rapid and healthy development of banks.

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Evaluation of Challenges to Modernization of Family Businesses: Grey Relational Analysis

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Abstract: Family businesses have contributed to the economic growth of economies globally. Family businesses face unique challenges that affect their efforts to modernize their operations and compete effectively on the global market. This study, therefore, aims at evaluating challenges affecting family business efforts to modernize. Using survey, the study collected primary data and evaluated twelve challenging factors using the Dynamic Grey Relational Analysis model. The findings indicate that there are several challenges affecting the modernization of family business, including resistance to change, rapid advancement of technology, rigid organizational structures, and succession planning. The study provides insight into how family businesses can reconcile traditional features with modern characteristics for sustainability in the long run.

Keywords: Sustainability; modernization; barriers; family business; grey relational analysis.

1. Introduction

Family businesses are among the most important sectors of the global economy (Eddleston *et al.*, 2019; 2010), serving as critical employers and economic drivers (Araya-Castillo *et al.*, 2021; Amato *et al.*, 2022). A family business represents a specific type of business model, and family businesses have a significant role in the global economy, accounting for 70–90% of annual GDP and a large proportion of the workforce (Biel & Ślusarczyk, 2022; De Massis & Foss, 2018; Herrero et al, 2024). Both economic and socio-emotional objectives influence their strategic decisions, with an emphasis on family authority and legacy preservation (Pongelli *et al.*, 2021). By projecting socio-emotional wealth (SEW) through firm ownership, owners pursue five dimensions: family control and influence, identification, bonding social ties, and renewal through dynastic succession (Pongelli *et al.*, 2021; Biel & Ślusarczyk, 2022).

Family business people are key to the economy, creating significant job opportunities and contributing to GDP across various countries. For example, family-controlled businesses comprise 80-90% of all businesses in the USA and employ more than half of the workforce (Hannadige & Harris, 2022). In contrast to other firms, family businesses exemplify continuity, serving as a foundation for local economic stability and intergenerational wealth transfer (Zellweger *et al.*, 2013). They increasingly incorporate social capital and nonfinancial objectives, strengthening the regional economy through community engagement (Arregle *et al.*, 2021). Guided by principles of longevity and community involvement, family firms foster long-term growth, provide stable

employment, and enhance regional economies. Indeed, their focus on values and resilience often enables them to weather economic downturns more effectively than their non-family counterparts, facilitating prolonged local development and intergenerational wealth transfer. Literature indicates that family firms are among the highest-performing types of enterprises. Family firms outperform their partners, whether in terms of profitability, shareholder value creation, or job creation capabilities (Poza, 2010). In navigating the challenging aspects of succession without compromising family peace or solidarity (Baltazar *et al.*, 2023), clear communication, transparency, and professional counsel prove essential. The preservation of cultural identity and continuity connecting generations represents a traditional challenge (Erdogan *et al.*, 2020). However, conservative tendencies may impede innovation and global expansion (De Massis & Foss, 2018; Biel & Ślusarczyk, 2022). Family companies should strive to balance this paradox of continuity and adaptability. Nevertheless, effective governance frameworks and strategic leadership enable these firms to remain innovative while upholding their values for the future (Erdogan *et al.*, 2020).

Sustainable growth requires balancing tradition with modernity, and family businesses must navigate a series of challenges. Additionally, cultural and geographical factors significantly influence whether a family business will endure for generations (Stamm & Lubinski, 2011). Approximately 10% to 15% of family businesses progress to the third generation, and about 30% last for more than one generation (Pyromalis & Vozikis, 2009; Stamm & Lubinski, 2011). Only 3% survive to the fourth generation and beyond (Mokhber *et al.*, 2017; Vallejo, 2008). These figures highlight succession as one of the most significant difficulties faced by family-owned businesses (Bocatto *et al.*, 2010). Family owners may also encounter serious conflicts within the family due to various sources of tension. Discrimination or perceived favoritism, along with differences in skills and merit among family members, can lead to disputes, especially when defining roles within the business (Ferrari, 2025).

Additionally, the potential consequences of business failure pose unique risks, impacting not only the financial standing of the business but also the family's reputation. Tensions may arise between upholding family customs and the business's need to improve and adapt continuously, as tradition can sometimes conflict with modernization efforts (Balzano & Marzi, 2024). The desire for family unity and cooperation can clash with the necessity of fostering diversity and competition, essential for growth. Finally, family loyalty may conflict with the need to provide equal opportunities to non-family employees, a challenge that can affect workplace morale and operational effectiveness (Siaba & Rivera, 2024). Many family businesses are disappearing due to problems and family conflicts in the inter-generational management era. The factors accelerating the collapse of family businesses include favoring family members in the business environment, competition among family members, role conflict, centralization, and transfer problems (Akca & Küçükoglu, 2019; Qiu & Freel, 2020). In examining compensation practices, some conclude that family members believe they are overworked and underpaid, while others suggest they receive higher salaries and perquisites (Sharma *et al.*, 1997). This contradiction required deeper exploration because if unrecognized and not addressed, the seeming discrepancy between perceptions and reality can lead to problems in strategy implementation (Sharma *et al.*, 1997). Various circumstances, such as the family business environment, management style, leadership, and type of supervision, may significantly influence the success or failure of a family business. Therefore, sustainability-related studies in family businesses are becoming increasingly popular in business environments.

The rest of the study is organized as follows. In the next sections some literature is reviewed and then potential challenges to the modernization efforts of the family businesses have been identified. In the suceeding section, research methodology is presented. In this section, the Dynamic Grey Relational Analysis and associated techniques are reported. In the next sections, the data is analysed and findings are discussed followed by the conclusion of the study.

2. Literature review

Change is necessary to adapt and continuously adjust to the environment, and it is essential for any firm's long-term survival (Miller *et al.*, 2008). Regarding the rigid organizational structure that

slows the decision-making process, negative factors that restrict innovation in family businesses include traditional organizational frameworks, risk-averse behavior, a desire for control, and the intention to protect family wealth (Zahra & Sharma, 2004). The disadvantages of a traditional rigid organizational structure have been extensively discussed in management literature, which often attributes issues such as conflict, inefficiency, and the maintenance of the status quo especially in family firms to these structures. Chen *et al.* (2008) argued that family firms are more conservative in financial reporting than non-family firms led by non-family professional CEOs. Additionally, conservatism increases with family ownership in professional CEO family firms but decreases with family ownership in firms run by founder CEOs. van Essen *et al.* (2015) noted that most family businesses adopted conservative financial strategies to protect the interests of their shareholders or members. Such families faced challenges related to the scarcity of working capital and other financial resources, which negatively impacted business expansion and development.

Shahzad and colleagues found that proactive succession planning, formal governance mechanisms, and successor training are critical for achieving smooth leadership transitions in Pakistani family-owned businesses (Shahzad *et al.*, 2024). Companies that implement structured governance and transparent succession processes experience fewer internal conflicts and greater business continuity. However, socio-cultural factors such as seniority-based preferences and gender biases present significant obstacles, often complicating transitions. Regarding limited external collaborations, studies found that as family management increases, family managers might pursue more family-centered strategies due to their mixed gamble, prioritizing family control and influence along with altruistic behavior, such as nepotistic hiring (Block *et al.*, 2023; Maharajh *et al.* 2024), over preferences that could lead to prospective financial gains, such as creating successful, long-term ties with distinct stakeholders.

Family-owned businesses are more than just economic entities; they are living embodiments of family traditions, values, and principles passed down through generations (Weenink, 2024; Pauceanu *et al.*, 2025). These businesses carry a deep sense of history and purpose, with their reputation and identity shaped not only by the products or services they offer, but also by the family behind them. Preserving this legacy is a key aspect of what makes family businesses unique, and ensuring its continuity requires careful, thoughtful succession planning (Weenink, 2024). The global challenges and drivers for growth in family businesses span cross-border business horizons. Globalization has become mainstream phenomenon and it is hard to avoid it as a strategic choice for family-owned businesses looking for growth. However, small and medium-sized family businesses are lacking in formulating globalization strategies (Patel *et al.*, 2012).

Literature indicates that digital technology challenges both family and non-family businesses, which is evident across several dimensions of business activities, notably in strategic options concerning technological innovation (Begnin, 2024). The digital transformation poses more challenges for family-owned businesses. These businesses encounter specific difficulties due to limited financial resources to support the digital transformation and the challenges related to understanding how to utilize technologies to gain a competitive advantage, which are unique issues to address. Given that the competitive landscapes and organizational environments have become increasingly complex, as demonstrated by the growing number of crises over shorter periods, such as geopolitical clashes, pandemics, economic downturns, climate change, and natural disasters, resilience has also garnered increasing interest in management research and related disciplines (Amann & Jaussaud, 2012; Yilmaz *et al.*, 2024).

As family businesses grapple with a problem of short-term focus that creates complex challenges in addition to the adversities they already face, empirical evidence shows that they are often more resilient than non-family businesses (Mahmud *et al.*, 2021). These findings present a scholarly puzzle and suggest there might be an idiosyncratic way in which family businesses develop and enact resilience. Another study discovered that various factors influence reactions to disruptive industry changes in two distinct phases: opportunity recognition and opportunity implementation (de Groote *et al.*, 2020). While some of these influencing factors, such as family influence, may function more effectively or ineffectively for incumbent firms, literature highlights that in firms

with a family disruptor, a family member in a powerful position who drives the adoption of new technology, obstacles can be overcome (König *et al.*, 2013). Firms tend to exhibit more successful strategies when responding to disruptive industry changes.

3. Research design and methodology

3.1 Data

Data was collected using a well-designed questionnaire, which was distributed to the respondents from Malawi with experience of working in family businesses in different countries. Twelve main tensions in the family business tradition vs. modern tendency were considered in this survey, challenge factors were built based on previous studies that worked in this field. *Table 1* lists a summary of the challenges covered by the questionnaire. 106 participants completed the survey. However, respondents with near-zero standard deviations in their responses and the questionnaires that were incomplete or were improperly filled were excluded from the analysis. One question was repeated twice with a gap of other questions and those who answered them differently were also excluded. The final sample comprised 38 participants, whose data were included in the further analysis.

The demographic information of these respondents is shown in *Table 2*. From *Table 2*, one can see that both genders were fairly represented despite the males having a slightly bigger percentage of 55 percent than 45 percent for females. With respect to the ages of the study participants, most of the study participants were of the youthful group, as 70% of the study participants were aged

Table 1. Key challenges to modernization of family businesses

Code	Challenge	Description	Literature
C1	Resistance to change	Failure to adapt to and adjust to changes due to the tension between continuity and the need for change	Miller *et al.* (2008)
C2	Rigid organizational structure	Increase the possibility of conflicts within the business and inefficiency of operations, and slows decision-making process	Zahra and Sharma (2004); Calabrò *et al.* (2017)
C3	Conservative financial practices	Failure to adhere to internationally recognized financial practices in order to protect the interest of shareholders	Chen *et al.* (2008)
C4	Succession issues	Leads to more internal conflicts and puts the business continuity in doubt	Shahzad *et al.* (2024)
C5	Limited external collaborations	Reduction in financial gains due to low market presence or limited partnerships	Gjergji *et al.* (2019)
C6	Focus on legacy preservation-Limits expansion	More interest in living embodiments of family traditions, values and principles passed down through generations	Weenink (2024)
C7	Rapid Technological Advancements	Technological advancements provide competitive advantage but demands investment that is sometimes not available	Begnini *et al.* (2024)
C8	Increased competition and slow adaptation	When competition grows, one needs faster adaptation	Amann and Jaussaud (2011)
C9	Globalization pressure	Inability to see outside silos and make right strategic choices	Patel *et al.* (2015)
C10	Short-term focus	Short-term gains and return on investments are prioritized over long-term sustainability of the business	Mahmud *et al.* (2021)
C11	Disruptive innovation	A need for members to develop strategies to cope with levels of innovation while recognizing opportunities and timely grasp them	de Groote *et al.* (2020)
C12	Data-driven decision-making	New skills are needed to survive in the era of data-driven business management	Chang *et al.* (2022)

Table 2. Demographic characteristics of the study participants

	Description	Frequency	Percentage
Gender	Male	21	55
	Female	17	45
	Total	38	100
Age	18 – 35	27	70
	36 – 45	6	15
	46 – 55	4	12
	56 – 65	1	3
	Total	38	100
Academic qualification	Tertiary qualification	34	90
	Secondary qualification	4	10
	Total	38	100

18 – 35 years. This is followed by those aged 36 – 45 years at 15%, those aged 46 – 55 years at 12%, and finally those aged 56 – 65 years at 3%. The study also found that 60% of the respondents were never married.

The study observed that 90% of the study participants have tertiary qualifications, such as a professional certificate, diploma, or degree. In addition, the remaining 10% have a secondary-level qualification, enhancing their ability to participate in this study duly. Thus, the primary group of respondents was youthful with tertiary qualifications.

3.3 Dynamic grey relational analysis

The Dynamic Grey Relational Analysis (Dynamic GRA, or DGRA) is one of the recent developments in the fields of the Grey System Theory and multiple criteria decision analysis. It is the generalized form of the classical GRA model, which was proposed by Professor Deng Julong in the 1980s. Other variants of the GRA are also available in market such as the ones proposed by Professor Liu Sifeng.

Even though the GRA models have seen a lot of applications in engineering and energy sectors they have rarely been used to study family businesses. Much of the work in this direction has been done by a Polish team. For instance, Więcek-Janka *et al.* (2016a) used Liu's GRA model to study differences in the impact of family aspects on the family businesses in Mexico and Poland. Więcek-Janka *et al.* (2016b) used Liu's GRA model to evaluate the barriers faced by Polish successors in family businesses during the first process of succession. Majchrzak and Więcek-Janka (2019) analysed the relationship between family businesses' communication and their market activities using Deng's GRA model. Więcek-Janka *et al.* (2021) used Liu's GRA model to study the influence of conflicts on family businesses. Majchrzak and Więcek-Janka (2021) studied family business succession process management using Deng's GRA model.

One can see that most of the literature have either used Liu's GRA or Deng's GRA models. Both of these models have their own limitations. For instance, Liu's GRA is not properly normalized and thus its output values never fall under 0.5 (Javed & Liu, 2019) and Deng's GRA has a parameter (Distinguishing Coefficient) whose value should vary between 0 and 1 but scholars have assumed its value to be 0.5 without any logical rationale (Mahmoudi *et al.*, 2020). Therefore, the current study uses the Dynamic GRA model (Javed *et al.*, 2022) as it represents an advanced form of Deng's GRA where the Distinguishing Coefficients are objectively estimated from data. The effectiveness of this model is validated from literature (Ervural, 2023; Darbinian *et al.*, 2023). The key components of the Dynamic GRA model are discussed below.

In the current study, the Grey Relational Grade (GRG) is:

$$\Gamma_{0k} = \sum_{j=1}^{n} \gamma_{0k}(j) \tag{1}$$

where, the Grey Relational Coefficient (GRC) is:

$$\gamma_{0k}(j) = \frac{\Delta_{min} + \xi(j)\Delta_{max}}{|\Delta_{0k}(j)| + \xi(j)\Delta_{max}}, k = 1,2, \ldots . m \quad (2)$$

where,

$$|\Delta_{0k}(j)| = |x_0(j) - x_k(j)| \quad (3)$$

$$\Delta_{min} = min_k min_j |x_0(j) - x_k(j)| \quad (4)$$

$$\Delta_{max} = max_k max_j |x_0(j) - x_k(j)| \quad (5)$$

$$\xi(j) = \{\xi(1), \xi(2), \ldots, \xi(n)\}, \xi(j) \in (0, 1] \quad (6)$$

The method proposed by Javed *et al.* (2022) was used to estimate the values of the Dynamic Distinguishing Coefficients $\xi(j)$. Meanwhile, the Grey Relational Standard Deviation (GRSD) can also be estimated as,

$$\text{GRSD} = \sqrt{\frac{\sum_{j=1}^{n}(\Gamma_{0k} - \gamma_{0k}(j))^2}{n-1}} \quad (7)$$

and, the Rank Product Score (RPS) as,

$$\text{RPS} = Rank(\text{GRG}) \times Rank(\text{GRSD}) \quad (8)$$

For details about the GRSD and the RPS, Javed *et al.* (2022) can be consulted. All calculations were done on Microsoft Excel.

4. Results and discussion

Table 3 below presents the original data, where R represents the respondents and C represents the challenges that affect the modernization of family businesses. *Table 4* presents background calculations of the Dynamic GRA – Delta, Delta Average, Delta Max, and Dynamic Distinguishing Coefficients. To optimize the space, Delta values are reported to zero decimal places, while other values are reported to two decimal places. For clarity, the challenges are labeled C1 to C12: C1 (resistance to change), C2 (rigid organization structure), C3 (conservative financial practices), C4 (succession issues), C5 (legacy preservation), C6 (limited external collaboration), C7 (globalization pressure), C8 (rapid technological advancement), C9 (increased competition), C10 (short term focus), C11 (disruptive innovation), and C12 (data-driven decision making). In contrast, respondents are labeled from the first respondent as R1 to the last respondent as R38.

The grey relational grades, the grey relational standard deviations and the rank product scores are reported in *Table 5*. The grey relational grades-based ranking of the twelve challenging factors (or barriers) is illustrated in *Figure 1*. The results indicate that C9 (increased competition), C1 (resistance to change), C4 (succession issues) is the most significant challenge, followed by C8 (rapid technological advancement, C2 (rigid organization structure), C10 (short-term focus), C6 (limited external collaboration), C3 (conservative financial practices), C7 (globalization pressure), C11 (disruptive innovation), C5 (legacy preservation), and C12 (data-driven decision making). The analysis, done through the Rank Product Scores as shown in *Figure 2*, shows that the first group (C9, C4, C10 and C10) represents the most significant challenges and managing them on priority is of critical importance in order to modernize family businesses.

It can be observed from the results that increased competition, resistance to change, and succession issues are considered to have a high impact as challenges on family businesses regarding the traditional and modern approaches to handling business. These findings imply that with

Table 3. The original data

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*
R1	7	5	5	7	4	7	1	5	7	7	4	2
R2	6	6	6	6	6	6	2	6	6	6	6	6
R3	7	7	7	5	4	6	6	6	7	2	6	6
R4	7	1	5	7	5	6	6	6	7	7	7	7
R5	6	6	6	6	1	5	4	6	4	6	4	6
R6	6	6	4	5	2	4	1	6	6	7	4	5
R7	6	7	4	4	4	5	4	4	5	6	5	4
R8	7	6	5	4	5	6	6	5	7	5	6	4
R9	2	2	2	2	2	2	6	6	6	6	2	6
R10	6	4	2	2	4	2	5	6	4	1	4	5
R11	7	7	4	7	7	7	7	5	7	2	7	5
R12	7	7	7	6	6	5	4	5	6	6	5	5
R13	7	7	6	7	6	7	5	6	7	7	5	6
R14	2	6	2	7	6	6	5	2	4	1	6	6
R15	7	7	4	5	5	7	4	5	5	6	6	6
R16	6	6	6	6	6	4	4	6	7	6	6	7
R17	7	7	7	6	2	6	6	6	6	7	6	4
R18	5	6	7	5	2	5	5	5	5	7	7	7
R19	7	7	7	7	7	2	7	7	7	7	7	2
R20	6	6	6	5	4	6	7	6	7	6	5	5
R21	4	6	6	7	6	6	7	7	6	7	4	1
R22	6	6	6	7	5	5	6	5	5	1	4	2
R23	7	7	5	7	7	6	6	7	5	6	5	6
R24	2	2	5	6	6	1	6	6	6	6	6	2
R25	5	4	6	7	6	6	6	5	7	5	6	5
R26	7	6	7	7	6	6	5	7	7	5	7	1
R27	6	4	4	5	5	6	6	5	5	4	4	6
R28	6	6	5	6	6	6	7	7	7	6	5	5
R29	4	4	6	7	5	7	7	7	4	6	2	2
R30	4	5	6	6	6	5	5	7	7	4	6	6
R31	4	5	6	6	6	5	6	5	4	4	5	5
R32	6	4	4	1	1	4	1	1	1	4	4	1
R33	6	6	1	6	5	6	1	6	6	6	5	6
R34	6	1	5	7	5	5	5	5	4	4	1	2
R35	4	5	6	6	6	6	2	7	6	5	5	2
R36	6	5	6	7	5	5	6	6	5	4	6	7
R37	6	6	6	6	6	6	4	5	2	2	5	5
R38	6	5	6	1	2	6	6	6	7	7	4	6

modernity, family businesses find it more challenging to compete with multinational corporations that have larger resources, scalability, and technological abilities. Now, they must adapt to new strategies and forms of technology while improving efficiency and not abandoning their traditional values. For resistance to change, there is generally a contradiction between the previous generations, who want things to remain the same, and younger generations, who tend to favour

Table 4. Delta, delta average, delta max, and dynamic distinguishing coefficients

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	$\Delta_{avg}\ (j)$	$\psi(j)$	$\xi(j)$
R1	0	2	2	0	3	0	6	2	0	0	3	5	1.91	0.32	0.44
R2	1	1	1	1	1	1	5	1	1	1	1	1	1.33	0.22	0.31
R3	0	0	0	2	3	1	1	1	0	5	1	1	1.27	0.21	0.29
R4	0	6	2	0	2	1	1	1	0	0	0	0	1.08	0.18	0.25
R5	1	1	1	1	6	2	3	1	3	1	3	1	2.00	0.33	0.46
R6	1	1	3	2	5	3	6	1	1	0	3	2	2.33	0.39	0.54
R7	1	0	3	3	3	2	3	3	2	1	2	3	2.17	0.36	0.50
R8	0	1	2	3	2	1	1	2	0	2	1	3	1.50	0.25	0.35
R9	5	5	5	5	5	5	1	1	1	1	5	1	3.33	0.56	0.77
R10	1	3	5	5	3	5	2	1	3	6	3	2	3.25	0.54	0.75
R11	0	0	3	0	0	0	0	2	0	5	0	2	1.00	0.17	0.23
R12	0	0	0	1	1	2	3	2	1	1	2	2	1.25	0.21	0.29
R13	0	0	1	0	1	0	2	1	0	0	2	1	0.67	0.11	0.15
R14	5	1	5	0	1	1	2	5	3	6	1	1	2.55	0.42	0.59
R15	0	0	3	2	2	0	3	2	2	1	1	1	1.42	0.24	0.33
R16	1	1	1	1	1	3	3	1	0	1	1	0	1.17	0.19	0.27
R17	0	0	0	1	5	1	1	1	1	0	1	3	1.17	0.19	0.27
R18	2	1	0	2	5	2	2	2	2	0	0	0	1.50	0.25	0.35
R19	0	0	0	0	0	5	0	0	0	0	0	5	0.83	0.14	0.19
R20	1	1	1	2	3	1	0	1	0	1	2	2	1.25	0.21	0.29
R21	3	1	1	0	1	1	0	0	1	0	3	6	1.42	0.24	0.33
R22	1	1	1	0	2	2	1	2	2	6	3	5	2.17	0.36	0.50
R23	0	0	2	0	0	1	1	0	2	1	2	1	0.83	0.14	0.19
R24	5	5	2	1	1	6	1	1	1	1	1	5	2.50	0.42	0.58
R25	2	3	1	0	1	1	1	2	0	2	1	2	1.33	0.22	0.31
R26	0	1	0	0	1	1	2	0	0	2	0	6	1.08	0.18	0.25
R27	1	3	3	2	2	1	1	2	2	3	3	1	2.00	0.33	0.46
R28	1	1	2	1	1	1	0	0	0	1	2	2	1.00	0.17	0.23
R29	3	3	1	0	2	0	0	0	3	1	5	5	1.92	0.32	0.44
R30	3	2	1	1	1	2	2	0	0	3	1	1	1.42	0.24	0.33
R31	3	2	1	1	1	2	1	2	3	3	2	2	1.92	0.32	0.44
R32	1	3	3	6	6	3	6	6	6	3	3	6	4.33	0.72	1.00
R33	1	1	6	1	2	1	6	1	1	1	2	1	2.00	0.33	0.46
R34	1	6	2	0	2	2	2	2	3	3	6	5	2.83	0.47	0.65
R35	3	2	1	1	1	1	5	0	1	2	2	5	2.00	0.33	0.46
R36	1	2	1	0	2	2	1	1	2	3	1	0	1.33	0.22	0.31
R37	1	1	1	1	1	1	3	2	5	5	2	2	2.08	0.35	0.48
R38	1	2	1	6	5	1	1	1	0	0	3	1	1.83	0.31	0.42

innovation. However, this reaction can restrict growth, miss opportunities, or make it difficult to adopt new technologies or business strategies that lessen the organization's competitiveness in the market. For succession issues, leadership handovers become complicated when successors are selected purely on familial connections rather than through professional expertise. A more complex

Table 5. The grey relational evaluation of challenges to modernization of family businesses

	GRG	Rank (GRG)	GRSD	Rank (GRSD)	RPS
C1	0.738	2	0.218	6	12
C2	0.683	5	0.214	7	35
C3	0.639	8	0.201	8	64
C4	0.737	3	0.226	2	6
C5	0.581	11	0.184	12	132
C6	0.639	7	0.185	11	77
C7	0.612	9	0.225	4	36
C8	0.687	4	0.193	9	36
C9	0.738	1	0.225	3	3
C10	0.652	6	0.241	1	6
C11	0.608	10	0.191	10	100
C12	0.566	12	0.220	5	60

Figure 1. Grey Relational Grades and their ranks

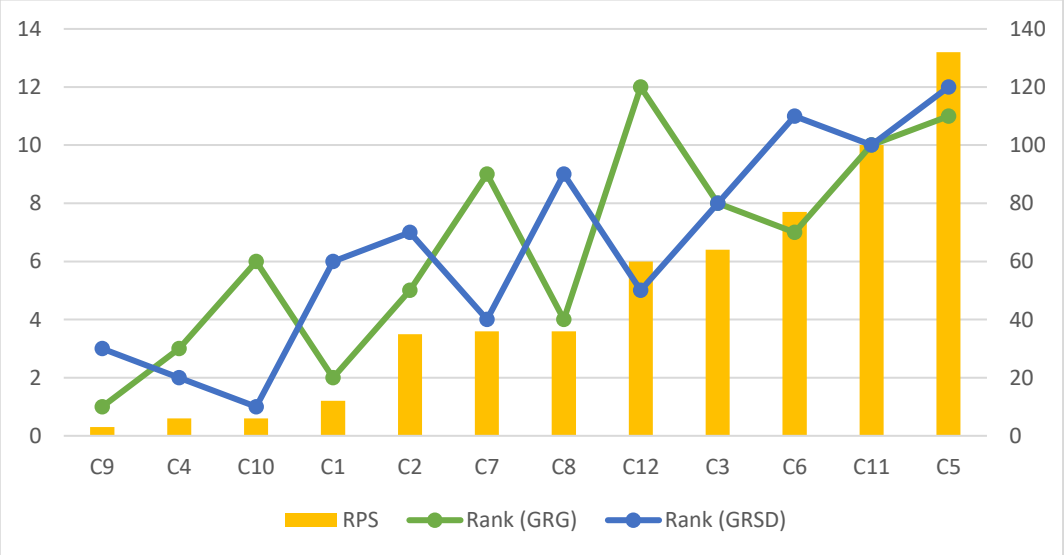

Figure 2. Rank Product Scores and the two ranks

picture of internal conflicts versus preparation and the calls for globalization versus the calls for traditional management practices.

Even though other factors are relatively low, it is observed that their impact is also high due to high GRG values. For instance, artificial intelligence and digitization also pose a challenge for Family Businesses that do not have the financial resources and/or the in-house expertise to deploy new technology. It makes it even more difficult when they are very conservative and reluctant to hire other specialists, which might have resulted in high values of automation. The study has also noted that most family businesses use centralized decision-making, which stifles innovation and adaptability. A demarcation creates a communication gap that frustrates younger members who want a more collegial approach, while elders oppose initiatives that would undercut traditional hierarchies. Such might have influenced the restrictive organizational structure and had an impact on the challenges of traditional to modernity.

Furthermore, family businesses are obsessed with short-term profits, which undermines family businesses' ability to grow investments and where they could create and research revolutionary products for the vast global market. It is a mentality that is going to make it difficult for them to compete with long-term future-oriented organizations. For limited collaboration with outsiders, A family business tends to want to do everything in house and not bring in much from the outside world. That sort of feeling of independence can cut them off from exposure to new ideas, new technologies, and the markets that they need to be competitive in a rapidly changing business environment.

On conservative financial practices, most family businesses focus on profits, not on reinvestment, in ledgers, and not on what the market will bear, with little or no interest in new technology. This cautious stance might ensure near-term stability, but it hampers long-run growth and international competitiveness. Due to the pressure of globalization, family businesses face the challenges of globalization, where individual values may clash with global competitive conditions. While being deeply rooted in local culture, local business, and relationships, they first must step up to modern-day practices like digitization, operational efficiencies, and international marketing in the context of multinationals. Innovative can also influence family business performance where contemporary practices might require the balancing act of balancing family traditions with evolving market needs. Younger members might push for technological innovation, while older ones lament that change will dilute the company's decades-old identity.

Data driven decision making is the practice of relying on data and analytics to make business decisions rather than relying on traditional methods or gut feelings. While family-oriented businesses may rely more on personal experience and tradition, adding data is an objective way to approach things. This may be a tough shift for organizations with a strong personal-judgment tradition, as this change may seem to undervalue experience. However, with thoughtful implementation, data driven decisions can allow family businesses to stay competitive, discover new opportunities, and streamline workflow, all while preserving the core principles that got them where they are. The real challenge is to strike the right balance between data that informs, but does not replace, the gut feeling and intuition that have made the business successful to date.

5. Conclusion and recommendations

This study has evaluated the challenges faced by family businesses in modernizing and achieving long-term sustainability. By applying the Dynamic Grey Relational Analysis, the study evaluated key factors that influence this modernization and provided strategic recommendations for family businesses to integrate traditional and modern elements effectively, as follows:

Family businesses are frequently firmly rooted in tradition and may resist changing their product offerings and business methods. Businesses need to know how not to forget who they are and where they come from while fostering a culture of change. Providing change at a pace, introducing small projects, piloting, and then building helps to find the resistance gap while keeping the business in touch with its core vision. Due to the nature of technological advancements, which call for investment, family businesses having traditional financial practices may find it challenging. The

methods to keep pace with are aggressive in deciding on the used technologies that help in boosting profit and try to achieve the goals of the organization. Technology that enhances operations rather than replaces them can allow family businesses to remain modernized without replacing the values upon which they were built.

Centralized decision-making slows responsiveness. Fostering younger generations and using flexible structures will allow agility, which will ensure guidance while also allowing needed experience from that experienced leadership. Family firms are facing new competitions from non-family businesses run by professionals. Market research, digital, and strategic partnerships can bring adaptability but should not lose sight of traditional skills. Traditional financial prudence is somewhat of a constraint. These modern financing options, alongside conservative management styles, allow many companies to function sustainably.

When expanding internationally, there are challenges related to regulations and the market. The most successful companies establish global networks and strategic partnerships or joint ventures to scale quickly and add value to their offerings while preserving their unique identity. Tensions between generations can arise over leadership transitions. Implementing organized succession plans and leadership development supports effective intergenerational transitions alongside incorporating contemporary business modalities. Prioritizing short-term profits over long-term strategy. A data driven approach can help to plan strategies, the benefits of which can accumulate over time.

A siloed working approach can slow down innovation and limit potential in the marketplace. Innovative practices and expansion opportunities arise through collaboration with external industry networks and partnerships. Identifying trends ahead of time and integrating innovations that align with family values can convert disruption into opportunity. Focusing too much on legacy restricts business expansion. Branding inclusion of family heritage alongside modernizing exploration of new markets allows businesses to evolve while not losing their identity. The demand for data-driven decision-making poses a challenge for family businesses that are not familiar with terabytes of big data and modern analytics. This indicates that family businesses need to prepare their leaders to use data effectively through investment in training and skills. Today, modern data collection and analytical tools allow them to make better decisions while ensuring that the business evolves with the changes in its environment, yet it holds on to family traditions.

From this study, we have learned that modernization comes with its own challenges, like resistance to change and many more; however, overcoming these challenges can lead to the promising growth of family-owned businesses.

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