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A Comparative Performance Assessment of Wealth Management Banks Using Multicriteria Analysis

Shuh Liang[1]

Abstract

This paper assesses a performance evaluation framework for wealth management (WM) banks. We propose a method that combines the analytic hierarchy process (AHP) with the assurance region (AR) model of data envelopment analysis (DEA) to enable a consensus decision. We also present several strategies for using this methodology, such as Delphi procedures. The analysis results indicate that evaluators (evaluation members) responsible for recommending the business performance of WM banks in Taiwan employ the AHP and DEA methods. In this study, we summarize the evaluation analysis process followed by the evaluators, emphasizing the methodological aspects.

JEL classification numbers: C81, G21
Keywords: Wealth management (WM) banks, group decision making, data envelopment analysis (DEA), analytic hierarchy process (AHP), assurance region (AR) model

1 Introduction

This paper examines a performance evaluation framework for wealth management (WM) banks in Taiwan. The Taiwanese banking sector comprises four categories, that is, consumer banking, corporate banking, wealth management, and financial markets. The slow growth of both consumer and corporate financing in Taiwan has prompted numerous top financial holding companies to focus on wealth management. Wealth management differs significantly from consumer or corporate financing because it profits from investments in stocks, mutual funds, and trust or insurance firms. Several years ago, wealth management operations enabled a number of top banks to survive the turmoil of credit-card debt with minimal damage. Numerous banks aggressively promoted wealth

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[1]Department of International Business, Soochow University, No. 56, Kueiyang Street, Section 1, Taipei, Taiwan, e-mail: sliang@scu.edu.tw.

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management business to earn risk-free and non-interest income. Banks have implemented management practices and improved organization to increase their competitiveness in wealth management services. In such an intensive environment, developing an effective method for evaluating the performance of wealth management banking has become a priority.

"Wealth management" was originally a term similar to that of "financial planning" in the broker dealership, banking, and insurance industries in the United States during the 1990s. Following the repeal of the Glass–Steagall Act in 1999, financial holding companies can provide all services from the same offices. Moehlman (2004) defines wealth management as "comprehensive, coordinated processes" that manage the personal financial affairs of high net-worth, affluent individuals and families. Wealth management business involves the entire spectrum of personal financial issues and activities, including portfolio management and rebalancing, investment management and strategies, risk management, trust and estate planning, income tax planning and consulting, retirement planning, funding, and administration. Important products may include stocks, equity-linked investments, structured savings and investments, foreign exchange, mutual funds, trusts, property investments, and insurance coverages. With the goal of sustaining and expanding long-term wealth, wealth management is most beneficial and effective for clients who have already accumulated a significant amount of wealth.

Target clients for wealth management are affluent retail banking customers. Numerous banks define these target clients by a minimum net worth or asset base that makes them attractive consumers for retail banks. The banks establish wealth management units and services to retain or attract these clients, who typically provide greater profit than other retail banking customers do. Wealth managers include independent advisers, large corporate entities, and other extensions of retail banking that focus on high net-worth customers. They usually have a steadily growing base of assets under management, and can afford to provide clients with the same services across a broad range of wealth segments.

This paper proposes a model to evaluate the business performance of wealth management banks. The business performance of wealth management banks is based on perspectives that balance and link the financial and non-financial, tangible and intangible, and internal and external factors. This study uses five perspectives to construct the performance measurement system, namely, the customer perspective, financial perspective, risk perspective, organization perspective, and learning perspective. Thus, the proposed model provides an integrated method for evaluating multicriteria decision making within wealth management banks.

The evaluators determined that the performance evaluation framework for wealth management must be rational, open to the public, and easy to understand. To meet these requirements, we propose a consensus decision-making method that combines the analytic hierarchy process (AHP) with the assurance region (AR) model of data envelopment analysis (DEA). However, this hybrid AHP/DEA method is limited by requiring both AHP and AR to be effective. Literature contains a number of previous attempts to merge AHP and DEA. For example, Shang and Sueyoshi (1995) used the subjective AHP results in DEA to select a flexible manufacturing system. Yoshiharu and Kaoru (2003) developed an integrated DEA and AHP model for relocating the Diet and other Japanese government organizations outside Tokyo. Furthermore, the methodology proposed by this study also integrates AHP/DEA; it involves a combined data envelopment and hierarchy analysis, which appears suitable for candidate-wealth management bank selection problems.

2 Literature Review

Paradi and Schaffnit (2004) applied DEA to evaluate the performance of commercial branches of a large Canadian bank. Lo and Lu (2008) applied DEA to evaluate the performance of financial holding companies (FHCs) in Taiwan. Kao and Liu (2009) applied stochastic DEA to evaluate the efficiency of commercial banks in Taiwan. Yang et al. (2010) applied a hybrid minimax reference point-data envelopment analysis (HMRP-DEA) approach to incorporate the value judgements of both branch managers and head office directors. In addition, they used the model to search for the most preferred solution (MPS) along the efficient frontier for each bank branch. Searcy (2004) used AHP to align a balanced scorecard with a firm's strategic approach. Wu et al. (2009) used the expert group decision technique to select the most effective bancassurance alliance strategy. Wu et al. (2010) employed the balanced scorecard and Delphi method to build a model to evaluate the business performance of wealth management banks in the U.S. and Taiwan.

Recently, the efficiency of various wealth management banks has received considerable attention; however, available studies have not provided a satisfactory solution to the problem of inadequate decision-making units (DMU), and *a priori* specification of input and output weights of the evaluation performance. We used DEA and AR models to investigate the technical efficiency and pure technical efficiency of the major wealth management banks in Taiwan. The DEA technique is valuable for measuring a wealth management bank's efficiency because its calculations are non-parametric, allows more than one output, and does not require an explicit *a priori* determination of the relationships between outputs and inputs, which is required for conventional estimations of efficiency using production functions. The AR approach overcomes the issues caused by the free running of input and output weights in basic DEA models.

Numerous researchers highlight the relationship between DEA and multiple Criteria decision analysis (MCDA): "Similar to numerous methods of multiple criteria analysis, DEA assigns weights to criteria" (Belton and Vickers, 1993; see also Belton, 1992; Cook et al., 1990, 1992; Stewart, 1996). Ranking is extremely common in MCDA literature, especially when a discrete list of elements or alternatives with a single criterion or multiple criteria exists to evaluate and compare or select. Various approaches for completely ranking elements are suggested in literature, ranging from the utility theory approach (Keeney and Raiffa, 1976; Keeney, 1982; Sinuany-Stern and Mehrez, 1987) to AHP.

AHP, a multicriteria decision-making approach introduced by Saaty (1980), is a subjective method for analyzing qualitative criteria to determine the decision criteria's weight of importance, and the relative performance of the alternatives on each individual decision criterion. Using their subjective judgment, the evaluators estimate weights for each criterion. AHP is useful for quantifying these subjective (or qualitative) judgments. Yang et al. (2000) used AHP to evaluate multiple-objective layout design alternatives generated from Muther's systematic layout planning (SLP) procedure. AHP provides objective weights against a set of qualitative layout evaluation criteria, but is not efficient for evaluating numerous alternatives, or for selecting performance frontiers.

Further insight into DEA can be obtained from the weights that are used. DEA assumes equally proportional improvements for all inputs or all outputs. However, this assumption is invalid if a preference structure regarding input or output improvements is present when evaluating inefficient DMUs. The unrestricted weight means some of the inputs or outputs may be assigned a weight of zero, especially if the DMU is performing poorly in a particular dimension. This assumption is untrue for this study, where all the variables contribute to the overall efficiency. To address this issue in the integrated model, AHP was employed to restrict the weights using the management input, ensuring that the weights assigned were more realistic. However, the results show that, when used alone, the AHP method involves only intuitive decision making. Because of the possibility of human bias, the validity and stability of the AHP result can be questioned. Thus, we considered a decision-weight framework that integrates objective and subjective information to compensate for each weakness caused by the methods. In the integrated method, AHP was used to prioritize and derive weights for the predefined criteria. The derived weights were then used to establish the constraints of the DEA model. The combined model enables a thorough decision-making process. Subjective approaches used in AHP determine weights that reflect subjective judgment, and objective approaches used in DEA determine weights using mathematical models. Combining these two methods eliminates most of the flaws associated with each method, thereby yielding a more accurate and justifiable result. Charnes et al. (1979) also indicated that the weights in a traditional DEA model may require improvements to increase efficiency. Other researchers have proposed CCR (Charnes, Cooper, and Rhodes)/AR and BCC/AR to improve the DEA model (Cooper et al., 2000; Dyson and Thanassoulis, 1988).

3 Strategic Use of the Methodology

The Taiwan Finance Council created a group of five of its members to select the methodology for evaluating the five wealth management banks. The group, aptly named the "evaluators," comprised five experts in bank decision making, economics and law, financial analysis, business management issues, and assessment. One of the evaluators' objectives was to survey and propose potential methods for reaching a consensus among the Council members. As previously explained, we propose a consensus-reaching method that combines AHP and the AR model of DEA. Similar to other typical banking and financial problems, multiple criteria, both quantitative and qualitative, exist for comparing candidate-wealth management banks. The five criteria for the candidate-wealth management bank evaluation are: (C1) customer perspective, (C2) financial perspective, (C3) risk perspective, (C4) organization perspective, and (C5) learning perspective.
The five important dimensions/criteria of this model are discussed below.

(C1). Customer perspective. Wealth management business requires long-term cultivation, and customer satisfaction is crucial for success. Implementing client management, managing customer relationships by customer segments, integrating customer needs, and providing professional and specialized sales services is required to increasing dealings with customers. The banks operate by completely understanding their clients and their needs, providing clients with professional planning for asset allocation according to their financial status and risk tolerance, conducting sophisticated client-group segmentation to provide custom services, and safeguarding their clients' entrusted assets. Additionally, banks use customer-data analysis skills to provide promptly the products and services

required by customers, and to improve customer satisfaction.

(C2). Financial perspective. Measures of financial performance indicate whether a company's strategy, implementation, and execution contribute to bottom-line improvement. Financial objectives typically relate to measures of profitability, including operating income, return on equity, cash flows, and economic value added. For example, banks may enhance the business share of newly developed products, popularize systematic investment plans, establish long-term steady income resources, and use the VISA Debit preferential program to stimulate card spending and consumption by clients, thus enhancing their fee income. Regarding the returns of wealth-managed clients, banks introduce pluralized new products and businesses based on the concept of sustainable management and the objective of all-round wealth management to ensure steady returns to investors in both bullish and bearish markets.

(C3). Risk perspective. Since the global financial crisis, customer regard for brands has increased because of greater systematic risk awareness. A balanced emphasis on loan risk management and profit making in the banking industry has lead to more virtuous competition. The wealth management units typically establish an appropriate and extensive sales and investment risk management system, and provide comprehensive investment risk monitoring management. Specifically, numerous banks may launch and implement a product evaluation system to enable comprehensive monitoring of products risks, sales risks, and customers risks.

(C4). Organization perspective. The organization perspective includes numerous business processes that have the greatest impact on wealth management business. We discuss a number of common factors as follows. A financial holding company may integrate resources from all departments to obtain synergy and maximize the efficiency of cross-selling. This is achieved by developing an integrated product platform, offering banking clients diversified wealth management products, and satisfying the wealth-planning requirements of different customer groups. Regarding physical channels, the bank expands the branch service platform, increases the frequency of customer contact, steadily develops new high-asset customers through cooperation marketing, and simplifies trading procedures to enhance trading convenience. Moreover, banks actively develop integrated electronic trading platforms, and provide customers with one-stop shopping for e-financial services. In summary, banks intensify product and channel services to expand their wealth management business, and to establish a solid brand image for wealth management.

(C5). Learning perspective. The learning perspective refers to an organization's future requirements for growth. The performance of wealth management units is evaluated not only using short-term financial returns, but also according to the education and training investments that improve the abilities of wealth managers, systems, and organizational processes. Banks consider the following possible disciplines: wealth managers' professional knowledge, wealth managers' complaint systems, and the policies for reward and punishment. In Taiwan, the demand for financial talent is growing overseas, which will lead to a talent drain at domestic banks. Therefore, management should increase their efforts to retain talent by strengthen the scale of wealth management teams, enhancing employees' expertise, and providing clients with professional planning for asset allocation.

Using the proposed five criteria for candidate-wealth management bank evaluation, the evaluators individually rated each wealth management bank by assigning each a cardinal number score. The higher the score, the better the evaluation is. The result was a score matrix comprising five columns (candidate-wealth management banks) and five rows (criteria).

The second problem was how to synthesize the five evaluations to reach a consensus. Several possible methods exist for reaching such a consensus. In this study, we use a methodology suitable for candidate-wealth management banks that combines DEA (Cooper et al., 1999) and AHP (Saaty, 1980). As shown below, DEA is used to evaluate the "positives" and "negatives" of the candidate wealth management banks. Considering all these factors, a reasonable conclusion was required for the group decision-making process.

Several practical issues are associated with using the proposed methods for candidate-wealth management bank selection. These issues include a multistage procedure for applying an AHP-like method to analyze the weights each evaluator allocated to the criteria, and employs the strength and weakness scores using the DEA method to characterize the candidate WM banks. These issues are addressed below.

3.1 Multistage Use of an AHP-like Method

When applying AHP, the number of paired comparisons grows in correlation with the alternatives. Some evaluators may regard this number to be excessive or unnecessary because it is typically their first experience with AHP. To reduce this stress, this study employs a multistage process.

During the first stage, the evaluators assigned their weights to criteria using either AHP or their subjective judgment. When using AHP, incomplete paired comparisons were allowed. Thus, the evaluators could skip the comparison if they had little or no confidence in comparing the criteria. At the end of the first stage, five sets of weights on five criteria were obtained. During the second stage, the distribution of weighted scores was shown to the evaluators. Each evaluator thus knew their position in the distribution, and had the opportunity to alter their decisions, which is a form of Delphi. This process was continued until this study obtained convergence.

This study then considers the sensitivity analysis required to generate a final decision. First, we analyze the sensitivities of selected criteria scores. Some criteria scores, for example, the ease of transferring to other forms of local transportation, have a degree of uncertainty despite the evaluators' rating. Thus, the sensitivity of these scores should be examined, and the robustness of any solutions verified. Second, the sensitivity of the criteria weights should be analyzed. The assurance region model used to evaluate the efficiency measures is sensitive to the values of the lower and upper bounds, L_{ij} and U_{ij}, which restrict the ratio of weights u_i and u_j as follows: $L_{ij} \leq u_i/u_j \leq U_{ij}$. These values are derived from the minimum and maximum ratios estimated by the five evaluators. If an evaluator's estimate of the ratio differs substantially from that of the others, yielding "too small an L_{ij}" or "too large a U_{ij}," we may neglect such extreme lower or upper bounds to reduce the interval that the ratio can accept. This rule is similar to that used for scoring a gymnast in the Olympic Games to avoid a "home-town decision."

Moreover, we also attempted to define "tightening the lower/upper bounds" in this study. The WM bank-selection problem comprises five targets (candidate-wealth management banks), five outputs, and five criteria. We assume that the number of inputs is one. These numbers suggest that we lack the degrees of freedom for discriminating efficiency among the five candidate-wealth management banks. A rule of thumb demands

$$n \geq \max \{m \times s, 3(m + s)\}$$

where n = number of targets, m = number of inputs, and s = number of outputs (see p. 252 of Cooper et al., 1999). Straightforward application of this formula reveals a severe disadvantage regarding discrimination. Thompson et al. (1986) introduced an AR model to obtain sharper discrimination in the wealth management bank-selection process for the Super Collider project. Although the assurance region constraints narrow the established production possibility and strengthen the discriminatory power of this problem, cases with no significant differences in efficiency may remain. For such cases, we are required to tighten the upper and lower bounds of the assurance region.

Finally, the performance evaluation of wealth management banks in Taiwan must be based on the evaluators' rational, open to the public, and provide easy to understand decisions. To meet these requirements, we propose a consensus-reaching method that combines AHP and the AR model of DEA.

3.2 Data Envelopment Analysis

DEA is a method for estimating the efficiency of units, typically called DMUs, when identifying absolute measures of efficiency is difficult (Charnes et al., 1978). A typical application may compare various distribution centers of a wholesale network, where the mixture of products distributed by the DMUs varies widely. Scenarios of only one input and two heterogeneous outputs clearly demonstrate this method. By calculating the output of each input unit, we can plot the outputs for each DMU on a two-dimensional graph. The envelope enclosing the data points represents an output akin to the optimum output mix, which is determined using the most efficient DMUs in the system.

Literature of DEA includes examples of benchmarking in healthcare (hospitals and doctors), education (schools and universities), banks, manufacturing, management evaluation, fast food restaurants, and retail stores. This method is employed to manage systems with multiple inputs and outputs, which are extremely difficult to visualize. The primary advantage of DEA is that, by comparing each unit to all similar units, the requirements of unifying inputs and outputs to a single scale, and weighting the relative importance of inputs and outputs, is avoided.

Ganley and Cubbin (1992) developed common weights for all units through maximizing their sum of efficiency ratios. Sinuany-Stern et al. (1994) used linear discriminant analysis to rank units based on their pregiven DEA dichotomous classification. Friedman and Sinuany-Stern (1997) used canonical correlation analysis (CCA/DEA) to rank the units completely based on common weights. Sinuany-Stern and Friedman (1998a, 1998b) proposed the discriminant analysis of ratios (DR/DEA) as an alternative to traditional linear discriminant analysis. Oral et al. (1991) used a cross-efficiency matrix to select R&D projects. Sinuany-Stern and Friedman (1998a, 1998b) used a cross-efficiency matrix to rank units.

Each method has limitations (Friedman and Sinuany-Stern, 1998); some are based on subjective data and others are limited to a portion of the units. Nevertheless, none provides an appropriate model for ranking units completely in a DEA context. This study also attempts to rank scale units completely in a DEA context, using a more popular MCDM method, AHP (Saaty, 1980). To rank the units, AHP provides pairwise comparisons between criteria and between units, which are assessed subjectively by the decision maker. The eigenvector of the maximal eigenvalue of each pairwise comparison matrix is used for ranking. Based on the hierarchy structure we describe, the experts judged the hierarchy elements on a pairwise basis regarding their parent element. Because the model comprises more than one level, hierarchical composition was used to weight the eigenvectors based on the criteria weights. The sum was obtained from all the weighted eigenvector entries corresponding to those in the lower level, and upward, resulting in a global priority vector for the lowest level of the hierarchy. Essentially, the global priorities are the result of distributing the weights of the hierarchy from one level to the level immediately below.

DEA is a nonparametric approach that does not require assumptions regarding the production function form. In the simplest case, when a unit has a single input (X) and output (Y), efficiency is defined as the output-to-input ratio: Y/X. DEA usually manages a unit k with multiple inputs (X_{ik} where $i = 1,...,m$) and outputs (Y_{rk}, where $r = 1,...,s$), which can be incorporated into an efficiency measure: the weighted sum of the outputs divided by the weighted sum of the inputs $h_k = \sum u_r Y_{rk} / \sum v_i X_{ik}$. This definition requires a set of factor weights u_r and v_i.

4 Empirical Study of Wealth Management Banks

In this section, the proposed method is employed to select the candidate-wealth management bank. The candidate-wealth management banks, criteria, and evaluators are detailed below.

4.1 Description of Candidate-Wealth Management Banks

The five wealth management banks are described briefly as follows. Bank 1 (B1), Bank 2 (B2), and Bank 3 (B3) are top financial holding companies in Taiwan, and have a common background worthy of note. First, they were founded by a number of noted entrepreneurs, and then expanded through a series of merges and acquisitions with other local banks and credit cooperatives during the 2000s. Second, they opened branches in major cities throughout Taiwan, and have been actively establishing overseas units according to the financial internationalization trend. Each bank has more than 100 domestic and overseas branches, demonstrating the extensiveness of their service network. Third, the banks’ wealth management operation includes appropriate financial planning, investment portfolio management, asset allocation recommendations, and a broad range of financial products, such as local and foreign currency deposits, derivatives, insurances, and loans.

Individually, the major wealth management target market for Bank 1 is Taipei. This is natural because most of this merged bank’s branches are located in the Taipei metropolitan area. Bank 1 currently operates a wealth management service center at its headquarters in Taipei, and plans to establish three to five additional centers in branches around the city. The bank plans to boost its wealth management work force by 30 % to 40 %, and to train 20 to 30 staff to provide special services to VIP clients with assets over NT$30 million each.

Bank 2 entered the wealth management business in 2002. Bank 2 has been recognized for its accomplishments in Taiwan's wealth management market regarding the number of wealth management customers, and the abundance and sales of its financial products. Following considerable effort, Bank 2 was rewarded a 45 % growth in its wealth management profit in 2006. Since December 2010, Bank 2 has had the largest market share of VIP customers with a ratio of 18 %, making it number one in the market. Northern Taiwan is the target wealth management market for Bank 2.

Bank 3 claims more than 10 wealth management bases, the largest number of any Taiwanese financial institution. The bank's vice president has reported that all of the bank's branches in Taiwan are capable of handling wealth management. The bank expects its wealth management business to continue expanding, and to produce a 25 % increase in profit.

State banks are also enjoying booming wealth management business. Formerly government-owned, Bank 4 (B4) established wealth management units for high-assets customers in 2010. They aim to achieve a 40 % growth in wealth management income. An official of Bank 4 noted that with the recovery of investment confidence among local people, the bank expects to earn NT$2 to 2.5 billion in wealth management income annually. Bank 4's interest-variable pension insurance policy is its most popular product to date.

Bank 5 (B5) is a commercial bank established in 1992. In 2007, the bank successfully terminated a capital injection by a consortium led by a private equity fund, and recruited a new management team to transform it into a customer-oriented financial services provider. The bank has provided each of its customers with financial and wealth management services. To maintain its competitive advantage, in addition to providing customers with a broad range of wealth-related activities and funding channels, the bank continues to enhance its risk management system, simplify its operating procedures, and renew its organizational structure. Currently, the Bank has more than 50 operating units across Taiwan.

4.2 Criteria for Evaluating Candidate-Wealth Management Banks

For simplicity, this study refers to the five candidate-wealth management banks as B1, B2, B3, B4, and B5, and the five proposed criteria, C1, C2, C3, C4, and C5, selected for comparison. Each candidate-wealth management bank is evaluated using five criteria, and the scores, in cardinal numbers, are shown in Table 1. In this evaluation, the highest mark for each criterion is 10, and the lowest is 0. Let us denote the matrix in Table 1 as $B = B_{ij}$, where i (= 1,2,3,4,5) is the index for criteria, and j (= 1,…,5) for candidate-management banks. The scores shown in Table 1 are averages, and obtained from the evaluators. This study recruited the evaluators from appropriate fields.

Table 1: Scores (B_{ij}) of WM banks

	WM bank				
Criterion	B1	B2	B3	B4	B5
C1	6	8	8	5	5
C2	7	8	6	7	4
C3	9	8	6	4	3
C4	8	9	5	6	4
C5	7	9	8	4	5
Sum	37	42	33	26	21

4.3 Evaluating the Importance of the Criteria

The evaluators estimate weights for each criterion using their own subjective judgments. Saaty's AHP (Saaty, 1980; Golden et al., 1989; Tone, 1989) is valuable for quantifying these subjective (or qualitative) judgments.

The estimated weights of the five evaluators for each criterion are shown in Table 2. For example, Evaluator 1 assigned the weights of 5, 1, 2, 4, and 3, respectively, to the five criteria. The sum of the weights was 15 (= 5+1+2+4+3) for each evaluator. The matrix in Table 2 is denoted by (W_{ki}), where k is the index for the evaluator and i for the criterion. However, with each evaluator providing different weights for each criterion, a consensus must be reached. One possibility is to average the weights provided by the evaluators (Table 2). Applying this average weight to the score matrix $B = (B_{ij})$ in a comparison of the five candidate-wealth management banks indicates that B2 (126) and B1 (107.2) are the leading candidates (Table 3).

Table 2: Criteria weights (W_{ki}) of the five evaluators

	Criteria				
	C1	C2	C3	C4	C5
Evaluator 1	5	1	2	4	3
Evaluator 2	4	3	2	5	1
Evaluator 3	5	2	1	3	4
Evaluator 4	4	5	1	2	3
Evaluator 5	5	3	2	4	1
Average	4.6	2.8	1.6	3.6	2.4

Table 3: WM bank scores obtained from averaging the weights

WM bank	B1	B2	B3	B4	B5
Score	107.2	126	100.4	80.2	65.4

However, using the average suggests that only one "virtual" evaluator was representative of all the evaluators' judgments. Thus, the evaluators' varying opinions are not considered. With the degree of scatter (Table 2), an average of the weights must be used cautiously from a consensus perspective.

This study assumes that the weights, u_i (Eq. 1), which denote a non-negative weight set, can vary between wealth management banks according to the principles chosen for characterizing the wealth management banks. Both represent the same meanings of the weighting scales. However, the W_{ki} obtained from the evaluators is the index of each of the evaluators. Furthermore, using the average suggests that only one "virtual" evaluator was representative of all the evaluators' judgments. Another method for considering the above approach is to assume that the weights are common to all wealth management banks. We may refer to this as a "fixed-weight" approach, which contrasts to the "variable-weight" structure. Each evaluator was allocated 15 evaluation points to be divided and assigned to the five criteria according to their judgment (Table 2). This study observed that, on average, criterion C4 (the organizational issues for developing each wealth management bank) and criterion C5 (the learning perspective) received high scores. However, u_i was used to maximize θ_{j0} under the same weights when evaluating all other wealth management banks, and the objective wealth management bank was compared to these. This principle agrees with the DEA method.

4.4 Uses of Variable Weights

This study proposes a linear programming (LP) method that integrates the DEA variable-weight concept with AHP to generate the most favorable weights for criteria, or alternatives based on a matrix of pairwise comparisons. Variable weights indicate that the preference structures were derived from different decision makers, which enables the interpersonal comparison of utilities as follows.

In contrast to MCDA models, which typically rank elements using multiple criteria (inputs and outputs), and provide common weights, DEA does not employ common weights. In DEA, the weights vary among the units; this variability is the essence of DEA. The weight variability is the advantage of DEA, because DEA is directed to frontiers rather than central tendencies. Instead of attempting to fit a regression plane through the center of the data, DEA floats a piecewise linear surface, the efficient frontier, to rest above the observations. In other words, DEA selects the set of weights that provide the highest possible efficiency score for each evaluated unit (Sinuany-Stern et al., 2000). This study assumes that the weights can vary between wealth management banks according to the principle chosen for characterizing wealth management banks.

To evaluate the positives of wealth management banks j_0, the weights (u_i) in Eq. 1 were selected to enable maximization under the same weights conditions. These are used to evaluate all other wealth management banks, which are compared to the objective wealth management bank. This principle agrees with the DEA method (Charnes et al., 1978; Cooper et al., 1999). The preceding statements also explain how AHP is incorporated into the DEA/AR model.

A recent paper by Wang et al. (2007) proposed an LP method for generating the most favorable weights (LP-GFW) from pairwise comparison matrices. The method incorporates the variable weight concept of DEA into the AHP priority scheme to determine the most favorable weights for the underlying criteria, and alternatives based on a crisp pairwise comparison matrix. The LP-GFW method differs from the LP-based approach presented by Chandran et al. (2005). The LP-GFW method uses variable weights for each criterion or alternative, and is comprised of n LP models. Whereas the LP-based approach uses fixed weights, and is comprised of a two-stage-goal programming model.

With the score matrix $B = (B_{ij})$, we evaluate the total score of wealth management bank $j = j_0$ using a weighted sum of B_{ij0} as

$$\theta_{j_0} = \sum_i u_i B_{ij_0} \tag{1}$$

with a non-negative weight set (u_i). Two extreme cases were examined, and are presented in Sections 4.4.1 and 4.4.2.

4.4.1 Evaluating the "positives" of each WM bank

To evaluate the positives of wealth management banks j_0, the weights (u_i) in Eq. 1 were selected to maximize θ_{j_0} under the same weight conditions when evaluating other wealth management banks, which are then compared to the objective wealth management bank. This principle can be formulated as follows:

$$Max \quad \theta_{j_0} = \sum_i u_i B_{ij_0}, \tag{2}$$

subject to

$$\sum_i u_i B_{ij_0} \le 1 \quad (\forall j), \tag{3}$$

$$u_i \ge 0 \ (\forall j). \tag{4}$$

Here, DEA is directed towards “effectiveness” rather than “efficiency” because is not related to resource utilization, as required when evaluating efficiency. Achieving the already stated (or prescribed) goals is the aim. The goals, initially stated broadly, are made sufficiently precise with accompanying evaluation criteria to enable (a) the proposed actions to be evaluated more accurately, and (b), once the proposals are implemented, any accomplishments (or lack thereof) to be subsequently identified and evaluated (see Cooper et al., 1999, p. 66, for an additional discussion).

Furthermore, the weights provided to each criterion should reflect the preferences of all evaluators. This can be represented using a version of the AR model. For every pair of criteria i_1, i_2, the ratio u_{i1}/u_{i2} must be bound by L_{i1i2} and U_{i1i2} as

$$L_{i1i2} \le u_{i1}/u_{i2} \le U_{i1i2} \tag{5}$$

where the bounds are calculated using the evaluator's weights (W_{ki}) as

$$L_{i_1i_2} = \min_k \frac{W_{ki_1}}{W_{ki_2}}, \quad U_{i_1i_2} = \max_k \frac{W_{ki_1}}{W_{ki_2}}. \tag{6}$$

Thus, Eq. 2 is maximized according to the constraints expressed by Eqs. 3 to 5. Therefore, the most preferable weight set is assigned to the target wealth management bank in acceptable ranges to ensure the “positives” of the wealth management bank are evaluated. However, the same weight is used to evaluate other wealth management banks, which are then compared with the target wealth management bank. If the optimal objective value θ^*_{j0} satisfies $\theta^*_{j0} = 1$, then the wealth management bank j_0 can be considered the best. However, if $\theta^*_{j0} < 1$, the WM bank is inferior to the others in some (or all) criteria.

The empirical process proposed by this study is detailed below. From Table 2, we obtain the lower/upper bounds of ratios for every pair of criteria shown in Table 4. These bounds were used as the assurance region constraints to solve the variable weight problem. The resulting optimal scores, rankings, and weights for all wealth management banks are shown in Table 5. For example, the score for wealth management bank B1 is 0.8730, and it is ranked second. However, B1’s weights (u^*_1 = 0.0317; u^*_2 = 0.0238; u^*_3 = 0.0159; u^*_4 = 0.0397; u^*_5 = 0.0079) are optimal under the constraints shown in Table 4.

Table 4: Upper and lower bounds of ratios

Ratio	Lower bound	Upper bound
u_1/u_2	0.80	5.00
u_1/u_3	2.00	5.00
u_1/u_4	0.80	2.00
u_1/u_5	1.25	5.00
u_2/u_3	0.50	5.00
u_2/u_4	0.25	2.50
u_2/u_5	0.33	3.00
u_3/u_4	0.33	0.50
u_3/u_5	0.25	2.00
u_4/u_5	0.67	5.00

Table 5: Optimal "positives" scores and weights

	Score	*Rank*	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5
WM bank	θ^*		u^*_1	u^*_2	u^*_3	u^*_4	u^*_5
B1	0.8730	*2*	0.0317	0.0238	0.0159	0.0397	0.0079
B2	1.0000	*1*	0.0542	0.0108	0.0108	0.0328	0.0108
B3	0.8403	*3*	0.0439	0.0108	0.0088	0.0219	0.0328
B4	0.6873	*4*	0.0354	0.0442	0.0089	0.0177	0.0147
B5	0.5405	*5*	0.0439	0.0108	0.0088	0.0219	0.0328

Note: $u^*_1/u^*_2 = 1.3333$, $u^*_1/u^*_3 = 2.0000$, $u^*_1/u^*_4 = 0.7998$, $u^*_1/u^*_5 = 3.9997$, $u^*_2/u^*_3 = 1.5000$, $u^*_2/u^*_4 = 0.6000$, $u^*_2/u^*_5 = 2.9998$, $u^*_3/u^*_4 = 0.3999$, $u^*_3/u^*_5 = 1.9888$, $u^*_4/u^*_5 = 4.9997$.

In the following paragraph, we verify that the optimal weights of all the wealth management banks shown in Table 5 also satisfied these weight constraints.

Wealth management Bank 1 could not attain a score of 1, even when assigned the best allowable weights. As can be verified, the weights provided a score of 1 to B2, which is considered a reference to B1, and is on the efficient frontier of the problem. Table 5 shows that the wealth management Bank 2 was the best performer. The scores in Table 5 reveal the relative distances of the efficient frontier. The lower the score, the weaker the "positives" of the wealth management bank are. Thus, the wealth management banks can be ranked as shown in Table 5.

4.4.2 Evaluating the "negatives" of each WM bank

In the preceding evaluations, each wealth management bank was compared with the best performer, B2. We refer to this evaluation scheme as "positives," because the candidate is observed from a positive perspective. For the opposite side, the candidate wealth management banks are evaluated from a negative perspective. For this purpose, the weights used are the "worst," namely, the objective function in Eq. 2 is minimized. Thus, this principle can be formulated as follows:

$$Min \quad \theta_{j_0} = \sum_i u_i B_{ij_0}, \tag{7}$$

subject to

$$\sum_i u_i B_{ij} \geq 1 \quad (\forall j), \tag{8}$$

$$L_{i_1 i_2} \leq u_{i_1} / u_{i_2} \leq U_{i_1 i_2} \quad (\forall (i_1, i_2)), \tag{9}$$

$$u_i \geq 0 \ (\forall j). \tag{10}$$

By dint of the reversed inequality in Eq. 8, the optimal θ_{j0} satisfies $\theta^*_{j0} \geq 1$. If $\theta^*_{j0} = 1$, then the wealth management bank is in the worst-performing group; otherwise, if $\theta_{j0} > 1$, the bank ranks higher than the worst-performing group. Each wealth management bank is compared to these worst performers, and gauged using its efficiency "negatives" as the ratio of distance from the "worst" frontiers in the same manner as ordinary DEA. Yamada et al. (1994) named this worst side approach "inverted DEA."

To enable straightforward comparisons of the "negative" and "positive" case scores, θ^*_{j0} was inverted as

$$\tau^*_{j_0} = 1/\theta^*_{j_0} \tag{11}$$

and called the "negative" score. Table 6 shows the negative scores thus obtained, and the optimal weights under the assurance region constraints.

Thus, we can determine that WM Bank 2 has the highest score for "positives" (Table 5); however, it also received the lowest score for "negatives" (Table 6), which means it is the highest ranked among the five WM banks. WM Bank 1 had similar positive and negative features. Consequently, the first three WM banks, B2 (positive = 1; negative = 0.5405), B1 (positive = 0.8730; negative = 0.6570), and B3 (positive = 0.8403; negative = 0.6669) are excellent for both "positives" and "negatives" (Fig. 1). However, the other WM banks lag behind WM Banks B2, B1, and B3 significantly. The results obtained using the DEA model show that the overall performance of each representative WM bank was influenced primarily by the specific factors considered in this study.

Table 6: Optimal "negatives" scores and weights

	Score	*Rank*	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5
WM bank	τ^*		u^*_1	u^*_2	u^*_3	u^*_4	u^*_5
B1	0.6570	*4*	0.0812	0.0200	0.0162	0.0406	0.0606
B2	0.5405	*5*	0.0812	0.0200	0.0162	0.0406	0.0606
B3	0.6669	*3*	0.0728	0.0227	0.0300	0.0910	0.0182
B4	0.9117	*2*	0.0812	0.0200	0.0162	0.0406	0.0606
B5	1.0000	*1*	0.0674	0.0843	0.0169	0.0337	0.0281

4.5 Decision Analysis using the AR Model

Next, the author uses the AR model of DEA to evaluate the candidate-wealth management banks. First, the lower (L_{ij}) and upper (U_{ij}) bounds were estimated on the ratio of criteria i and j in (Eq. 1) by

$$L_{ij} = \min_{k=1,\ldots,5} \frac{W_{ki}}{W_{kj}}, \quad U_{ij} = \max_{k=1,\ldots,5} \frac{W_{ki}}{W_{kj}}. \tag{12}$$

These bounds were used for the AR model.
Using both the traditional weighting method and the AR/DEA method, each wealth management bank was evaluated numerically regarding the chosen criteria set. These evaluations may be conducted objectively (quantitatively) or subjectively (using expert knowledge). Second, each evaluator used their own judgment regarding the relative importance of the criteria. Thus, either AHP or direct subjective judgments may be used. When these conditions were satisfied, we used the proposed methods to rank the candidate-wealth management banks to reach a consensus among the evaluators. Results obtained using the AR model have several merits for both the candidates and the evaluators. For candidate-wealth management banks, the results are acceptable because the most preferable weights for the wealth management bank were assigned within the evaluators' allowable bounds. The optimal weights vary between wealth management banks to ensure the best set of weights is assigned to each bank. Similarly, the relative weaknesses of each wealth management bank can also be evaluated. These two measures are then used to characterize the candidate-wealth management banks. Each evaluator can be assured their judgments regarding the criteria are considered and that the ratios of every pair of weights are within the allowable range. Despite the exclusion of several evaluators' ratios for discrimination purposes, this approach is more reasonable and acceptable compared to using the average weights of all evaluators, especially when a relatively high degree of scatter must be considered.

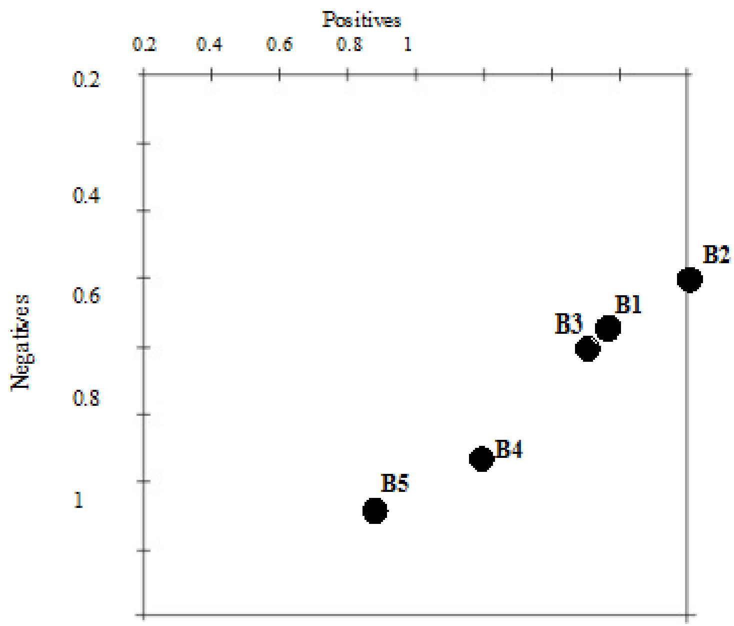

Figure 1: Positives and negatives of the five WM banks

5 Conclusion

This paper presented a method-oriented study of the selection process for evaluating the performance of wealth management banks. We believe that the proposed method can be used to conduct the evaluation, which is critical to the project. Finally, bank wealth managers and other decision makers in the financial sectors can employ this model to evaluate the business performance of wealth management banks.

The key characteristics of the proposed method are as follows. Each wealth management bank is numerically evaluated using the chosen criteria set. These evaluations can be conducted objectively (quantitatively) or subjectively (using expert knowledge), and each evaluator can provide their judgments regarding the relative importance of the criteria using AHP or direct subjective judgments.

A wide array of methods and approaches for making decisions regarding uncertainty, optimization, and interactions between human and biophysical domains have been developed (Hill et al., 2005). However, implementation of these methods within practical frameworks for making decisions, and in forms accessible to the lay policy analyst or regional planner, have been frustrating deficient. Because the AHP/MCDA approach has numerous advantages, including simplicity and flexibility, it is highly successful (Ramanathan, 2001). However, MCDA can be greatly improved with a suite of different methods and approaches that enable the user to explicitly propagate uncertainty, and to apply various fuzzy and probabilistic approaches.

Numerous problems contain uncertain data because of imprecision, ongoing variation, an inability to foresee future events, or a combination of these factors. Several approaches have been developed to manage this uncertainty in distinct contexts. Kouvelis and Yu (1997) represented this uncertainty using scenarios, each of which was a specification of data. Their justification for these measures was that under uncertainty, considering all possible consequences, including the worst, is necessary because we do not know which scenario may one day become a reality. Wang and Elhag (2006) also stated that the normalization of interval and fuzzy weights is frequently necessary in MCDA under uncertainty, and especially in AHP with interval or fuzzy judgments. Therefore, corrective methods, such as normalization and scenarios, may be an appropriate future research direction.

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