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Multidimensional Efficiency in Banking Sustainability

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Abstract

Moving towards sustainability has become challenge for banks. Sustainable bank is responsible for the environment and society while only financial risks are evaluated. There is insufficient evidence for sustainability and efficiency. Admitting being sustainable for the environment and society while making performance, banks need to manage resources efficiency that will contribute to sustainable development. This study shows that improving multidimensional efficiency is a basic challenge for managing sustainability in banks. This implies that the resource optimization is a key factor to improving performance in the banking system. However, banks must also measure their progress from a sustainable performance including social and environmental resources in addition to the purely economic factors. This analysis aims to approach banking efficiency in an innovative way. It is about integrating the economic, social and environmental dimensions in the measurement of efficiency. More precisely, this study involves the concepts of socio / eco-efficiency in banks. Applying this approach allowed us to assess a bank's contribution to sustainability. We developed a framework through the Data Envelopment Analysis (DEA) for the 27 largest banks in the world for a period from 2007 to 2022. The results revealed that banking sustainability depends on multidimensional efficiency that includes economic, environmental, and social dimensions.

Keywords: Sustainability, Eco-efficiency, Socio-efficiency, DEA.

1. Introduction

The concept of sustainable banking has further evolved to promote respectful practices in the banking sector. In this context, banks are going beyond traditional financial banks by adopting more and more sustainable practices, while integrating environmental, social and governance criteria into their main strategy. Sustainable banking has become a fundamental aspect in effective management of sustainability. Thus, the aspiration to economic growth, the assurance of a better quality of life and the promotion of a healthy environment must be inextricably linked. Indeed, the importance of sustainability for society is to ensure the current and future management of resources. Therefore, the issue of rational and efficient management of any resources is also included in the theme of sustainable bank. In addition, any bank sustainability initiative should be associated with a specific sustainability indicator, namely sustainable performance. However, sustainable performance is multifunctional, covering a wide range of topics, namely costs and resources consumption. In this context, the multidimensional efficiency analysis can provide insight into the bank performance. The new literature considers that banks have great potential to improve their internal environmental and social efficiency. In addition, efficiency aims to reduce all forms of waste and ensure an expected level of satisfaction. At the same time, efficiency is an economic measure of the effectiveness of production, which is related to the size of the resource's consumption. The most important aim of efficiency is to achieve maximum utility which resources are the main factors of production: labor, capital, and natural resources. In general, the definitions of efficiency include several elements namely economic benefits and reduction of adverse impact on the environment and on society. In each of these aspects, there are additional elements namely performance and costs, which are related to the concept of sustainability. In this regard, it is advisable to refer to the theory of sustainable development, which concerns intergenerational equity. The sustainable performance involves the efficient use of the resources necessary to meet the needs of present and future generations, while minimizing negative effects on the natural environment and on society.

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Indeed, banks have recognized that environmental and social factors increasingly affecting their own performance. In addition, the new literature of sustainability considers banks have great potential to improve their internal environmental and social performance.

Traditionally, bank efficiency has been measured from a general economic perspective, but for the purposes of this analysis, more social, environmental and sustainable aspects have been taken into account. Here it is important to note that performance is a function of both efficiency and effectiveness. Effectiveness associated to «doing things" and efficiency related to "doing the right things" (Drucker, 1977). In sum, efficiency and effectiveness are two mutually exclusive components and are a measure of overall performance. However, the efficiency of banks is a major problem that has still not been resolved, at least from the social and environmental perspective. In addition, a measure of sustainable performance must include benefits, present and future costs, and must consider any damage to natural and social environments that could potentially hamper future well-being. Therefore, the measurement of socio/eco-efficiency becomes a crucial element of a sustainable bank. Indeed, one way to assess the contributions of banks to sustainability is to subtract the costs from the profits created by a bank, considering internal and external costs. Our approach is based on the contributions to be reported in this line.
In this study, we discuss previous theories, which stipulate that sustainability must be achieved by integrating economic, social, and environmental efficiency gains.
We also examine the concept of Socio / Eco-efficiency cited by WBCSD[3] in 1992. The term Eco-efficiency or Ecological efficiency is often used to represent the correlation between the economic value and the environmental damage of a system. Socio-efficiency refers to the notion of social efficiency, which describes the link between a company's added value and its social impact. Based on this idea, an analysis of the socio / eco-efficiency aspects at the micro banking level not only contributes to performance but also to sustainable development in general.

The article is organized as follows. Section 2 describes the multidimensional efficiency of banks. Section 3 dedicated to the data methodological framework. In section 4 we present the empirical investigation as well as the results, and section 5 provides the conclusion.

2. Towards the multidimensional efficiency of banks

The efficient use of resources is a key objective of every banker. Recently, several studies revolved around the extension of the notion of efficiency. The way companies embrace changing attitudes towards environmental and social issues. Nowadays, a new sense of sustainable business is emerging that emphasis link between three criteria, namely efficiency, eco-efficiency, socio-efficiency. At this point, the bank's new sustainability models require additional theoretical development, which can be best achieved from an empirical study. The intention is to test efficiency by taking the sustainability of the bank beyond economic analysis towards an integrated approach that links social and environmental cases of efficiency.
Indeed, the improvement of Socio / Eco-efficiency is a basic challenge for the management of the sustainability of banks. Eco-efficiency and socio-efficiency increase positive ecological and social performance in relation to the creation of economic value (Schaltegger and al., 2002, Dyllick and Hockerts, 2002). It must be recognized that Socio-Eco-efficiency leads to relative ecological and social improvements, which can be offset by economic growth. Therefore, according to this concept, efficiency contributes to economic sustainability, but not necessarily also to ecological and social sustainability. Although, in order to ensure a basic corporate sustainability of companies the impacts on the environment and society must be taken into account (Dyllick and Hockerts, 2002). In fact, over the past decade, Eco-efficiency approaches have clearly been the focus of attention (Schmidheiny, 1992). The idea is simple, produce more but with less negative environmental and social impact. Contrary to this, the development of similar approaches to socio-economic efficiency has been neglected so far.

The optimal allocation of resources to maximize the desired performance is a central question of companies (Koopmans, 1951). In the banking sector the input and output parameters are often limited to financial variables, such as capital, deposits and short-term financing are transferred mainly in credit. However, this definition only considers the financial capital of banks. However, the banks do not only use financial capital to create value, but also environmental and social resources. However, sustainable management supposes a global approach to track waste and improve performance in three dimensions (environmental, social and economic).

The definition of socio / eco-efficiency in the context of technical assessment is complex, as ecological, economic, environmental, and social parameters must be considered and their attributes selected. Therefore, no common denominator for socio / eco-efficiency exists, and only relative comparisons can lead to value judgments. In

[3] WBCSD: World Business Council for Sustainable Development.

addition, WBSC recommended taking material consumption, energy consumption, water consumption, and greenhouse gas emissions as well the total waste, as applicable general indicators. In other publications, water consumption has been considered as one of the input indicators to assess eco-efficiency (Zhang and al., 2008). Energy consumption has been chosen as one of the input indicators to measure eco-efficiency (Yin and al., 2014). However, the social efficiency of banks is a major problem that has still not been resolved. At least, the social efficiency perspective is a gap in the bank efficiency literature; our approach is based on carryover contributions in this row. Over the past decade, this social vision has focused on specific types of financial institutions, such as microfinance institutions (Goiria and al., 2017). This is because their social purpose is inherent and aims to reduce poverty. Indeed, the notion of socio-efficiency is a compromise between the creation of social value for communities and the resources used for its activities (Chang, 2000). The societal impact is made up of indicators such as the number of jobs and the number of industrial accidents that have occurred during production. For the social criteria, it has been defined in particular: industrial accidents, training, wages, research and development expenses. In 2009, the methodology was extended to other economic parameters, such as taxes and subsidies (Minto, 2016). However, the work was one of the most important inputs and that it was considered as the social indicator to measure socio-efficiency (Mahlberg and Sahoo, 2011).

3. Methodology

3.1. DEA model

In our present study, we use the Data Envelopment Analysis to evaluate the economic, social and environmental efficiency of certain banks. The DEA is a non-parametric method that allows the conversion of inputs into outputs. DEA is indicated in the literature as the appropriate measure to assess the socio / eco-efficiency of companies (Waddock and Graves, 1997). This method has been used, for example, as a tool for measuring the social efficiency of Italian banks Piatti and Cincinelli (2015).
Currently, under the name of DEA, a group of many sophisticated models evaluating the efficiency of various objects. In our research, the efficiency measurement model is based on the study of Banker and al., (1984). According to the DEA method, it is possible to calculate efficiency in two ways: the output orientation (maximization of the output variables) or the input orientation (minimization of the input variables). We generalized the DEA models and found that most of them used an input-oriented model (Camanho and Dyson (2008), Linand al., (2009), Paradi and al., (2010)). So, we apply the DEA Oriented Inputs method.
The DEA approach is used to empirically determine the relative efficiency of entities, called decision-making units (DMUs), which are mutually comparable: they consume the same inputs, and they create the same outputs. In basic DEA models, DMUs are generally classified as efficient and inefficient. Thus, inefficient, and most efficient entities can be easily classified according to their efficiency scales.

We assume that there is a DMU. In the present study, the DMUs represent the banks. Each DMU_j (j = 1; 2; …. ; n) uses an input vector, x_j (= x_{1j}; x_{2j};…; x_{mj}) to produce an output vector, y_j (= y_{1j}; y_{2j};… .; y_{sj}). The efficiency of DMU, among others, can be measured using the following DEA model:

$$\begin{cases} \text{Min } \theta_{j0} \quad \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_{j0}\, x_{ij0}, \ i = 1, 2, \ldots, m \\ \text{Under constraint} \quad \sum_{k=1}^{k} \lambda_k y_{rj} \geq y_{rj0}, \ r = 1, 2, .., s \qquad (1) \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \geq 0, \ j = 1, \ldots, J \end{cases}$$

The variables describing the banks examined are divided into inputs and outputs. Such a division is necessary to assess the efficiency scales of banks by using DEA models. When the optimal value to model (1) equals one, we conclude that a specific DMU evaluated as a best practice of others DMU. Model (1) assumes that the best practice frontier has constant returns to scale. In other words, a best practice DMU is both technically efficient and economical. If economical scale is allowed in the best DMUs, we can assume variable returns to scale (VRS) and incorporate as $\sum_{j=1}^{n} \lambda_j = 1$ into the model (1). However, in several studies, the DEA method is applied with the variable return to scale assumption because the constant return to scale (CRS) assumption is appropriate when the organization is in optimal size. Which is rarely the case, given imperfect competition does not allow organizations to operate at their optimal size.

When DEA is used to measure the efficiency of banks for a set of DMUs, the linear programming algorithm calculates the return of each DMU from the same inputs and outputs to find the maximum ratio between the weighted sum of the output and the weighted sum of the input.
The most efficient DMU should be used as a reference to other DMUs, ensuring that best practice DMUs are located on the efficient frontier line. This means that the units with the best practices are relatively efficient and can achieve the efficiency scale equal to 100%.

3.2.The specification of the input and output variables

The selection of inputs and outputs is important in the DEA method. When selecting inputs and outputs, Humphrey. (1985) made a useful distinction between the production approach and the intermediation approach for banks. In the production approach, banks produce loans and deposits using capital, labor, and materials. However, in the intermediation method, banks transform funds and deposits into loans and other assets (Assaf and al., (2013). The intermediation approach may be preferable for valuing entire financial institutions because it includes interest expense, which typically accounts for more than half of the total costs. In this study, we consider the main function of banks as intermediation and therefore we use the intermediation approach (Srairi (2010). The inputs and outputs of the study are selected as follows (Table 1): deposits, tangible fixed assets, and wages. In addition, we have set up donations and the number of employees to assess socio-efficiency. In eco-efficiency, we introduce the consumption of electricity, water consumption and total paper consumption. Porrit (2001) pointed out that the indicators of environmental pressure (impact) are relatively simple, such as the control of inputs (energy resources and water). In addition, a study by Zhoua and al., (2018), showed how the DEA can be used to construct composite sustainability indicators. The authors claim that sustainability indicators can be categorized as economic, environmental / ecological, and social. They then discuss various existing sustainability indicators.

Table 1: Input and output variables used in the DEA analysis.

Variables	Description	Source
Input		
• economic		
Deposits	Total customer deposits in thousand dollars	Bankscope
Tangible fixed assets	Asset expressed in thousand dollars	Bankscope
• Social		
Wages	Expressed in thousand dollars	RA[4]
Number of employees	Expressed in number	RA
Donation	Expressed in thousand dollars	RRSE
• environmental		
Electricity consumption	Expressed in KWH	RRSE
Water consumption	Expressed in M3	RRSE
Total paper consumption	Expressed in tonnes	RRSE
Output		RRSE
Credits	Total customer loans in thousand dollars	Bankscope
Investments	Expressed in thousand dollars	Bankscope

3.3.The data

Our sample includes 27 largest banks in the world covering Chinese, American, European and Canadian banks for the period 2007 to 2022. Data are obtained from the database BankScope data, annual reports, CSR reports, financial and extra-financial information disclosed published on the respective websites. The Table 2 illustrates

[4] RA: Annual report, RRSE: CSR report.

the structure of the sample. The Table 3 retraces the general descriptive statistics of DEA data. This table thus provides the mean and standard deviation of the inputs and outputs used in the DEA.

Table 2: sample structure

Region	Country	World ranking
ICBC	China	1
China Construction Bank	China	2
JP Morgan Chase & Co	US	3
Bank of China	China	4
Agricultural Bank of China	China	5
Bank of America	US	6
Citigroup	US	7
Wells Fargo & Co	US	8
HSBC Holdings	UK	9
Credit Agricole	France	10
BNP Paribas	France	11
Groupe BPCE	France	12
Bank of Communications	China	13
Goldman Sachs	US	14
Barclays	France	15
Royal Bank of Scotland	France	16
Deutsche Bank	Germany	17
Lloyds Banking Group	UK	18
Societe Generale	France	19
Credit Suisse Group	Switzerland	20
UniCredit	Italy	21
ING	Netherlands	22
UBS	Switzerland	23
Royal Bank of Canada	Canada	24
Rabobank Group	Netherlands	25
scotiabank	Canada	26
nordea bank	Sweden	27
Total number of banks in the sample		27

Variable	Obs	Mean	Std. Dev.	Min	Max
Deposit	297	955767359.975	533 618 334.671	1,760,627,000	2971363204.884
Tangible asset	297	30450 106.190	105587992.326	1,619,311,000	651 147,000,000
Number of employees	297	165.2091	118.5309	29,248	503,082
Wages	297	13189.610	8481.471	861,160	63700
Donations	293	2198.363	2593,595	203.32	32661
Electricity consumption	297	43937457.081	155094067.955	9791.997	887,000,000,000
Water consumption	296	2952.658	3149.045	217,597	14912.820
Paper consumption	297	20.14003	23.42861	1.087653	148.9040

Credits	297	633 547 434.315	331107953.464	46669182	1837079429.489
Investments	297	773250 180.098	455099 705.456	50807171	2449260253.000

Table 3: Descriptive statistics of DEA data

4. Results

4.1. The basics of DEA analysis

Before starting any summary of the results, it is important to introduce the Returns to Scale (RTS) assessment. Banks may exhibit constant returns to scale (CRS) or variable returns to scale (VRS) or decreasing returns to scale (DRS). To verify the type of scale a bank has, it is necessary to break down the overall technical scale. Using the DEA analysis, this study aims to measure the level of technical, purely technical, and scale efficiencies gains. In the case of the bank, technical efficiency allows it to exploit the minimum resources to obtain the maximum output. The pure technical efficiency reflects the managerial performance in organizing inputs into production process in terms of size and quality. The DEA method then makes it possible to measure the level of overall technical efficiency. More precisely, the DEA approach allows decomposing the overall technical efficiency derived from the assumptions of constant returns to scale (CRS) into two components: pure technical efficiency (ETP) (also called VRS efficiency) efficiency scale (EECH) (see thus Scale). In addition, the first measures the proportional reduction in the use of inputs if they are not wasted. The second measures the proportional reduction in costs if the bank operates at constant returns to scale. We obtain the formula for calculating the overall technical efficiency:

$$ETG = ETP * EECH$$

We measured the overall technical efficiency scales by following the decomposition. The measurement of these funds provides the ability to choose the optimal size of the resource, or in other words to choose the scale of production that meets the expected level of production. Noting that, the inappropriate size of a bank (too big or too small) can sometimes be a cause of technical inefficiency. This is also known as scale inefficiency which takes two forms: decreasing returns to scale and increasing returns to scale. The decreasing returns to scale imply that the bank is too large to take full advantage of scale and has a supra-optimal size of scale. In contrast, a bank with increasing returns to scale is too small for its scale of operations and, therefore, operates at a sub-optimal scale. A bank has an efficient scale if it operates at a constant rate of returns to scale.

Since our goal in this study is to measure efficiency in several different dimensions and then combine them, we can use the linear programming problem (1) to obtain efficiency in linked with sustainability. Our suggested method improved the standard DEA analysis by categorizing the inputs across economic, environmental, and social indicators. The results produced by the DEA method have been compared in the following sections. Thus, the results of the efficiency scales estimated according to the DEA method respectively under the assumption of CRS and VRS. The efficiency of the scales is obtained by calculating the average scale of each bank.

4.2. Results of Economic efficiency analysis

The economic efficiency scales obtained with using inputs such as deposits, tangible fixed assets, and outputs such as loans and investments. The results are presented in Table 4.

First, economic efficiency combined both profit and cost-efficiency, such a bank investigate less expensive technical combination between input and output. These reflect the bank's ability to face the constraints of competition in the market.

According to the table 4, the results show that on average the efficiency scale of the ING group bank is higher than the other banks in the order 98%. Then comes, Deutsche Bank, Lloyds Banking Group, Rabobank Group and then Citigroup, Credit Agricole then Bank of Communications, which are respectively in the order of 97%, 96%, 95%, 94%, 93.1%, 91.5%, these banks are already classified as economically efficient. On the other hand, the ICBC bank represents on average the lowest scale of order 68%. The latter must find the most effective means that reduces unnecessary loss of financial resources to increase its performance. The remaining banks have an average efficiency between 70% and 80% such as China Construction Bank, Nordea bank, and Credit Suisse Group. It seems then that most of the banks obtained almost high scales, which testifies to their capacity to master the technical aspects of their production and manage to offer the maximum of service with the minimum of resources. In this context, to understand sustainable performance, it has become imperative to highlight the efficient management of the resources available to banks.

The decomposition of the overall technical efficiency scale indicates that it derives in a non-equivalent way from technical efficiency and pure efficiency. Under the assumption of constant return to scale, some banks produced 100% of the quantity of outputs that they could have produced from their resources such as the ING group, Royal Bank of Scotland. These banks have an optimal management of their resources, and this is accompanied by a reduction in costs. On the other hand, other banks such as for example Agricultural Bank of China, ICBC have more advantage if they increase the size of their production scale since they represent averages of low efficiency scales which are respectively of order 53% and 46%. The banks which represent scales below 50% must follow the strategies of the banks which represent the best practice of efficiency. In addition, some banks manage to choose the least expensive and more profitable combination of inputs, such as the case of UniCredit, Barclays, etc. their efficiency scale varies between 70% and 88%.
Based on the year 2007 economic data established, the 27 banks were efficient, but could not achieve the maximum efficiency scale, and the efficiency scale was 70%. The average efficiency for the year 2008 was 78.5%. According to the technical efficiency scales, 7 banks were fully efficient, such as Goldman Sachs which was also identified as sustainable, in exchange for 5 inefficient banks such as for example Agricultural Bank of China Bank of China. According to the results of the year 2012, the number of efficient banks was 15, the average efficiency of this period being 92.4%.
Finally, the DEA model is used to assess the efficiency of sustainable banks. The economically efficient sustainable banks for the period 2006 to 2022 are: JP Morgan Chase & Co, Citigroup, Credit Agricole, Lloyds Banking Group, Societe Generale, UniCredit, ING group, Royal Bank of Canada, Rabobank Group. And the lowest scales of all periods were for Chinese banks. The efficiency scales of sustainable banks have the most productive scale size, as these banks have an efficiency scale of 1 in terms of technical efficiency, pure technical efficiency scales.

Table 4: Average economic efficiency per bank

Bank	CRS_ET	VRS_TE	SCALE
ICBC	0.536847	0.841732	0.688966
China Construction Bank	0.655734	0.816141	0.823212
JP Morgan Chase & Co	0.566641	0.581574	0.975991
Bank of China	0.467447	0.616967	0.742929
Agricultural Bank of China	0.467024	0.577322	0.834191
Bank of America	0.698527	0.852643	0.820984
Citigroup	0.708729	0.748587	0.949313
Wells Fargo & Co	0.801071	0.913118	0.882276
HSBC Holdings	0.834404	0.977827	0.853832
Credit Agricole	0.899777	0.967101	0.931140
BNP Paribas	0.697076	0.808522	0.877053
Groupe BPCE	0.549780	0.735748	0.778946
Bank of Communications	0.915612	1.000000	0.915612
Goldman Sachs	0.691462	0.798128	0.869297
Barclays	0.767496	0.889985	0.871580
Royal Bank of Scotland	1.000000	1.000000	1.000000
Deutsche Bank	0.903788	0.925137	0.974193
Lloyds Banking Group	0.810204	0.841520	0.961819
Societe Generale	0.633611	0.672096	0.926366
Credit Suisse Group	0.590213	0.758691	0.777744
UniCredit	0.805842	0.832981	0.961149
ING	0.973894	0.987868	0.985938
UBS	0.696809	0.783536	0.888791

Royal Bank of Canada	0.920118	0.990778	0.928783
Rabobank Group	0.854203	0.889927	0.950445
Scotiabank	0.864922	1.000000	0.864922
Nordea bank	0.680247	0.805657	0.765673

4.3.Results of the social efficiency analysis

Social efficiency scales are obtained using inputs such as salaries, number of employees and donations and outputs such as loans and investments. The results are given in table 5.
Following the table; on average ICBC, China Construction Bank, JP Morgan Chase & Co, Agricultural Bank of China, Citigroup, HSBC Holdings, Credit Agricole, Groupe BPCE, Bank of Communications, Barclays, Royal Bank of Scotland, Deutsche Bank Lloyds Banking Group, Societe Generale, Credit Suisse Group, UniCredit, ING, UBS, nordea bank achieved high socio-efficiency scales for all the years analyzed. Other banks are particularly efficient on the social level. They operate at constant return to scale; examples include Scotia bank, Wells Fargo & Co and Royal Bank of Canada. Thus, they visually showed ways of social efficiency for sustainability. These banks have shown that they have used all social resources efficiently.
In 2007, 16 banks were efficient, while 7 banks could not achieve the maximum socio-efficiency scale and the average efficiency was 56%, namely Groupe BPCE, nordea bank and Bank of China. These banks used resources less efficiently than other banks.
Following the social efficiency measure of banks for the year 2008, 7 banks obtained efficiency scales of 100%, while 3 banks were judged inefficient. Although there was a marked improvement in socio-efficiency in 2008, deterioration was reported in 2007.
In the year 2010, the average efficiency was 92%. As a result, 24 banks were efficient. The contributions of social resources have followed a trend with an improvement in 2010 in 2008 compared to 2007 and deterioration in 2008. In contrast, for 2015, only 5 banks were considered inefficient.
In addition, in 2022 the number of fully efficient banks increased to 24, which gives an average efficiency of 91% and the number of inefficient banks is 3. This reasoning implies that a bank's contribution to sustainability included more and more social resources. Finally, the measure of socio-efficiency helps indicate whether a bank is contributing to sustainability in an effective manner.

Table 5: Average social efficiency per bank

Bank	CRS_TE	VRS_TE	SCALE
ICBC	0.909848	0.981467	0.925092
China Construction Bank	0.888724	0.956221	0.925289
JP Morgan Chase & Co	0.552509	0.584164	0.947538
Bank of China	0.704986	0.860861	0.780646
Agricultural Bank of China	0.860551	0.889563	0.959438
Bank of America	0.546176	0.657035	0.847524
Citigroup	0.607461	0.639994	0.946158
Wells Fargo & Co	0.407028	0.478474	0.858217
HSBC Holdings	0.865628	0.951418	0.912163
Credit Agricole	0.910888	0.940576	0.963917
BNP Paribas	0.720177	0.920505	0.780146
Groupe BPCE	0.929114	0.966650	0.940715
Bank of Communications	1.000000	1.000000	1.000000
Goldman Sachs	0.644807	0.792931	0.830641
Barclays	0.983772	0.994034	0.989137
Royal Bank of Scotland	0.992005	1.000000	0.992005
Deutsche Bank	0.736911	0.776679	0.945078
Lloyds Banking Group	0.845410	0.879940	0.952051
Societe Generale	0.630625	0.656541	0.960918
Credit Suisse Group	0.841258	0.906451	0.922842
UniCredit	0.571545	0.589729	0.968653

ING	0.903483	0.951770	0.950140
UBS	0.684695	0.715884	0.957651
Royal Bank of Canada	0.630803	0.793973	0.784093
Rabobank Group	0.847275	0.937322	0.895773
Scotiabank	0.649479	0.970798	0.669214
Nordea bank	0.949737	1.000000	0.949737

4.4.Results of the environmental efficiency analysis

Environmental efficiency includes three main inputs, namely electricity consumption, water consumption and total paper consumption. The eco-efficiency results show how a bank optimizes its environmental resources and its negative effects on the environment while providing economic benefits to society (see Table 6 below).
Sustainable and environmentally efficient banks are: ICBC, Bank of China, Agricultural Bank of China, Credit Agricole and Societe Generale. In addition, inefficient banks are China Construction Bank, Bank of America, HSBC Holdings, BNP Paribas, BNP Paribas, Groupe BPCE, Credit Suisse Group, Royal Bank of Canada, scotiabank and Nordea bank.
The average environmental efficiency scalee over the entire period was 46% with CRS and 64% with VRS. There is heterogeneity in the level of eco-efficiency between banks. Indeed, Credit Agricole stands out for its maximum efficiency of 98.8%. Agricultural credit uses its environmental resources more efficiently than other banks.

While ICBC, Bank of China, Societe Generale are slightly inefficient. ICBC could reduce all environmental pressures by 1.2% and the general company by 4% by improving its efficiency.
The evolution of technical efficiency scales per year reveals that in 2007 was around 44.6%. The special case is the downward trend in technical efficiency scales from 2007 to 2008 and upward thereafter. On average, efficiency in 2008 shows the lowest scale. Indeed, for environmental resources, inefficiency affects only HSBC Holdings.
In addition, between 2009 and 2010, there was a slight improvement. The contribution of environmental resources to sustainability is positive. This implies that banks begin to consider the effects of their activities on the environment. Also, this seems to indicate that banks tend to minimize the consumption of resources which will have negative effects on society.
The efficiency scale improved over time, going from a low value in 2007 to an increasing scale between 2013 and 2022. Environmental resources are therefore used in a more efficient way than in previous years. These results confirm that efficient use of resources improves performance over time. Therefore, it is concluded that the eco-efficiency measure indicates whether a bank has contributed to sustainability and optimized its environmental resources.

Table 6: Average environmental efficiency per bank

Bank	CRS_TE	VRS_TE	SCALE
ICBC	0.977787	0.994754	0.982484
China Construction Bank	0.187453	0.605249	0.528797
JP Morgan Chase & Co	0.092194	0.112718	0.831209
Bank of China	0.931751	1.000000	0.931751
Agricultural Bank of China	1.000000	1.000000	1.000000
Bank of America	0.272675	0.589715	0.594961
Citigroup	0.415960	0.512345	0.860296
Wells Fargo & Co	0.061955	0.101640	0.798790
HSBC Holdings	0.212392	1.000000	0.212392
Credit Agricole	0.962668	0.970490	0.988419
BNP Paribas	0.240906	0.636651	0.472450
Groupe BPCE	0.054560	0.105942	0.518461
Bank of Communications	0.508384	0.704091	0.702375
Goldman Sachs	0.921443	1.000000	0.921443
Barclays	0.420696	0.616200	0.761512
Royal Bank of Scotland	0.830758	0.955651	0.860457
Deutsche Bank	0.639434	0.712807	0.871147

Lloyds Banking Group	0.225980	0.342290	0.753032
Societe Generale	0.240876	0.252303	0.960770
Credit Suisse Group	0.352776	0.588264	0.565968
UniCredit	0.285979	0.419282	0.735714
ING	0.846325	0.958205	0.883354
UBS	0.299847	0.363788	0.836801
Royal Bank of Canada	0.365000	0.635751	0.565707
Rabobank Group	0.806076	0.933409	0.867499
Scotiabank	0.418923	0.790264	0.528339
Nordea bank	0.519947	0.790653	0.686137

5. Conclusion

This study integrates a multidimensional approach of banking efficiency. Thus, is innovative way to involve the relationship between the efficiency and all different dimension of sustainability. Based on this idea, an analysis multidimensional efficiency at the micro banking level contributes not only to performance but also to sustainable development. Obviously, the main contribution of this article is the new application of DEA to the measurement of socio /eco-efficiency. The proposed DEA model not only helps bank management to establish detailed sustainable strategies the use of resources, but also to assess the effects of resources consumption. As the proposed DEA model provides detailed criteria for banks, it also enables banks to continue improving their performance and competitiveness. The results reveal that the rationalization of resources is a key factor of sustainable performance. In addition, the improvement efficiency of the resources involves the contribution ecosystem. So how banks can actively contribute to green finance initiative to address environmental challenges and promote environmental sustainability?

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