St. Petersburg State University

Graduate School of Management

Master in Management Program

An Empirical Study on Museum Performance Evaluation

Master thesis by the 2nd year student

Master in Management program

Li Yiyang

Academic Supervisor:

Y.V. Fedotov

St. Petersburg

2022

ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ
ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

Я, Ли Иян, студентка 2 курса магистратура направления «Менеджмент», заявляю, что в моей магистерской диссертации на тему «Эмпирическое исследование оценки результатов деятельности музея», представленной в службу обеспечения программ магистратуры для последующей передачи в государственную аттестационную комиссию для публичной защиты, не содержится элементов плагиата.

Все прямые заимствования из печатных и электронных источников, а также из защищённых ранее курсовых и выпускных квалификационных работ, кандидатских и докторских диссертаций имеют соответствующие ссылки.

Мне известно содержание п. 9.7.1 Правил обучения по основным образовательным программам высшего и среднего профессионального образования в СПбГУ о том, что «ВКР выполняется индивидуально каждым студентом под руководством назначенного ему научного руководителя», и п. 51 Устава федерального государственного бюджетного образовательного учреждения высшего профессионального образования «Санкт-Петербургский государственный университет» о том, что «студент подлежит отчислению из Санкт-Петербургского университета за представление курсовой или выпускной квалификационной работы, выполненной другим лицом (лицами)».

(Подпись) _Ли Июн_

02.06.2022

STATEMENT ABOUT THE INDEPENDENT CHARACTER OF
THE INTERNSHIP REPORT

I, Li Yiyang, second year master student, program «Master in Management», state that my master thesis on the topic « An Empirical Study on Museum Performance Evaluation», which is presented to the Master Office to be submitted to the Official Defense Committee for the public defense, does not contain any elements of plagiarism.

All direct borrowings from printed and electronic sources, as well as from master theses, PhD and doctorate theses which were defended earlier, have appropriate references.

I am aware that according to paragraph 9.7.1. of Guidelines for instruction in major curriculum programs of higher and secondary professional education at St. Petersburg University «A master thesis must be completed by each of the degree candidates individually under the supervision of his or her advisor», and according to paragraph 51 of Charter of the Federal State Institution of Higher Professional Education Saint-Petersburg State University «a student can be expelled from St. Petersburg University for submitting of the course or graduation qualification work developed by other person (persons)».

(Signature) _Li Yiyang_

02.06.2022

ABSTRACT

Master Student's Name	Li Yiyang
Academic Advisor's Name	Yury V. Fedotov
Master Thesis Title	An Empirical Study on Museum Performance Evaluation
Description of the goal, tasks and main results the research	The objectives of this study is to evaluate the relative technical efficiency of museum affair's performance in 31 provinces in China and then to investigate the relationship between external macroeconomic factors and technical efficiency museum affair. Methods of Data Envelopment Analysis (DEA) were utilized to determine the relative efficiency of these Decision-making units (DMUs). We building a model with multiple inputs and outputs to support the various museum activities, including preservation, research, and cultural transmission. We applied the following input indicators: Number of showpieces, Space of museum, Number of experts, and Financial funding. And the following outputs: Number of visitors, Number of exhibitions, and Number of publications. In the second stage, we utilized regression models to determine how and to what extent external macroeconomic factors affect the level of technical efficiency of museum affair. We evaluated Population and Per Capital Disposable Income (PCDI) as indicators. The results of the study indicate that there is still considerable opportunity for museum development in China and that regional disparities exist. Additionally, PCDI and relative technical efficiency of museum affair has negative correlation, which means the wealthier a population is, the less likely they are to visit museums. The study's findings may be useful to the regional authorities that s responsible for the cultural development. They may be able to adjust financial resource allocation or promote the efficient use of museum resources.
Keywords	Museum management assessment, Performance evaluation, Data Envelopment Analysis, Relative technical efficiency, Macroeconomic factors.

АННОТАЦИЯ

Автор	Ли Иян
Научный руководитель	Федотов Юрий Васильевич
Название ВКР	Эмпирическое исследование оценки результатов деятельности музея
Описание цели, задач и основных результатов исследования	Цели данного исследования - оценить относительную техническую эффективность функционирования музейного дела в 31 провинци Китая, а затем исследовать взаимосвязь между внешними макроэкономическими факторами и полученными оценками технической эффективности. Для определения относительной эффективности этих единиц принятия решений (DMU) были использованы методы анализа объема данных (Data Envelopment Analysis, DEA). Были построены модель с несколькими входами и выходами для поддержки различных видов музейной деятельности, включая сохранение, исследование и передачу/экспонирование культуры. Мы применили следующие входные показатели: Количество экспонатов, Площадь музея, Количество экспертов и Финансовое финансирование. И следующие выходные показатели: Количество посетителей, Количество выставок и Количество публикаций. На втором этапе мы использовали регрессионные модели, чтобы определить, как и в какой степени внешние макроэкономические факторы влияют на уровень технической эффективности музейного дела. В качестве показателей мы оценивали численность населения и располагаемый доход на капитал (PCDI). Результаты исследования показывают, что в Китае все еще существуют значительные возможности для развития музейного дела и что существуют региональные различия. Кроме того, PCDI и относительная техническая эффективность музейного дела имеют отрицательную корреляцию, что означает, что чем богаче население, тем меньше вероятность посещения музеев. Результаты исследования могут быть полезны для региональных властей, ответственных за развитие культуры. Они смогут скорректировать распределение финансовых ресурсов или способствовать эффективному использованию музейных ресурсов.
Ключевые слова	Оценка управления музеем, Оценка эффективности, Data Envelopment Analysis, Относительная техническая эффективность, Макроэкономические факторы.

Table of Contents

Chapter 1.   Introduction

The museum is an integral component of the cultural services infrastructure. It is responsible for maintaining cultural history while utilizing these resources to host exhibitions and execute museum functions such as knowledge dissemination, education, entertainment, and recreation. Additionally, museums are viewed as a source of revenue and a factor in boosting regional tourism.

The significance of museums in China is likewise increasing daily. First, the Chinese government is actively encouraging the growth of cultural enterprises. The history of museum development is a component of a governmental agenda designed to foster social harmony through cultural creation. Therefore, the significant expansion in the number of museums can be attributed to the policy drive. Secondly, museum have become an integral element of citizens' recreational and leisure activities, more and more people come to visit museum. The increase in number and free admission has made museums more accessible.

Museums in Chian are non-profit institutions that are mostly supported by the government. In order to assess whether or not resources are used efficiently, it is necessary to measure their performance and compare it to the resources they use.

Museums' non-profit status is a unique component in their efficiency evaluation. Typically, economic and financial indicators, such as balance sheets, can be used to assess the success of a corporation. In contrast, the success of non-profit organizations, such as museums, is contingent on the accomplishment of societal aims. Evaluation difficulties arising from the pursuit of management and social aims complicate the assessment of museum performance.

This study will handle the issue by picking indicators in accordance with the balanced scorecard theory. The balanced scorecard consists of four perspectives that enable the study to focus on the critical success criteria of a museum. For quantitative analysis, this work used a nonparametric model. This approach does not necessitate an

explicit mathematical functional relationship between inputs and outputs, is more flexible, and is frequently used to evaluate public services.

This paper serves two objectives: 1) Evaluate the relative technical efficiency of the museum affair in each province, from 2015 to 2019; 2) Investigate the relationship between macroeconomic factors and relative technical efficiency of museum affair.

This work takes Museum affair in a province as one Decision-making unit (DMU). Our research focuses on museum affair in 31 Chinese provinces, from 2015 to 2019.

Firstly, a DEA approach is utilized to assess the relative technical efficiency of each province. Moreover, the statistics of 31 provinces are compared across a five-year period, removing the effect of time.

Secondly, by using regression analysis, the work investigates the impacts of population size, per capita disposable income (PCDI), and Gross Regional Products (GRP) on Museum Affairs' technical efficiency in the province.

The conclusions of this paper may be of interest to those responsible for allocating public resources in the region. The findings of the study may add to considerations regarding the allocation of public resources and the usage of museum resources. In addition, this study attempts to contribute to the assessment of the performance of public nonprofit institutions from a theoretical standpoint. It is intended that the analytical approach utilized in this work will serve as an example for evaluating the performance of other nonprofit organizations.

The remainder of the paper is structured as follows, with the following section of Chapter 1 outlining the relevance and objectives of the study as well as the research questions. The Chapter 2 provides a summary of previous research on museum efficiency. The Chapter 3 discusses the study's context and the characteristics of the Chinese museum sector. The Chapter 4 undertakes an empirical analysis that analyzes the relative technical efficiency of the museum business in each Chinese province and investigates the effect of macroeconomic factors on museum efficiency.

1.1. Relevance of study

This contribution intends to evaluate the performance based on the use of Data Envelopment Analysis (DEA). And then exploring the relationship between museum performance and a set of macroeconomic factors.

Measuring the performance has become an important issue also in the cultural sector (Basso, Casarin, & Funari, 2018). Performance measures can be linked to the objective of either management or the external stakeholders of the organization.

From a management point of view, the success of museums are consistent not only with the managerial efficiency but also with the social purposes they are pursuing. Museums performance and management have usually been evaluated by taking their functions as repositories of heritage and venues for exhibitions as references. Nevertheless, other functions such as providing an area for education and for cultural research have been gaining ground, making this an aspect to be taken into account when assessing the performance of organizations. These different functions represent museum output today and generate an array of outcomes that may entail economic, cultural and social implications.

Furthermore, a higher level of transparency is required in museums, as well as in the other non-profit organizations. Museums conduct their activity in the public sector, and are mainly financed by the public funding that is collected by the state through taxes. This implies a kind of acit contract between the government and the citizens, who agree to pay taxes in exchange for being provided with a range of cultural goods and services that include cultural facilities (Barrio & Herrero, 2019). Therefore, there is a desire to gauge museums' performance and to relate it to the resources used, then to ascertain whether museums are efficient in their work. Stakeholders ask for more detailed information regarding gaining an understanding of how museums make use of funds and regarding whether previously established objectives are achieved. Indeed, the public funding of museums requires a strong need for measurement of the social impact of the activities.

Consequently, measuring the performance of museums might prove to be a complicated task mainly for following reasons: firstly, as public or non-profit entities, museums do not often follow cost minimization behavior, such that management success cannot easily be measured in the market (Barrio & Herrero, 2019). Secondly, because museums involve a wide range of resources, many of which are not easy to evaluate due to their precious nature and cannot be reproduced. And thirdly, because museums' ultimate mission is to provide a complex and multiple product that is not always tangible or commercial in nature, such as cultural services.

This does not mean that the efficiency of museums should not be measured or that we cannot apply a proper tool that allows us to reflect the work done in museums. Nevertheless, works addressing the performance evaluation of museums have recently given a rise to abundant literature (Barrio & Herrero, 2021), proving the usefulness of analyzing the accountability of the museums.

China has experienced a museum boom over the past 20 years. On the one hand, the number of museums has increased dramatically. In these years, China has been building thousands of museums, many small, low budget and locally managed museums are established. The average size and fiscal expenditure has increased, also significant governmental financial investments in a few large and representative museums. Museums are becoming more and more accessible and require less money, public museums are formally required offering free admission.

On the other hand, the development of museums is part of China's policy agenda. The objective of museums is not only to preserve cultural relics, but also considered to be an important means of patriotic education and shaping cultural identity.

Although museums have experienced rapid growth, museum management is flawed. Museums in China are administered by different levels of government. There are more than five thousand museums in China in 2020. The government simply divides large museums into three classes based on a complex set of indicators, and there are many more small museums that are not classified.

In the meanwhile, the debate on Chinese museums is still in its fancy. In terms of performance evaluation, the Chinese government has issued a series of guiding documents. However, the evaluation indicators are vague and ignore the fundamental problems. Therefore, it is essential to provide a simplified but also synthetic system to assess the performance of Chinese museums.

1.2. Research objectives and research questions.

1.2.1. Research objectives

A museum's activity may be regarded as one production function, involving inputs such as employees, space occupation, public funding, together with the showpieces in the museum, in order to obtain various goods and services, corresponding to the main functions allocated to a museum.

The initial thought of the study is to evaluate the efficiency of separated museums. That pattern of research allows the dissemination of the best practices in the museum network of reference (Basso et al, 2018). However, the study toward the specific museum often requires detailed data and the help from the internal employees. In the process of data collection, we realized that the exposed data is not detailed enough to support the study toward each museum.

Therefore, we changed the analysis unit from a separated museum to broader level - consider each province as one unit and analyze the relative efficiency of the museum sector of 31 provinces.

In the first stage, this contribution will evaluate the museum performance based on the use of Data Envelopment Analysis (DEA). And then, in the second stage, exploring the relationship between museum performance and a set of macroeconomic factors. There are following three research objectives of this study:

1) Measurement of the museums' relative operational efficiency in all Chinese provinces.

2) Discovering and assessment of the potential for improvement in museums' operational efficiency.

3) Identification of relationship between macroeconomic factors and the museums' operational efficiency.

1.2.2. Research questions

In order to achieve the above research objectives, this study will answer the following four questions:

1) How to evaluate the operational efficiency of museum?

In the study of museum operational efficiency, input variables are resources that museums invest in to maintain its operations and achieve its mission, such as funds, showpieces, experts, occupation area, etc., The output variables are the results generated by the museum operations, such as the number of exhibitions held using the showpieces, the number of visitors attracted, etc. Efficiency studies the relationship between an organization's inputs and outputs, and seeks to minimize costs or maximize benefits.

2) What variables should be selected to evaluate the operational efficiency of a museum?

We used Balanced Scorecard (BSC) theory to select variables that can reflect the success of the museum. The BSC is a framework that links the performance of an organization to its strategy and emphasizes the connections between strategy, actions and results (Kaplan & Norton, 1992). Enabling BSC in museum performance measurement allows us to create a system of quantitative information on critical variables of museums' success. Also, BSC gives information from four perspectives, minimizes information overload by limiting the number of measures used.

3) Which tool can be used to measure the efficiency of a museum?

In this work, Data envelopment analysis is applied to evaluate the museum performance. Performance measurement systems aim at enabling transparent, simplified and standardized comparative assessments by providing synthetic

information about the efficiency and effectiveness of the services (Basso et al, 2018). Parametric models require a precise definition of the function form of the production function. Although they are more rigid than the nonparametric model, this approach has not enjoyed widespread success apart from the seminal work. DEA as a nonparametric technique has more flexibility when defining the frontier, and is able to adapt to a situation of multiple output production function.

This work will also apply DEA approach for quantitative study, which will show us the best practices. Then, by comparing with best practices and comparing efficiency within the same region over time, we will conclude how efficient the museums are in each location and how the efficiency has changed.

4) Which macroeconomic factor is related to the efficiency of the museum?

We will apply regression analysis to explore the relationship between macroeconomic factors and museums' performance.

1.2.3. Research gap

1) Theoretical Contribution

First, the efficiency of Chinese museums is less discussed, and this work analyzes the efficiency changes in 31 provinces over five years, which fills the gap in this area.

Second, the joint DEA-BSC has some advantages in performance assessment compared to the DEA-only model. As we mentioned in the previous section, the government's rating system has the disadvantages of complex indicators, vague directionality and prone to unfairness. On the one hand, BSC reduces the amount of information by focusing attention on critical success factors. On the other hand, DEA can deal with multiple inputs and outputs, thus taking into account the issues raised by the social purpose of the museum.

2) Practical Contribution

First, this work proposed a simplified but synthetic measurement system based on Balanced Scor ecard theory. With the rapid growth of the museum industry has driven related research. Academics have also made many suggestions to improve the existing

rating system. Li, Sakurazi (2013) argues that the current assessment criteria and rationale are vague and do not take into account the needs of all types of museums. Improvements have not been shared, and the results of the assessment have not been used effectively.

This work takes museums affair in 31 provinces as the subject of the study, and by comparing them over time and space, it helps managers and policy makers to understand their relative performance in similar institutions. The study of relative efficiency can provide theoretical support to optimize resource allocation methods for under-efficient museums. At the same time, it also provides a reference for performance assessment of other cultural institutions.

Furthermore, the analysis of external influences provides alternative perspectives for improving the efficiency of museums.

Chapter 2.   Overview of Museum Performance Studies

Museums provide a variety of functions such as education, recreation, and entertainment. The aim of this work is to assess the efficiency of museums in 31 Chinese provinces from 2015-2019 by developing a DEA-BSC model and to investigate the relationship between regional GDP, population, and disposable income per capita and museum efficiency. Assessing the efficiency of museums allows for the identification of effective benchmarks and the dissemination of best practices among museums' reference networks. At the same time, museums face challenges from both internal and external sources, and regular assessments serve as a monitoring and supervisory tool for museum development.

2.1.   Complicated of Museum Performance Evaluation

The performance of museums is a complex issue.

The first is due to its nature as a non-profit organization and its pursuit of social impact. For-profit organizations such as corporations can measure their performance using a range of quantifiable financial metrics such as profit return on investment. However, museums, as not-for-profit cultural institutions, offer products that are non-material and non-commercial. The resources used and the outputs produced are also often difficult to quantify. Evaluation issues arising from the pursuit of the organization's social purpose further complicate museum performance.

Second, traditional performance measurement tends to focus primarily on economic and financial aspects, ignoring other resources that are significant to business development, such as employee skills, trusting relationships with customers, and a culture of innovation. These problems are exacerbated in nonprofit organizations such as museums (Kaplan & Norton).

Furthermore, performance measurement in companies or other for-profit organizations often relies on balance sheet metrics to analyze the performance of the business. Positive key performance indicators are considered good, and negative are

considered bad. But in nonprofit organizations, positive financial results can be as bad as a loss. This is because a positive result means that they are not using all of the available funds to achieve their mission.

In conclusion, it is necessary for museums to use reasonable tools to evaluate their performance.

2.2. Definition of Museum Performance

Museums have always tracked the number of visitors detected, creating metrics such as budgets. But it is only in recent decades that a system of performance measurement has been introduced to provide a comprehensive and holistic picture of museum development. For this reason, it is necessary to discuss the definition of museum effectiveness in order to know what is being measured.

Wagner defines performance as the way in which a research subject, in this case a museum, performs certain activities based on similarity to a reference way of performing the same activity (Prokůpek, 2016). It follows that the interpretation and evaluation of this process presupposes the ability to compare the phenomenon under study and the reference in terms of a set criterion scale.

The earliest concepts of museum evaluation emerged in the late 19th century to justify the educational role of museums for the public and government subsidies for museums. The museum accreditation system introduced by the American Association of Museums in the 1970s expanded the range of metrics. Because it was developed by the accreditation system with museum staff, the accreditation system is more professional, taking into account museum collections, restoration, and research.

Today, museums are under increasing pressure to be effective and transparent in their management. Many museums are funded by public money or donations, and in order to maintain public trust, institutions have an obligation to show the government and donors that funds are being used wisely.

The key issue is the definition of a successful museum operation. Operational success should be based on management, decision-making, financial condition, assets, and services. Tools for assessment should include both quantitative and qualitative indicators. Provide a comprehensive representation of the museum's activities.

2.3. Review of Previous Study about Museum Performance Evaluation
2.3.1. Balanced Scorecard

Balanced scorecard (BSC) is a strategy performance management tool, which can connect an organization's performance to its strategy, emphasizing the relationship between strategy, actions and results (Kaplan and Norton,1992). In addition to being a measurement performance tool, the Balanced Scorecard is also used as a tool for strategic management that is implemented to improve clarification and communication of strategy.

The concept of the Balanced Scorecard comes from the recognition that no single performance indicator can capture the complexity of an organization's performance (Epstein, J.F. Manzani). On the one hand, financial indicators can present the results of organizational decisions in measurable currency figures, it also captures the cost of trade-offs between resources as well as the cost of spare capacity. On the other hand, financial indicators have a lag in the consequences of decisions made by the organization (Epstein, J.F. Manzani). Companies are therefore using a combination of financial and non-financial measures to help decision making.

Therefore, in the 1980s, going through the Total Quality Management movement, some experts proposed the use of non-financial indicators to complement shortcoming of financial indicators. Financial and non-financial indicators should not be seen as substitutes. While financial indicators remain as the basic parameter, improvements in non-financial practices will be reflected in better financial performance ultimately (Epstein, J.F. Manzani).

Another feature of the Balanced Scorecard is that it is strategy-oriented and binds short-term activities to long-term objectives through a series of processes (Kaplan, Nortan, 1996). Some companies do not realize what their clear strategy is, others have varying views from different people. The Balanced Scorecard forces the managers to give a unified and clear statement of the company's vision and strategy. The strategy developed is communicated to all levels of the business through the balanced scorecard and translated into targets and measures for each specific group. For each indicator, the company should also set ideal milestones to measure progress through the tracking of results for further learning and feedback.

In general, the BSC allows managers to look at the business from four important perspectives (Kaplan 1992). The financial, the customer, the Internal process, the innovation and learning perspectives.

The Customer perspective is used to answer the question "How do customers see us?" This question. The metrics in this perspective should reflect what is really important to the customer and generally fall into four categories, time, quality, performance and service, and cost. Examples of metrics from this perspective include loyalty, customer satisfaction, number of new customers, etc.

Internal Processes perspective answers the question "What must we excel at?". This is what the company must do internally to meet customer expectations, usually based on processes, decisions and actions across the organization, and is reflected in the core competencies that differentiate the company from other companies. Examples of indicators include employee skills and productivity factors. In the process, managers need to break down the overall metrics to the local level to ensure that employees at lower levels of the organization have clear goals for actions and improvement activities that will contribute to the overall company goals.

The Innovation and Learning perspective will answer the question, "Can we continue to improve and create value?". While the customer and internal processes perspective reflects the key factors for successful operations, the innovation and learning perspective reflects the company's ability to operate in the long term. Indicators will reflect the company's ability to create more value for customers, continuously improve operational efficiency, etc. Indicators will address the company's investment in human resources and equipment.

The Financial perspective answers the question, "How do we look to shareholders?". Financial performance is typically reflected in the company's profitability and growth and ability to meet the needs of shareholders. Metrics include operating income and return on investment.

In the original formulation of Kaplan and Norton (1996), the BSC operates based on an assumption that the four perspectives are connected together in a system through the relationship between means and ends (or causes and effects). In this system, the innovation and learning perspective is at the bottom, influencing the quality and timing of the internal process perspective, which in turn influences the customer perspective (customer satisfaction) and ultimately the performance of the financial perspective at the top of the chain.

Figure 1.How One Company Linked Measures from the Four Perspectives. (Kaplan, Norton, 1996)
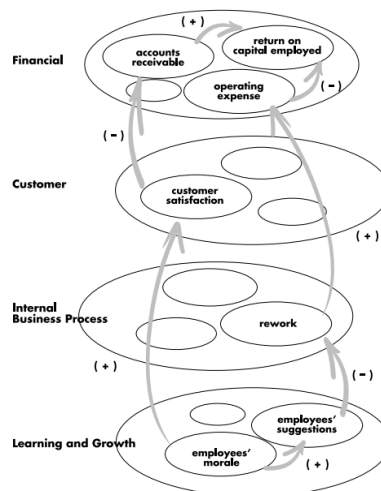
The Balanced Scorecard works better in nonprofit organizations than it does in private companies (Kaplan 2001). However, due to the unique nature of nonprofit organizations, some adjustments need to be made to the BSC.

The first is the alignment of the Financial perspective. In nonprofit organizations, the financial perspective provides constraints rather than goals. In the for-profit sector, the financial perspective reflects the profit objectives of the business. But the failure and success of a nonprofit's operations are not measured through expenses and budgets; the role of the financial perspective is to maximize external funding sources rather than to generate profits or maintain financial stability.

Achieving financial success is not the primary goal of nonprofits. Kaplan (2001) suggests changing the original order of the balanced scorecard by moving the Customer perspective to the top and placing the Financial perspective at the bottom. For nonprofits, the mission of the organization represents the accountability between it and the society, which is the rationale for its existence. Therefore, Kaplan suggested that organizations should place a general mission at the top of the BSC (2001). The mission reflects the long-term objective of the organization, such as reducing poverty, homelessness, disease, etc. The mission should be reflected and measured at the top of the scorecard.

Nonprofit organizations should also consider the client base when using the scorecard. In for-profit organizations, clients usually enjoy services while paying for them. But in nonprofits, those who provide the funds, such as donors, and those who enjoy the services are different populations. In some cases, nonprofits tend to consider both the donor and the service population as their clients.

Some of the ideas in the literature in designing of BSC proposed for museums attempt to take these issues into account. These papers propose different indicators for assessing the performance within the BSC framework, considering the types and regions of the museums studied.

The models discussed by PROKŮPEK and Marek , Haldma and Laats, Carolina Asuaga & Carina Peombo all give detailed indicators and discuss specifically how to create a BSC framework applicable to museums, emphasizing the museum's objectives and activities. PROKŮPEK and Marek apply framework at Greece Benaki Museum and The Finnish Labor Museum Werstas, demonstrate the applicability of BSC in museums. It can flexibly combine quantitative and qualitative elements and make it possible to inform other stakeholders about the work.

Carolina Asuaga & Carina Peombo (2010) focus on the customer perspective, proposing different types of indicators to achieve the goal of increasing audiences, while also highlighting the needs of a broad spectrum of citizens for certain assets. The products and services offered by the organization should be based on the type of visitors it wants to attract and the image it wants to present to society. Indicators that can be used are Permanent exhibitions, Temporary exhibitions, the Number of visitors online, and an increase in the number of Friends Association members. Managers should also take into account the demand for certain heritage assets from a public other than non-visitors (Carolina Asuaga & Carina Peombo). Relevant indicators could be the number of newspaper articles published, the number of scientific publications, etc.

2.3.2. Data Envelopment Analysis

Data Envelopment Analysis (DEA) technique was originally proposed by Charnes et al. in 1978, which can be used to measure and compare productive efficiency of Decision Making Units (DMUs) empirically by compute multiple inputs and outputs, leading to "Best-practice frontier" among DMUs. DEA is a nonparametric model and overcomes the difficulty to seek a common set of input and output weights by suggesting to choose for each museum the most favorable weights (Basso and Funari, 2020).

In the nonprofit area, DEA has been applied to measure the performance of the government (Mohamed Nejib Ouertani et al, 2018), hospital (B. Nguyen and V. Zelenyuk,2021), library (Linfeng Tian and Aiyun Zhang, 2018).

There is substantial literature on the application of DEA to museums. For example, Basso and Funari (2003) compares the results obtained with a CCR and BCC model with those provided by a FDH (Free disposal hull) model on a set of Italian museums; Del et al. (2009) apply CCR, input-oriented BCC and superefficiency model with principal components and cluster analysis to measure the efficiency of a set of museum in Spain; Del Barrio and Herrero (2014) analyze the Spanish museum with a CCR and BCC model as well as the Malmquist index.

Most of these studies assume a situation in which a series of inputs (Labor and different versions of capital such as cultural endowments, equipment, etc.) are used to generate multiple outputs. These outputs represent the various functions of cultural institutions.

These DEA models are based on the design of a single production process (black box), where they manage a unidirectional production function between resources and outcomes. These models do not distinguish between the control of the different activities carried out by the museums, or the change over time. It also makes it impossible to identify the causes of production inefficiencies.

The work by Mairesse and Vanden Eeckaut's (2002) might be considered as the first attempt to open the black box of the production function and to uncover how museums undertake their activities (Barrio, Herrero, 2022). They divided the main activities of the museum into three categories, Preservation, Research, and Communication (PRC). The performance of each activity was independently assessed through the resources used and the products obtained. However, this study does not have indicators of global efficiency and overlooks the interrelations that exist between the different activities carried out in the museum.

Basso et al (2018) firstly proposed a new joint two-stage DEA-BSC model to measure the performance of a set of museums in Venice. The first stage computes the DEA efficiency score for each perspective of the BSC, and then defines a

comprehensive DEA model for the second stage, combining the efficiency scores of the various BSC perspectives into an overall performance indicator.

Based on the two stage DEA-BSC model and to apply different restrictions on the weights, Basso et al (2020) proposed a three-stage DEA model to measure the museum's performance. This model combines the DEA and BSC methodologies with the analytic hierarchy process (AHP) method, overcoming the preference problem among a group of experts by imposing proper restrictions on the weights of the DEA model.

In order to consider the effect of the time factor on efficiency, many studies have analyzed the dynamic efficiency of museums. Mairesseh and Vanden Eeckaut (2002) proposed the use of window analysis in the efficiency analysis of museums, given the tendency of museums to schedule their activities over a number of years. Barrio (2014) and G. Pignataro (2002) measured total factor productivity over time using the Malmquist indices. However, these works do not take into account the specificity of museum collections. Unlike the money and materials invested in a company's production, collections are long-lived rather than consumable.

The work of Barrio and Herrero (2021) measures the productivity of a group of Spanish museums over an eight-year time span, analyzing how performance evolves. This work uses the model of dynamic-network DEA (DN-DEA). The production function is broken down into production activities and time intervals, with inputs that are inter-related horizontally (production links) and vertically (time carry-overs). In this, the work takes into account the inheritable nature of some capital elements. The museum services were divided into two phases. The first of these phases is the provision of culture controlled by managers. The second stage is related to the public and depends on whether visitors visit the museum or not.

2.3.3. Evaluation of museum performance in China

In the last two decades, China has been building thousands of museums, called China Museum Boom (CMB), also known as the museification of China (The

Economist, 2018). This boom is partly about better management and preservation of cultural heritage. The Cultural Revolution of the decade 1966-1976 in particular caused serious damage to cultural relics and monuments. On the other hand, with the rapid economic development, the government wanted to build national cultural identity. To meet the growing cultural needs of the people. In the museum boom, the innovation and modernization of museums were emphasized. The first step is to create innovative museums that are attractive to the audience. The themes should be diversified, and in addition to cultural heritage categories, there should be museums in technology, transportation and other industry categories. Another axis is to increase the accessibility of museums through free/low ticket prices.

The most important feature of the CMB is that it is a cultural development strategy carefully planned by the central government. It demonstrates the government's ability to shape the public and expand the scope of museums.

Financial subsidies are an important source of revenue for public museums in China. The impact of government funding on the operation of nonprofit organizations such as museums has become a controversial topic. Peter and Mark discuss the impact of government investment on the administrative efficiency of nonprofit institutions. Some studies have argued that government autonomy may lead to a tendency toward bureaucracy in nonprofit organizations. Institutionalism argues that the time pursued by organizations may have little to do with maximizing efficiency (Peter,). Organizations develop strategic journeys, etc., not always to improve operational efficiency, but to cope with pressure from external scrutiny.

The policy of free admission based on financial subsidies is also another feature of Chinese museums. In 2008, the Chinese government issued the   'Notice on the Free opening of the

National Museum and Memorial', which required free admission to public museums managed by the State Administration of Cultural Heritage, more than two-thirds of the total number of museums. The impact of free admission on museums has

been explored in the literature, and Michael discusses the financial sustainability of membership-based museums in the United States in terms of equity and efficiency. Michael's work builds on the example of the British Museum to demonstrate that free admission attracts more visitors. Large numbers of visitors may have a negative impact on the quality of the experience offered by the museum, thereby reducing the overall benefits (David, Terry).

Discussions about Chinese museums are still in their infancy, including the assessment of performance.

In 2016, the Chinese government introduced the Museum Grading and Assessment Standards and graded museums in turn. The grading of museums depends on the scores from three perspectives: general management and infrastructure, collection management and scientific research, and display and social services. Museums are graded from highest to lowest based on their overall scores.

From the government's perspective, grading helps to determine the amount of state funding and to promote the development of the sector. From the public's perspective, the ratings reflect the cultural offerings and the ability to provide cultural education.

This grading scale combines the internal and external functions of museums. Attention is given to the museum's ability to provide social services, such as accessibility, accessibility for people with disabilities, and website support for foreign languages. However, this grading method does not provide a comprehensive measure of a museum's operational performance, and the evaluation indicators are complex, with vague overall objectives and inaccurate measurements of the gaps in the level of development of each tube. Therefore, there are more and more studies on museum performance based on quantitative analysis in recent years.

Studies by Yue Nan (2017), Yue Nan and Liu Shu-guang (2019), Zhao Ya-wen, and HU Hui-yuan (2020) all provide a large number of specific indicators, and these papers propose different frameworks for different objectives. Yue Nan (2017) proposes that the evaluation subjects of Chinese state-owned museum performance There should

be diversity. Performance assessment of museums that rely on the fiscal system should be government-led, but also involve industry, the public, and third-party rating agencies.

Museums that rely on financial subsidies suffer from low levels of innovation and management, so Yue Nan and Liu Shu-guang (2019) tracked the performance of a group of museums over five years to clarify that performance evaluation can be used as a means to stimulate innovation and improve management capacity. Zhao Ya-wen and Hu Hui-yuan's studies are both based on the BSC theoretical framework.

2.4. Summary of Chapter 2.

This chapter begins by discussing the complexities of museum performance evaluation. The section next provides a critical analysis of the methods utilized in previous studies for estimate museum efficiency. It then provides an overview of the current state of research on museum efficiency in China.

The complexity of museum performance evaluation is partly attributable to its non-profit nature. As non-profit cultural institutions, museums are constrained by limited financial resources and various responsibilities, including the preservation and restoration of cultural heritage, education, research, and dissemination of culture. Therefore, the achievement of social aims and the efficiency of management are significant issues that should be considered in the operation of museums. Second, the performance of a corporation can be evaluated by analyzing economic and financial indicators like balance sheets. However, as a non-profit organization, the museum's financial success is not the objective of its operations. A surplus of funds may indicate that the museum has not utilized all of its available resources to fulfill its mission of cultural transmission.

Therefore, museum performance evaluation must account for the variety of organizational functions. In addition, museums' non-profit status should be considered while picking input and output variables. Adjustments made in this study mostly involved using financial resources as input indicators rather than output indicators.

As a tool for strategic management and performance measurement, the Balanced Scorecard helps connect the organization's performance indicators to its strategy. Simultaneously, the balanced scorecard incorporates four perspectives, and the selection of indicators can be a combination of financial and non-financial criteria, with a concentration on elements closely related to organizational success.

Much effort has been expended to demonstrate the Balanced Scorecard's application in museums. It permits a customizable combination of quantitative and qualitative measures, with the capability to report on the business to numerous stakeholders. In this study, we selected input and output metrics for the subsequent phase of DEA analysis based primarily on the balanced scorecard theory.

Several cultural organizations have utilized Data Envelopment Analysis (DEA), a non-parametric approach with better adaptability, to evaluate their efficiency.

DEA does not require a precise production function, but rather measures the relative performance of a decision unit by identifying best practices among a set of decision units. In addition, by comparing comparatively inefficient decision units to their more effective counterparts, the DEA approach gives a roadmap for their improvement.

Importantly, DEA permits a multiple-input, multiple-output framework that may take into consider the variety of museum functions.

We conclude by examining the present state of research on museum efficiency in China. China's museums are rarely discussed in terms of their efficiency. This may be attributable to the late emergence of the museum sector in China and the fact that it is mostly influenced by government policy. There is little motivation for museums to enhance their efficiency because they are dependent on financial resources. The absence of data is a significant obstacle that inhibits research. During this study, we discovered that museum-related data were highly dispersed and poorly compiled. Due to a lack of data, our study change the DMU from separate museum to provincial level.

In general, assessing the efficiency of museums as representative cultural institutions presents a degree of difficulty, although a substantial number of studies demonstrates that their efficiency can be investigated. Second, the study of museums may assist to the examination of the efficiency of other cultural organizations.

Chapter 3.   Context of Research

Evaluation is an important part of museum management and the work of other non-profit organizations and is one of the effective ways to promote continuous improvement in the management efficiency and operational standards of the organizations. The Chinese government has increased its financial investment in cultural development in recent years, hoping that cultural development will keep pace with economic development and emphasizing national cultural identity. In this context, the number of domestic museums in China has increased rapidly. It has also become increasingly necessary to assess their performance.

3.1.   Definition and Mission of Museum

Museums are one of the most traditional cultural institutions and an important part of the regional public cultural service system. Museums provide local residents with a wealth of historical knowledge, heritage appreciation and recreational services. And through cultural tourism they become an engine of economic development, as well as contributor to social cohesion, natural environment sustainability and resilient communities (Pop & Borza, 2016). As a complement to the traditional museums, which focus on cultural heritage, many new types of museums have emerged in recent years. For example, science and technology museums, eco-museums, industrial museums, digital museums, etc.

3.1.1.   Definition of Museum

Museums are changing from object oriented to people oriented (Ige, 2013). They try to promote two way communication with visitors and engage them in museum processes and functions. Recently, museums take the initiative to attract audiences by concentrating on visitor satisfaction research issues, playing game changer instead of classic steady roles. Thus, the management skills and efficiency of museums have also drawn attention to academic research.

A museum is a complex non-profit cultural organization. Its complex body stems from its goal of achieving both sociocultural and commercial ministry objectives. While preserving and interpreting cultural heritage, it develops activities that can increase museum revenues such as cultural tourism and consumption (Pop & Borza, 2016). Therefore, to conduct a study of the performance of museums, it is necessary to first clarify the definition of "museum".

The widely used definition of museum is from the International Council of Museum (ICOM), the current definition is as follows:

"A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment."

There are definitions from other major museum professional organizations. The definition from the Canadian Museums Association highlights the public value of the museum, their contribution to society. The United Kingdom's museums association mentions the inspiration and enjoyment that visitors acquired from the collections. Among many others, there is a legal definition from the United States' Institute of Museum and Library Services, which defines the non-profit principle of the museum as well as using a professional staff, and exhibition of both animate and inanimate objects.

As long as the differences, the common ground in all definitions are public value, preservation and interpretation of collections.

In this work, the nonprofit characteristic of the museum is highly emphasized to distinguish the museum performance evaluation from traditional business performance.

The Non-profit nature of the museum refers to that the goal of the organization is nonfinancial. Traditional businesses generally evaluate their performance using financial factors. However, the performance of the nonprofit organization could be

evaluated from nonfinancial terms, such as educational, researching, public services. Museums as nonprofit organizations are subject to the non distribution constraint, revenues exceeding expenses must be committed to the organization's purpose, not taken by private parties.

3.1.2. Mission of Museum

The mission of each museum will vary, which will have an impact on the selection of indicators and is therefore explained here. Some museums focus on research and provide limited public cultural services to the community. Some museums emphasize the achievement of social responsibility and provide broader services such as entertainment and education alongside their exhibitions. Each museum has its own mission and corresponding strategic goals that it wishes to achieve and, therefore, should have a control panel that fits.

Modern researchers have interpreted the museum's mission as "an intended purpose defined as generating culture, both present and future, based on preservation and maintenance of the most valued parts of all types of heritage, as [...] a policy statement, which outlines the main purpose of the Museum, its role and public nature".

Views on the mission of museums are divided into conservative and reformist. The conservatives emphasize the cultural value of artifacts and believe that preservation is the main goal of museums. In this view, visitors to museums are mainly based on educational purposes, learning about, and becoming familiar with these culturally important objects. Moreover, conservatives believe that museum collections should be owned by the state and that the state has the obligation to fully support museums.

The reformists strongly believe that the conservation of heritage should be based on the principle of active use. They believe in a cooperative-based and project-oriented approach, keeping in mind that web technologies will be an effective way to raise funds and develop long-term development strategies. The educational function of museums should be replaced by the function of disseminating information.

AM Kulemzin argues that "the primary mission of the Museum is not just performing specific functions but is more extensive and includes, inter alia, shaping human development. and includes, inter alia, shaping the mindset of the wide population". SI Sotnikova also shares this view; the Museum is an instrument for shaping the basics of a person's mindset".

There are also views that link the museum's mission to practice, arguing that contemporary museums attempt to jump into the realm of actual cultural production (Morkovkin, 2004).

3.2. Current Situation of Museums in China

3.2.1. Development of Museum in China

During the past two decades, thousands of museums have been built in China, which is known as the museum wave. The development of museums is characterized by the following main features: a). Rapid growth in the number of museums b). The functions of museums have increased to include not only the storage and exhibition of artifacts, but also educational and research functions. c). The free opening of museums has led to a significant reduction in admission fees, and state financial subsidies have become the main source of museum income.

According to the Chinese Museum Medium-Term Plan for its Development, the government plans to achieve an average of one museum per 250,000 people by 2020 in order to increase the accessibility of cultural services. Public museums receive support from the central and local governments, and private museums can also apply for public funding on a project-by-project basis. As of 2019, there were 5,355 registered museums in China, 181 more than the previous year, and the goal of one museum per 250,000 people has been reached.

In China, the management of cultural relics and museums is primarily the responsibility of the State Administration of Cultural Heritage. The State Administration of Cultural Heritage has issued the Cultural Relics Protection Law, which classifies movable cultural relics into four classes according to their intrinsic

value: from Class I "rarest value" to Class IV "ordinary. At the same time, the Bureau of Cultural Heritage divided China's state-owned museums into three classes based on a range of indicators, including level of management, level of research, and level of public service. According to the assessment in 2020, there are 204 First-Class museums, 455 Second-Class museums, and 565 Third-Class museums, for a total of 1,224 museums. Only 22.1 % of all museums made the rating. Compared to the total number of museums, The number of rated museums is small.

*Figure 1.*Number of Museums in China from 2010-2019
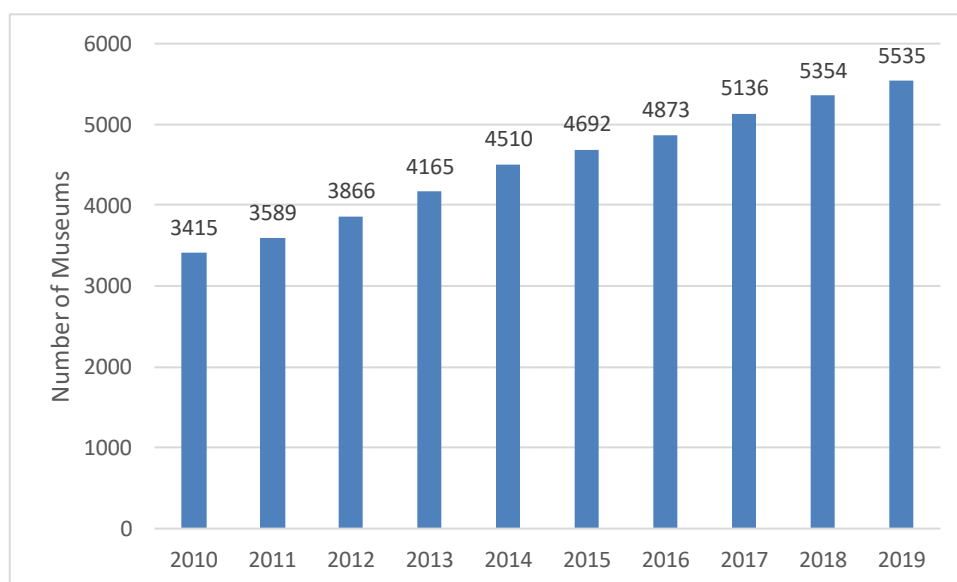
In addition to the growth in numbers, the functions of museums are also increasing. Museums are no longer just institutions that store and display cultural relics, but also serve as a basis for patriotic education and the establishment of cultural diplomacy. Museums provide patriotic education through the display of cultural heritage and the history of the Zen master nation, helping visitors to build Chinese cultural identity and promote national culturalism. In order to meet the needs of the market economy, new science and technology are used for exhibitions and the number of international exhibitions increases again.

In addition, culture plays an important role in the quality of life of every person, and the Chinese government has introduced a number of policies requiring free access

to state-owned museums in order to increase their accessibility. The free admission policy is one of the key strategies to attract visitors, and in 2003, China conducted a pilot program in cities such as Hangzhou to encourage free admission to museums. And in 2006, the government officially required free admission to public museums managed by the State Administration of Cultural Heritage. The government provides financial subsidies to these museums to compensate for the reduced admission revenue due to free admission.

There are also challenges in the development of the museum system. First, there are few studies on the systematization of museums. Beyond reporting on the growth in the number of museums, we have not found any work that attempts to systematically quantify changes in the supply of museums in China (Zhang & Courty, 202). Discussions and research on museums in China are still in the preliminary stages. Second, museums are accountable to different national and local authorities. On the one hand, museums are governed from the cultural heritage sector. At the same time it belongs to the local cultural institutions and is accountable to the local government. This type of management can lead to ambiguity in management, overlapping responsibilities, inefficiencies, etc.

3.2.2. The basic feature of museums in China

The Ministry of Culture and Tourism (MCT) is responsible for the implementation of cultural policy in China, and in 1988, the State Administration of Cultural Heritage (SACH) was established as a sub-supporting agency of the MCT to manage museums. Over the next few years, SACH issued regulations to help manage the definition and classification of museum objects, guidelines for museum management, and policies for the allocation of metals based on the assessment and classification of museum systems. In 2006, the MCT formalized the Museum Management Regulations, which govern the definition, functions and social responsibilities of museums, the establishment and management of museums, including exhibition and service obligations (opening hours), and the allocation of government subsidies and tax revenues.

The State Administration of Cultural Heritage of China states that, as an important collection organization for cultural relics and specimens, museums are important institutions for publicity and education, as well as for scientific research. China is a member of the World Association of Museums (WAM), and the definition of a museum coincides with the IAM definition of a museum.

China's State Council has promulgated the Museum Regulations to promote the development of museums. This regulation helps to give full play to the functions of museums, meet the spiritual and cultural needs of citizens, and improve their ideological, moral, and scientific and cultural qualities.

According to the Museum Regulation, the state must ensure the overall equity of domestic museums in terms of their service content, standardized operation, professional content, and financial and tax support strategies before museums are opened. The characteristics of state-owned and non-state-owned museums are clearly defined in the Regulations, but the basic attributes they assume are basically the same. According to the Museum Regulations, the basic attributes of both state-owned and non-state-owned museums can be summarized in the following four areas.

Non-profit. "Non-profit" is an important characteristic that describes museum institutions. Museums are traditionally non-profit institutions in China, and their essential idea is to protect the interests of the public, as well as being an important social welfare institution in China.

At the beginning of the 21st century, China promulgated the "Measures for the Administration of Museums," which clearly states that museums are non-profit social service institutions open to the public. In recent years, non-profit has been regarded as the most basic attribute of museums.

Since most museums transfer admission revenue to the government departments they report to, the state has set up additional subsidies to compensate for the loss of admission revenue at all levels of government. Second, to encourage free museum access, China promulgated the Circular on Free Access to National Museums and

Monuments, which formally requires free access to public museums managed by the State Administration of Cultural Heritage.

Permanence. Permanence refers to the permanence of museum collections and the permanence of visitors. The collections collected, preserved and exhibited by museums are important cultural treasures from the development of history. Museums need to preserve and clean the relevant collections they exhibit on a regular basis as a way to extend the life of the collections and protect their value as historical heritage.

A constant flow of visitors is also a reflection of the permanence of the museum, and an outward expression of the value of its collections and displays.

Openness. Openness refers to the accessibility of museums. Museums are no longer the exclusive social venues of royalty or the rich and powerful, but have been transformed into institutions of popular culture.

Openness is an important prerequisite for the museum's educational function. The museum's collections are a bridge between modernity and history, a reflection of precious human civilization. By opening the museum to the public at home and abroad free of charge, visitors can visit the museum's artifacts and specimens and fully realize their need for cultural learning, and then achieve the purpose of education.

Social Service. Chinese museums are institutions established for the benefit of the public, and the provision of public services is an important part of their purpose. The basic social services provided by museums are: operational services, educational services, and visitor convenience services. The standard of comprehensive operational services involves education and science, consultation and guidance. Educational services, which are provided for various categories of people. Audience services, mainly with the help of service programs and equipment, allow the audience to have a better visiting experience and visit.

3.2.3. Functions of Museum in China

The functions of a museum include collecting objects, preserving objects, conducting scientific research on objects, documenting objects, and displaying objects

to the public. With the development of modern museology, the functions of museums have been expanded. The fulfillment of each function involves performance evaluation and its relationship to the election of inputs and outputs. Therefore, it is necessary to discuss and define the functions of museums before further research.

From the first public museum, the Ashmolean Museum in Oxford, to the many different modern museums, the functions of museums have evolved as have the expectations of the public.The functions of modern museums are to collect, preserve, interpret, and display The functions of modern museums is to collect, preserve, interpret, and display objects of artistic, cultural, or scientific significance for the education of the public.

The functions of museums, as defined by the Museum Regulations and the Museum Administration, can be listed as follows.

Cultural dissemination. Culture is an integral part of social development and plays a key role in ensuring the quality of life and fulfillment of every human being. Museums are regarded as important public facilities used to organize assistance for the access of people to cultural products.

Second, museums are an important part of China's cultural soft power. Through the soft power of culture, the state hopes to promote a "harmonious society" and to reduce social injustice and inequity.

Collection and conservation of showpieces. The showpieces is the basis for the museum's exhibitions and educational activities. Museums are first and foremost repositories of knowledge, playing the role of collecting artifacts and presenting them to the public. Exhibitions usually communicate ideas or concepts to the public only through visual means.

Each new object that a museum adds to its collection is called an acquisition. Museums acquire objects in a variety of ways, with private collections and deliveries from other institutions being the most common sources. Both the quality and quantity of the collection affect the level of the museum's operations and the benefits to society.

The protection and preservation of objects for future generations is another important function of museums. Various countries have invested a great deal of effort and expense in preservation efforts to slow the aging and decomposition of artifacts and works of art.

Scientific research. Museum collections do not exist purely for visitors; research is one of the fundamental core tasks of museums. Research on collections can uncover hidden histories, change the way museums interpret artifacts, and increase our understanding of the collections. While the public is important to the life of the museum, collections can also provide valuable information for research.

Second, research helps maintain a museum's important reputation as a repository of reliable information and expertise, cementing the public's trust in the institution. Collection-based research can expand the scope of knowledge, reassess and revise existing knowledge, identify and investigate exhibition themes, and provide depth and breadth of information about the collection.

Education. In a report published by the American Association of Museums entitled "Excellence and Equity," the educational role of museums was identified as central to their service to the public. This is reflected in the museum's purpose "not only to preserve, collect and examine various artifacts, but also to influence the community by arousing the creative potential of school children, by helping them with their self-determination and self-realization" (Milovanov, Nikitina, Sokolova, & Sergeyeva, M. G. 2017).

Each museum contains collections in the form of tangible and intangible heritage. These collections help enrich students' learning in various fields, gain experience in new environments, and provide a unique environment for educators to teach students a wide range of topics.

Second, museums visually transmit scientific and cultural knowledge, concretizing and visualizing distant and unfamiliar historical and cultural knowledge through exhibitions. 2007, the International Council of Museums (ICOM) adjusted the primary

purpose of museums to "education," underscoring the international museum community's recognition and emphasis on the function of museum educational services. This underscores the recognition and importance that the international museum community places on museum educational services. (There is a document that describes what it is like to be confronted with exhibits in a museum, which can be added)

Nowadays, museums have evolved from being places for collecting and displaying artifacts into centers for education, research, interaction, and conservation. This paper focuses on these functions and attributes of state-owned museums and uses the theory of the balanced scorecard to design a performance evaluation index system.

3.2.4. Management of Museum in China

China's state-owned museums are state institutions and are managed by all levels of government. Each museum is managed by one of four levels of government: national (also called central), provincial, municipal (sometimes called prefecture) and county. National museums are directly managed by a ministry of the central government. Local museums are managed by local economic development plans implemented by the local government. Thus, cultural activities are implemented by various overlapping public actors and are coordinated and jointly implemented in a complex contractual framework.

The Ministry of Culture and Tourism (MCT) is the constituent department of the State Council of China in charge of culture and tourism. MCT carries out regulatory actions through laws and direct actions enacted by the Standing Committee of the National People's Congress. The main responsibility of the department is to implement the guidelines and policies of government on propaganda and culture. Responsibilities include the formulation of culture-related policies and measures and the coordination of planning, etc. In 2012, the Ministry of Culture and Tourism promulgated the Museum Development Plan (2011-2020), which proposes to reach the goal of one museum for every 250,000 residents during the 13th Five-Year Plan. It is the cultural services of museums that cover the whole of China and enhance museum services in terms of quality and quantity.

In 1998, the State Administration of Cultural Heritage was established as a branch of MCT to manage museums. Over the next few years, SACH issued regulations to help manage the definition and classification of museum artifacts, guidelines for museum management, and a policy for the allocation of metals based on the assessment and classification of the museum system. In 2006, the MCT formalized the Museum Administration Regulations, which govern the definition, functions, and social responsibilities of museums, the establishment and management of museums, including exhibition and service obligations (opening hours), and the allocation of government subsidies and tax revenues (Zhang, & Courty, 2021).

Museums are organizations organized by the state using state-owned assets to provide public services, and financial resources are an important source of funding for museum operations. The activities of museums in China are usually financed by: financial subsidies, provision of paid services, and assistance from the community, most of which originate from government subsidies, resulting in museums not having autonomy over some aspects of finance and personnel, and are often restricted and limited by the government or higher authorities.

3.3. Problems of Museum Development in China
3.3.1. Existing Problems of Management and Performance Evaluation

This section will first describe the problems in the development of Chinese museums, then describe the problems in performance assessment, demonstrate the need to assess the performance of Chinese museums, and provide a basis for the subsequent research.

The main problems in Chinese museum development are insufficient investment funds, lagging scientific research, and unclear development strategies. Since 2006, the state treasury has increased its investment in cultural development, but the proportion of fiscal expenditure is very low, remaining between 0.39% and 0.41%. This percentage

is much lower than what developed countries, such as the United Kingdom (2.0%-2.6%), spend on culture and the arts.

Second, the scientific research function of museums is marginalized. Scientific research can provide a deeper interpretation of cultural objects and is an important part of a museum's sustainable development. First, scientific research is limited by inadequate financial resources. Organizations do not have sufficient funds will conduct a significant amount of research. This leads to shortcomings such as the exhibition department reflecting the latest research, lack of character and weak appeal to the audience. It also results in insufficient cultural dissemination and, affects the educational function of the museum.

Due to the excessive use of new technologies, the mission of the museum is weakened. On the one hand, electronic docents and virtual exhibitions have improved the visitor experience. Imaging technology also helps reduce the destruction of original collections, among other advantages. On the other hand, the use of technology as a selling point to attract visitors ignores the attributes of museums for cultural communication. More attention is paid to new technologies during the visit than to the cultural connotations of the collections themselves. The excessive use of technological tools also results in a waste of funds.

In terms of management, there is the problem of administrative museum management and few methods of performance evaluation.

On the one hand, museums are under the jurisdiction of the government. Chinese state-owned museums are not independent non-profit institutions, but governmental institutions. The museum's income and expenditure are under the jurisdiction of the government. On the other hand, as professional trustees of cultural resources, museums need to be managed by professionals. However, the current managers apply political thinking to manage museums, resulting in a waste of resources and a loss of professional talent. The lack of professional knowledge among practitioners affects the performance of museums' public cultural service functions.

In terms of performance evaluation, the Chinese government has issued a series of guiding documents. For example, the National Museum Assessment Measures, the Rules for Operating Apples of National-level Museums, etc. However, the evaluation indicators are vague and ignore the fundamental problems. For example, in the indicator "conservation and restoration of collections", the quantity of restoration equipment and professional staff is emphasized, while the quality of restoration is neglected. The assessment framework adopted by the Bureau of Cultural Heritage is complex and lacks overall clarity of focus. The personal opinions of the evaluation committee also influence the final results and are prone to unfairness. In addition to internal evaluation, peer evaluation as well as a social rating system should be introduced (Shan, 2013).

Second, there is a lack of benchmarking studies. The Bureau of Cultural Heritage classifies museums into levels. But there is a lack of studies between museums in the same sector, or museums of the same level. The current assessment approach is only a superficial description of numbers, and lacks deep research, such as comparative analysis and benchmarking analysis.

The problems of the assessment system reduce the organization's response to the assessment and grading work and affect the performance of the assessment and grading guidance. Therefore, this work will address the above-mentioned problems and use benchmarking analysis to analyze the true performance of museums and discover the potential for growth.

3.4. Summary of Chapter 3.

This chapter provides an overview of the study's context and justification. The chapter begins by defining and analyzing the evolution of museum functions. In addition, the non-profit status of museums examined in this study is clarified. Then, we explore the growth of the museum industry in China. Finally, we highlight the distinctive characteristics of the Chinese museum sector to offer context for the subsequent analysis.

First, museums of the twenty-first century are not just halls where exhibits are presented; they also seek to allow two-way connection with their audiences. Efficiency assessment provides the opportunity for museums to more actively engage with viewers. Second, the functions of modern museums have expanded. In addition to the conservation and restoration of objects and the organization of displays, museums have also assumed the roles of education, cultural diffusion, and scientific research. To distinguish museum performance assessment from typical business performance assessment, the nonprofit nature of museums is highlighted in this attempt.

The growth of the museum industry in China is largely attributable to government initiatives. During the past two decades, the number of museums in China has expanded rapidly, with the majority being public institutions. Due to the fact that financial financing is the primary source of museum revenue, it is vital to investigate if museum resources are being utilized effectively during a period of population expansion.

The state-owned museums in China are managed by government and governed by the State Administration of Cultural Heritage. There are numerous local and regional museums that are not classified, in addition to the three categories of large museums in China. The drawback of the government's existing evaluation system is that it consists of too many indicators, unclear indications, and subjective variables. Therefore, it is imperative to provide an understandable methodology for evaluating the efficiency of the museum affair in China.

Chapter 4.   Methodological and Empirical study

4.1.   Methodology

4.1.1.   Overview of research methods

1) *Literature analysis.* The literature analysis method is used in this work to summarize previous research on museum efficiency and the selection of input and output indicators. First, a critical summary analysis of research results about museums and other non-profit institutions was conducted to determine the research direction and the tools to be applied in this work. Second, the literature was read to understand the characteristics of Chinese museums and to collect data. The processed data were used to analyze the current situation of museums and to construct a performance assessment indicator system.

2) *Quantitative analysis.* First, this work uses a DEA model to measure the performance of museums in 31 Chinese provinces from 2015 to 2019, using them as the decision-making unit. The current operational efficiency of Chinese museums is judged by the temporal changes and regional variations of the integrated efficiency.

   Secondly, in the second stage, this work applied the regression model to analyze the external factors that may affect museums, identify the external factors related to museum efficiency.

3) *Comparative analysis.* In this paper, when analyzing the empirical results of DEA model, on the one hand, the vertical analysis and comparison of the historical efficiency change trends of museums in each province, and on the other hand, the horizontal differences between different provinces and three major economic regions are explored, to reflect the comparative analysis of performance issues horizontally and vertically

4.1.2. Research Design

This study will be conducted in two phases. In the first phase we will use a DEA model to measure the relative efficiency of the museum sector in each province. In the second phase, we will explore the relationship between museum efficiency and external macroeconomic factors through regression analysis.

The first stage, we will calculate and compare relative efficiency DMU. Firstly, we will select indicators describing the performance of museums by BSC theory. And then, compute the relative efficiency score for each province over the five years, by using of the DEA model. And then, compare the efficiency of the same region among the five years; Compare the efficiency of the different region.

In the second stage, we will choosing macroeconomic factors that may have an impact on the efficiency of the museum affair. And then, using the regression analysis explore the relationship between technical efficiency of museums affair and external macroeconomic factors.

4.2. Variables and data of DEA analysis

Among the variables selected for the four BSC perspectives, many different indicators are listed in the Museum Assessment System issued by the Bureau of Cultural Heritage and related academic studies. However, some indicators require a survey of museum professionals or require tracking detailed internal data. Therefore, based on the characteristics of Chinese state-owned museums, the following indicators were selected. These indicators focus on the main characteristics of museum activities and are computable for all analyzed museums.

Among them, we consider the financial, internal processes, and learning and growth perspectives as input variables, indicating the resources that museums need to invest in order to maintain their daily operations and to provide cultural services. We consider the public dimension as an output variable that expresses the evaluation of the museum's cultural communication incapacity.

The Input (I) and output (O) variables are the following:

Inputs	I_1: Number of Showpieces
	I_2: Space of museum (Square Meters)
	I_3: Number of Experts
	I_4: Financial Revenue
Outputs	O_1: Number of Visitors
	O_2: Number of Exhibitions
	O_3: Number of Publications

- Input indicators

a. Internal Processes Perspective

The internal process perspective refers to what the museum must do exceptionally well to meet the needs of its stakeholders.

Number of showpieces. Collections are the basis for museums' display and educational activities. Both the quality and quantity of collections affect the level of museum operations and social benefits.

Space of the museum.

b. Innovation and Learning Perspective

The perspective of innovation and learning is considered as the ability of the organization to develop and learn sustainably in order to successfully deal with medium and long-term issues.

Number of experts. The learning and growth perspective refers to the museum's ability to develop sustainably. A museum is not only a collection of artifacts, but also a place for research and education. Therefore, museum professionals are.

c. Economic Finances Perspective

In for-profit institutions, financial indicators reflect the profitability of the organization and are usually expressed in terms of indicators such as return on investment. But in nonprofit organizations such as museums, the

Financial revenue. Finances are the foundation of museum operations. As a nonprofit, museums do not need to generate profits like for-profit organizations, but they still need to adhere to certain budgets based on financial revenues.

- Output Indicators.

d. Customer Perspective

The customer perspective refers to the organization's efforts to achieve its mission by.

Number of visitors. The number of visitors is a direct reflection of the cultural function of the museum.

Number of exhibitions. The number of exhibitions reflects the museum's ability to use its collections as a resource, to curate exhibitions, and to engage audiences.

Number of Publications. The number of papers represents the museum's research function. Also, as a cultural institution, the number of papers published shows the museum's concern for other stakeholders.

4.3. First Stage: Data Envelopment Analysis

Studies of museum efficiency can be divided into two categories. The first type is through the development of a set of performance indicators that allow a comparison of various museums within the selected activities. However, this analysis does not provide a ranking among museums. The second type of research approach is to measure the efficiency of a group of museums using cutting-edge techniques. This approach allows for comparisons between museums, not just between activities.

Frontier technology can define the process of converting input resources into outputs. There are two ways to achieve this transformation, the first being parametric

models. Parametric models require an explicit mathematical functional relationship between inputs and outputs, such as stochastic frontier analysis. Non-parametric models, on the other hand, do not require an explicit definition of the production function and therefore offer greater flexibility.

The DEA technique allows us to measure the relative efficiency of a group of organizations by measuring the effective frontier, considering many inputs and many outputs at the same time. In DEA, the efficiency index is based on a weighting process of inputs and outputs, where the weights should reflect the relative importance given by decision makers. Variables are weighted by multiplying each variable by an adopted positive scalar weight and then summing the weights to form a composite output (or input). By calculating the ratio between the combined output and the combined input, a global efficiency indicator can be defined as follows:

$$\frac{Weighted\ sum\ of\ outputs}{Weighted\ sum\ of\ inputs} = \frac{u_1 y_1 + u_2 y_2 + \cdots + u_r y_r + \cdots u_t y_t}{v_1 x_1 + v_2 x_2 + \cdots + v_r x_r + \cdots v_m x_m}$$

Where y_r and u_r denoted the amount of output r ($r = 1, \ldots, t$) provided by the organization and the weighted assigned to it. Whereas x_i and v_i represent the amount of input i ($i = 1, \ldots, m$) that the organization uses and the weight associated with it (Basso & Funari, 2004).

Different weighting vectors lead to different efficiencies. There are often difficulties in defining a common set of weights due to decision makers have different preferences. The DEA technique overcomes the obstacle of choosing a common set of weights by selecting the most powerful weights for each decision unit. That is, DEA selects for each decision unit the weights that maximize its efficiency.

In the DEA model, the organization under study are called the Decision-Making Units (DMUs). When assessing performance, the model can be classified as input-oriented output-oriented. Input-oriented refers to minimizing inputs while maintaining a given level of output. Output-oriented refers to maximizing output without changing the size of the input.

There are two main types of DEA models applied in the calculation of relative efficiency. The first Constant Returns to Scale (CRS) model, also known as the CCR model, is a well-known DEA theory published by Charnes, Cooper and Rhodes in 1978, and CCR is derived from the initials of their last names.

CCR model built on the notion of efficiency as defined in the classical engineering ratio. The CCR ratio model calculates an overall efficiency for the decision-making unit, in which both its pure technical efficiency and scale efficiency are aggregated into a single value.

The second model is the BCC model, which was proposed by Banker, Charnes and Cooper in 1984. Based on the CCR model to estimate global efficiency, the BCC model decomposes global efficiency into pure technical efficiency and scale efficiency, assuming that a variable returns to scale relationship between inputs and outputs.

In this work, we choose the Output oriented CCR model in the empirical study.

In our study we have chosen the input-oriented CCR model. This approach has efficiency indicators that show the extent to which we can improve the use of existing inputs to achieve the same outputs as before. In other words, what is the potential to maximize radial reduction of inputs while maintaining a given level of output.

4.3.1. CCR model

The Constant Returns to Scale (CRS) model, also known as the CCR model, was published by Charnes, Cooper and Rhodes in 1978 and is considered to be the original DEA model, with CCR being derived from the initials of their surnames. The model assumes constant returns to scale, and the efficiency derived from this basic DEA model is also known as the combined efficiency, as it involves the effects of scale efficiency in its theoretical calculations.

CCR model assigns to each given decision-making unit an efficiency measure, which is define as a ratio of weighted outputs to weighted inputs. The efficiency score in the presence of multiple input and multiple output variables is defined as following:

$$Efficiency = \frac{Weighted\ sum\ of\ outputs}{Weighted\ sum\ of\ inputs}$$

We can assume the follow conditions in the performance evaluation: A set *n* of decision-making units whose performances will be evaluated; Each DMU uses a total number *m* of inputs (resources required for its activities and daily operation) to produce a total number *t* of outputs (services and product provided by the museum).

4.3.2. Data analysis

This work uses the input-oriented DEA-CCR model to study the relative efficiency of museum affair in 31 provinces of China. We take the Number of showpieces, Space of museum, Number of experts, and Financial funding as input variables, and the Number of visitors, Number of exhibitions, and Number of publications as output variables. Using *DEA-solver* software, the relative technical efficiency of museum affair in each region of China from 2015 to 2019 was measured, and the results are shown in the following table:

Table 1. Technical Efficiency of Museum affair in each province from 2015-2019

DMU	2015	2016	2017	2018	2019	Average
Beijing	1.00	0.94	0.75	0.66	0.54	0.78
Tianjin	0.78	0.85	0.89	0.89	0.97	0.87
Hebei	0.86	0.84	1.00	1.00	0.83	0.91
Shanxi	0.52	0.48	0.68	0.52	0.46	0.53
Inner Mongolia	0.70	0.46	0.52	0.57	0.67	0.59
Liaoning	0.76	0.63	0.83	0.88	0.76	0.77
Jilin	1.00	0.94	0.90	0.91	0.83	0.92
Heilongjiang	0.90	0.95	1.00	1.00	1.00	0.97
Shanghai	0.74	1.00	0.76	0.97	0.78	0.85
Jiangsu	0.93	0.95	0.98	0.81	0.78	0.89
Zhejiang	0.99	0.96	1.00	1.00	0.96	0.98
Anhui	1.00	1.00	1.00	0.94	0.93	0.97
Fujian	1.00	1.00	1.00	1.00	1.00	1.00
Jiangxi	1.00	0.95	0.98	1.00	0.94	0.97
Shandong	0.91	1.00	0.79	0.84	0.88	0.88
Henan	1.00	1.00	1.00	1.00	1.00	1.00

Hubei	0.97	0.83	0.71	0.59	0.66	0.75
Hunan	1.00	1.00	1.00	1.00	1.00	1.00
Guangdong	0.94	1.00	0.92	0.95	1.00	0.96
Guangxi	1.00	0.94	1.00	1.00	1.00	0.99
Hainan	1.00	1.00	1.00	1.00	1.00	1.00
Chongqing	1.00	1.00	1.00	1.00	1.00	1.00
Sichuan	0.87	0.82	0.98	0.94	0.82	0.89
Guizhou	1.00	1.00	1.00	1.00	1.00	1.00
Yunnan	1.00	1.00	1.00	1.00	1.00	1.00
Tibet	1.00	0.54	1.00	1.00	0.50	0.81
Shaanxi	0.70	0.68	0.76	0.79	0.71	0.73
Gansu	1.00	0.93	1.00	1.00	1.00	0.99
Qinghai	0.65	0.53	0.64	0.53	0.44	0.56
Ningxia	0.91	0.92	1.00	0.92	1.00	0.95
Xinjiang	1.00	0.89	0.86	0.70	0.65	0.82
Average	0.91	0.87	0.90	0.88	0.84	0.88

It can be seen score of relative technical efficiency of some provinces is equal to 1.00 in 2015-2019, meaning that the relative efficiency of these museums has been efficient over the measured period. In contrast, the relative technical efficiency in some provinces has gradually decreased. Next, we will analyze the changes in the relative efficiency of the museum affair in each province in terms of both time series and regional changes.

1) Analysis of Technical efficiency changes over time

Figure 1.Number of relative Efficient and Inefficient DMUs from 2015 to 2019.
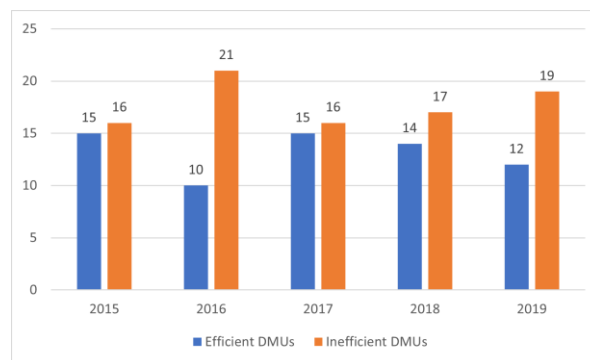

According to the data in Table 1, the average value of the overall technical efficiency of the museum affair from 2015-2019 is 0.88. On the one hand, this

indicates a moderate level of overall efficiency of the museum industry. On the other hand, *Figure 1* shows that the number of efficient units is still less than the number of relatively inefficient units. Therefore, it is necessary to further improve the overall efficiency of the Chinese museum industry.

Further, the following graph shows the change in the mean value of the combined technical efficiency over time.

Figure 2. Change in average value of TE from 2015-2019
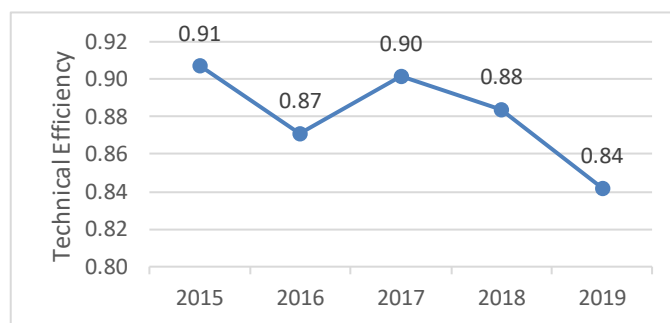
As can be seen from the *Figure 2*, the overall technical efficiency of the museum industry from 2015-2019 is on a downward trend, although it increased slightly in 2017. Therefore, it is necessary to explore ways to improve the efficiency of museums.

2) Differences in the efficiency of museums between provinces

From the Table 1, it can be observed that TE of museum affairs in 7 provinces performed relatively effectively over a five-year period. These regions are: Yunnan, Hunan, Henan, Guizhou, Hainan, Fujian, Chongqing. The technical efficiency of the museum business in these regions has been on the frontier of efficiency. That result indicates that these regions are using the input resources efficiently, without redundancy of inputs or inadequate outputs, and making the most efficient output level of the resource inputs.

Contrast this with relatively inefficient regions, such as Beijing. Beijing is the capital and economic and cultural center of China and has the largest number of collections. It is generally assumed that technical efficiency of museum affair in Beijing should be efficient. But what surprises us is that, according to the result, Beijing is the inefficient unit from 2016-2019, and the efficiency score is gradually decreasing. In

2019, the DEA score of the museum affair in Beijing is even only 0.54, which is nowhere near even the average score (0.84) of the 31 regions. This is due to the large number of collections Beijing possesses and the large space of the museums, but at the same time it indicates that these resources are not being used efficiently.

Therefore, this work will analyze the relative technical efficiency of the museum affair in Beijing, using data from 2019 as an example, and seek paths for efficiency improvement. The projection results of the input-output factors of the museum affair in Beijing in 2019 are shown in the following table:

Table 2. Projection results of the input-output variables of the museum affair in Beijing in 2019

	Variable	Original Value	Target value	Difference	Diff. (%)
Input	Showpieces	2033344	413538.50	1619805.5	79.662
	Experts	585	313.54	271.46	46.403
	Space	928.3	497.54	430.76	46.403
	Financing	1913081	1025361.60	887719.40	46.403
Output	Visitors	24888.4	0	24888.4	0
	Publications	198	0	198	0
	Exhibitions	501	0	501	0

One of the advantages of the DEA approach is that it provides a slack analysis that shows the redundancy of inputs or shortage of outputs. We can identify potential areas of improvement by comparing relatively inefficient decision units with those located on the efficiency frontier. This analysis identifies target values that underperforming decision units should meet, dubious relative to the optimal productivity level of the reference group.

From the data in *Table 2*, it appears that museum affair in Beijing are putting in redundancies in 2019. To become the relative efficient unit, changes are needed respectively in: 1) reducing number of showpieces by 79.7% and museum space, number of experts and financial funding by 46.4%.

These figures show that the resources of museums in Beijing are not being used efficiently. Beijing should make use of the showpieces to hold exhibitions and attract more visitors. Also, the cultural value of the museum collections themselves should be explored. Beijing should take advantage of the large number of experts to explore the value of the collection and product more publications.

Next, we exclude the time factor to examine more about the technical efficiency of museum affair in each province. We put together data from 31 provinces for the five-year period (from 2015 to 2019) for the analysis, with a total of 155 observations.

Table 3. Result of DEA-CCR model based on 155 observations

Number of observations	155
Number of Efficient DMUs	31
Number of Inefficient DMUs	124

The results of the DEA-CCR analysis show that out of 155 observations, there are 31 efficient DMUs and 124 inefficient DMUs. The number of inefficient DMUs is much higher than the number of efficient DMUs, which indicates the need to analyze the efficiency of museum affair in each province.

Moreover, among the 31 efficient decision-making units, some provinces appear more than once.

Table 4. Efficient DMUs based on data from Fujian Province.

DMU	Score
Fujian -16	1
Fujian -18	1
Fujian -19	1

For example, Fujian-16, Fujian-18, and Fujian-19 based on the data from Fujian Province are all relatively efficient decision units. This provides inspiration to conduct the next step of the study, which is to explore the relationship between macroeconomic factors and museum performance.

4.4. Second Stage: Macroeconomic Factor Analysis

4.4.1. Selection of variables

We have analyzed the technical efficiency of museum affair in each province through DEA, and this section examines the relationship between macroeconomic factors and museum technical efficiency. Since there are few research articles on the performance of museums in China, the selection of macroeconomic factors in this work are selected with reference to other public cultural institutions such as libraries.

This paper will examine the relationship between the following three macroeconomic variables and technical efficiency of museum affair in each province.

a. *Population size.*

A large population size implies a high number of potential visitors to the museum.

b. *Per Capita Disposable Income (PCDI).*

From an economic perspective, disposable income is considered the most important determinant of consumer spending and is thus often used to measure changes in a country's standard of living. First, a higher level of income generates more consumer spending. Thus, regions with higher per capita disposable income and a higher standard of living might see people spending more on cultural services, thus contributing to higher museum performance.

c. *Gross regional product (GRP).*

Gross regional product, which is the sum of the value of all final goods and services produced by all resident units in a region over a certain period of time, is an important indicator of the overall state of the economy. Governments in regions with high gross regional product invest relatively high amounts of financial resources in cultural institutions.

4.4.2. Regression Analysis

In this task we were constructing the four models explore the correlation between macroeconomic factors and efficiency of museums. We chose two types of models, the

Linear model and the Logarithmic model. In each type of model, we also consider the cases where the $constant \neq 0$ and the $constant = 0$ separately. Four Models are as in the following table:

Table 5. Optional Models

	Model	Function
$Constant \neq 0$	Linear Model 1	$TE_{it} = c + \alpha \cdot Var_1 + \beta \cdot Var_2 + \tau \cdot Var_3$
	Cobb-Douglas Model 1	$\ln(TE_{it}) = c + \alpha \cdot \ln(Var_1) + \beta \cdot \ln(Var_2) + \tau \cdot \ln(Var_3)$
$Constant = 0$	Linear Model 2	$TE_{it} = \alpha \cdot Var_1 + \beta \cdot Var_2 + \tau \cdot Var_3$
	Cobb-Douglas Model 2	$\ln(TE_{it}) = \alpha \cdot \ln(Var_1) + \beta \cdot \ln(Var_2) + \tau \cdot \ln(Var_3)$

Where,

TE_{it}=Technical Efficiency of the museum

Var_1= Population

Var_2= Per Capital Disposable Income (PCDI)

Var_3= Gross Reginal Products (GRP)

After constructing these models, we will choose the best one for our further analysis. The results of the models are as following:

Table 6. Model of Total Units. (Dependent Variable-Technical efficiency of the museum affair in a province; Independent variables-Var_1 − population; Var_2 − PCDI; Var_3 − GRP)

Model	Multiple R	R^2	adjusted R^2	$Std.Err$	F	$p-value$
Linear 1	0.29849	0.08910	0.071	0.16347	4.92322	0.00272
Cobb-Douglas 1	0.34363	0.11808	0.10056	0.22529	6.73922	0.000269
Linear 2	0.95460	0.91127	0.90352	0.24985	520.3438	2.27E-79
Cobb-Douglas 2	0.73767	0.54417	0.53159	0.22617	60.48457	9.69E-26

From *Table 3*, it can be seen that when the $constant \neq 0, (Model - Linear\ 1\ and\ Logarithmic\ 1)$, the $adjusted\ R^2$ of the model is lower, which means variance in the dependent variable is rarely explained by the independent variable. And when the $constant = 0, (Model - Linear\ 2\ and\ Logarithmic\ 2)$, the model has a good fit. Therefore, in the further study, we will use the model with a zero constant term.

Furthermore, it can be seen the second linear model shows better explanatory power. From the table, the F-statistics of second model shows the highest values which mean that the general significance of the model. Also, the p-value of $F - statistic$ is less than 5%. Moreover the $adjusted\ R^2$ of second model also shows the highest value that is 90.35%, which means that we are explaining 90% of variance in the dependent variable.

A key goal of regression model is to isolate the relationship between each dependent and independent variable. The independent variables in a regression model should be independent. When the independent variables are correlated it leads to the problem of multicollinearity. Multicollinearity can lead to large fluctuations in the estimates of some of the coefficients in the model, causing the coefficients to become very sensitive to small changes in the model. Also, multicollinearity can reduce the accuracy of the estimation system, thus weakening the statistical power of the regression model.

To avoid these problems caused by multicollinearity, we first performed correlation analysis on the independent variables, and the results are shown in the following table:

Table 7. Correlation between Independent variables

	Population	PCDI	GRP
Population	1		
PCDI	-0.02345	1	
GRP	0.83453	0.37907	1

As can be seen from the graph, the correlation between population and GRP is 0.835, which is greater than 0.8. It can be tentatively determined that there is a linear correlation between these two independent variables.

To ensure the accuracy of the model, we decided to remove GRP and use population and Per Capita Disposable Income as independent variables. The results of the model are calculated as follows:

Table 8. Regression Statistic of Models. (Dependent Variable-Technical efficiency;

Independent Variables-Var_1 − population; Var_2 − PCDI)

Model	Multiple R	R^2	adjusted R^2	$Std.Err$	F	$p − value$
Linear	0.92801	0.86121	0.85377	0.31146	474.6906	4.29E-66
Cobb-Douglas	0.73767	0.54416	0.53464	0.22543	91.32116	8.95E-27

Table 9. Parameters of *Linear model.*

	$Coefficients$	$Std.Err$	$t − Stat$	$p − value$
Intercept	0	N/A	N/A	N/A
Variable 1	0.088	0.021	4.153	5.44E-05
Variable 2	-0.11	0.022	-5.190	6.6E-07

$$TE_{it} = 0.088 \cdot Var_1 − 0.11 \cdot Var_2$$

which means that on average an increase in the Population by 1 unit of measurement leads to a increase in the Technical Efficiency of museum by 0.088 units. And an increase in the PCDI by 1 unit of measurement leads to a decrease in the Technical Efficiency of museum.

This result shows that population size and museum efficiency are positively correlated, while per capita income is negatively correlated with museum efficiency. That is, when the population of an area increases, the efficiency of the museum increases. When the overall income of a region increases, the efficiency of museums decreases. The possible reason for this situation can be that higher incomes bring more entertainment options. People are no longer satisfied with visiting museums and instead seek other entertainment and leisure activities.

To further confirm the results and explore the actual impact of Population and PCDI on the efficiency of museums, we excluded efficient units and focused on examining the linkages present in inefficient units. Of the 155 observations, there were 31 efficient units and 124 inefficient units. We first calculated the effect of population and income on museum efficiency in the 124 inefficient units. However, in order to take the efficient units into account and at the same time ensure the validity of the model

and avoid bias caused by the 31 observations. We calculated the Average of the effective units and added it as one observation to the calculation of the inefficient units. Finally, we compared the results of the three models.

During the above calculations, we found that the value of $adjusted\ R^2$ is larger when the constant equal to zero in the model, and therefore has higher explanatory power. Therefore, in this section of the study, we will consider the models with a constant of zero. The results of the models were calculated as follows.

In the table, Total units contains a total of 155 observations from 2015-2019 in 31 provinces. The second technical efficiency model (Ineffi_1) with inefficient units contains 124 observations, all of which are inefficient units calculated by the CCR model. The third technical efficiency model (Ineffi_2) contains 125 observations, including 124 inefficient units and one unit present the average value of 31 efficient units.

*Table 10.*Regression Statistic of models.

Model	Multiple R	R^2	$adj.R^2$	$Std.Err$	F	$p-value$
Linear (Total Units)	0.92801	0.86121	0.85377	0.31146	474.69063	4.29E-66
Linear (Ineffi_1)	0.93828	0.88036	0.87119	0.27288	448.87151	1.05E-56
Linear (Ineffi_2)	0.93807	0.87998	0.87088	0.27399	450.91810	4.40E-57
C-D (Total Units)	0.73767	0.54416	0.53464	0.22543	91.32116	8.95E-27
C-D (Ineffi_1)	0.93828	0.880368	0.87119	0.82132	126.44510	2.28E-30
C-D (Ineffi_2)	0.81895	0.67068	0.65987	0.21370	125.24597	2.69E-30

*Table 11.*Parameters of the models.

	Intercept	Variable 1 (Population)	t-statistic	p-value	Variable 2 (PCDI)	t-statistic	p-value
Linear (T)	0	6.39E-06	8.41863	2.55E-14	1.69E-05	11.87323	1.86E-23
Linear (Ineffi_1)	0	6.52E-06	9.02274	3.23E-15	1.47E-05	11.08517	3.51E-20
Linear (Ineffi_2)	0	6.55E-06	9.02260	3.05E-15	1.48E-05	11.08118	3.26E-20
C-D (T)	0	0.08783	4.152559	5.44E-05	-0.11376	-5.18966	6.60E-07
C-D (Ineffi_1)	0	0.10737	4.80860	4.38E-06	-0.13950	-6.03138	1.79E-08
C-D (Ineffi_2)	0	0.10813	4.83550	3.88E-06	-0.14008	-6.04654	1.64E-08

As can be seen in *Table 6*, the linear models have relative higher $adjusted\ R^2$ value and therefore have higher explanatory power. However, we still choose to use the

logarithmic model for the next step of interpretation. This is because the parameters of the linear model are small and close to zero as can be seen in *Table 7*. Moreover, in the logarithmic model, the parameter of PCDI is negative, which means that the technical efficiency of the museum has negative correlation with PCDI. This result may implying that, the richer people are, the less they visit museums, provides a more meaningful and interesting perspective to proceed to the next analysis.

Among the three logarithmic models, the model only involved efficient units (C-D Ineffi_1) has better explanatory power. However, in order to include efficient units in the model, we chose the third model (C-D Ineffi_2) for the explanation. The model is formulated as follows:

$$TE_{it} = 0.11 \cdot Population - 0.14 \cdot PCDI$$

which means that on average an increase in the Population by 1 unit of measurement leads to a increase in the Technical Efficiency of museum by 0.11 units. And an increase in the PCDI by 1 unit of measurement leads to a decrease in the Technical Efficiency of museum by 0.14 units.

To test the above result that museum efficiency is negatively correlated with PCDI, we examined the relationship between Visitor numbers and PCDI. We used five years of statistics, which is 155 observations. In the model, the dependent variable is the number of visitors, and the first independent variable is population, the second independent variable is PCDI. The result is as following:

*Table 12.*Regression analysis on the number of Visitors

Regression Statistics	
Multiple R	0.99830
R^2	0.99660
$adjusted. R^2$	0.98838
$Std. Err$	0.58582
F	17914.01
$p - value$	2.45E-15

	Coefficients	Standard Error	t-stat	P-value
Intercept	0	N/A	N/A	N/A
Variable 1	1.10955	0.05814	18.09345	2.42E-36
Variable 2	-0.16730	0.06026	-2.63375	0.00954

$$Visitors_{it} = 1.11 \cdot Population - 0.17 \cdot PCDI$$

It can be seen the number of Visitors and the PCDI has negative correlation. On average an increase in the PCDI by 1 unit of measurement leads to a decrease in the Number of visitors by 0.17 units.

This result confirms the impact of people's income on their interest in visiting museums. When the per capita income of a region is higher, the fewer visitors visit the museum.

4.5. Results discussion

In this chapter, we first using DEA approach evaluate the relative technical efficiency of museum affair in each province, from 2015-2019. And then, we use regression analysis explore the relationship between macroeconomic factors and technical efficiency of museums. Based on the analysis, the following conclusions were drawn:

1) The technical efficiency of the museum affair in China is on a decreasing trend and is generally inefficient. Only 20% of the provinces out of a total of 155 observations from 2015-2019 are considered to have achieved relative efficiency and provided optimal management.

2) Regional differences in the performance levels of museum affair are relatively pronounced. From the results of the DEA analysis, it can be seen seven regions, such as Guizhou and Yunnan, consistently provided efficient management over the five-year period and were always located at the efficiency frontier surface. In contrast, the relative technical efficiency of the museum affair in, such as Beijing, Xinjiang, and Qinghai province, is on a decreasing trend.

3) The results of the second-stage regression analysis show that Population size and relative technical efficiency of museum affair in a province has positive correlation.

4) Per Capita Disposable Income is negatively correlated with the relative technical efficiency of museum affair in a province. This was an unexpected finding, and to verify this conclusion, we analyzed the relationship between the Number of visitors and PCDI. The result shows that the Number of visitors is negatively correlated with PCDI. This finding supports our previous result - the richer the people become, the less they visit the museum.

With the above findings, we give the following recommendations.

The results of the DEA analysis show that the level of technical efficiency of the museum affair in China has much room for improvement. Regions that experience input redundancy, such as Beijing, should make full use of museum showpieces for exhibitions. To solve the problem of uneven development between regions, Beijing can use its own showpieces to hold exhibitions in other provinces. This would not only improve the utilization of Beijing's resources, but also promote cultural exchange between regions.

In terms of financial fundings, the agency that manages the state's financial allocations should adjust the amount of funding given to each regional. For example, authority managers should increase financial funding invested in provinces that consistently provide efficient management to encourage the development of museums in that region. However, for regions that are relatively technically inefficient and have a high level of redundancy in financial funding, invest should be reduced and museums should be urged to improve their management level.

Conclusion

In this work, based on panel data from China 2015-2019, 1) First, we propose a DEA model to assess and compare the relative technical efficiency of museum affair in 31 provinces of People's Republic of China; 2) Second, we investigate the correlation between macroeconomic factors and technical efficiency of museum affair in a province.

In the first stage, we use the balanced scorecard (BSC) to select input and output indicators for the further DEA analysis. The combination of these two methods allowed us to focus on key success indicators of museum, and DEA allowed to consider multiple input and output factors simultaneously from the BSC. By comparing different museum organizations, DEA facilitates the identification of suitable benchmarks for the organization and the dissemination of best practices. In the second stage, we used regression analysis to explore the impact of Population size, Per Capital Disposable Income (PCDI), and Gross Regional Production (GRP) on the technical efficiency of the museum affair in each province.

According to the results of analysis, there is still a lot more room for improving the efficiency of China's museum business. China as one of the countries with a long history, has a large number of collections of cultural relics of various types. On the one hand, the large population base places demands on the number of museums, while on the other, it demonstrates the market of potential museum visitors. As a result, museum administrators should take advantage of these benefits to improve the efficiency of museum operations.

We also have some surprising but intriguing findings. The first is the relative technical efficiency of museum affair in Beijing is lower, which even ranks 28th out of 31 in 2019. Beijing is China's capital and the primary location for the government's cultural policies. Beijing's population, number of museums, and number of showpieces are all at the top of the list. We usually think of Beijing as a leader in every way, but

the results of this study demonstrate that Beijing's museum resources are underutilized and that scientific research on cultural objects is inadequate.

Another intriguing finding is the link between disposable income per capita and museum attendance. It is commonly expected that when people's incomes rise, their consumption of cultural things will grow. However, the study reveals a negative correlation between per capita disposable income and the number of museum visitors. Thus, when individuals' incomes rise, their willingness to visit museums declines. This may be related to the fact that when affluence improves, more entertainment options become accessible, limiting the number of museum visits.

It is important to note that the number of visitors in this work refers to the total number of visitors to the museums in the region. The data do not distinguish the origin of the visitors, so the visitors of museums in a province in this work include visitors from the region and also visitors from other provinces.

Moreover, in the second stage of exploring the correlation between Population size and technical efficiency of museum affair in each province, we did not take into account the educational level of the population. According to previous studies, educational level may affect people's willingness to visit museums and, consequently, the efficiency of museums. Taking the educational level of the population into account could be a direction for subsequent research.

Our research has some limitations, but it also presents avenues for future investigation. First, the Decision-making unit (DMU) in this study is the museum affair in a province as opposed to a single museum. This study is important for those in charge of regional cultural policy, although museum administrators may find studies on isolated museums more useful. Second, as stated previously, this study does not divide the population by educational level, and future research could build on this point. Not only can the population be segregated by education level, but also by age, to examine the relationship between age and museum effectiveness. Thirdly, this work applies the CCR model under the assumption that scale efficiency remains constant. The following

study can use both CCR and BCC models to divide global technological efficiency into pure technical efficiency and scale efficiency, and then examine the impacts of pure technical efficiency and scale efficiency on worldwide technical efficiency.

This study is of interest not only for its utility to authorities responsible for local cultural policy, but also because it demonstrates how public cultural institutions, such as museums, are performing increasingly diverse functions and maximizing financial resources to provide a broader range of cultural services. China's cultural construction enterprise continues to expand fast, with government backing. Consequently, it is of utmost importance to investigate if, in addition to the quick increase in the number of museums, there has also been an increase in the relative technical efficiency of museum operations in each province amidst rapid development.

References

1. Agapova. D (2012). Culture of participation: millions of dialogues. SHCHERBAKOV, AA Museum as an educational space: game, dialogue, culture of participation. Moscow.

2. Asuaga, C., & Peombo, C. (2010). Museums and Balanced Scorecard- A Customer Perspective Adaptation. Revista Costos y Gestión, 78, 28–39.

3. Basso, A., Funari, S.: Measuring the performance of museums: classical and FDH DEA models. Rend. Stud. Econ. Quant. 2003, 1–16 (2003)

4. Basso, A., & Funari, S. (2004). A quantitative approach to evaluate the relative efficiency of museums. Journal of cultural economics, 28(3), 195-216.

5. Basso, A., Casarin, F., & Funari, S. (2018). How well is the museum performing? A joint use of DEA and BSC to measure the performance of museums. Omega, 81, 67–84.

6. B. Nguyen, V. Zelenyuk. (2021). Robust Efficiency Analysis of Public Hospitals in Queensland, Australia.

7. Burton, C., & Scott, C. (2003). Museums: Challenges for the 21st century. International journal of arts management, 56-68.

8. Charnes, A., Cooper, W. W., & Rhodes, E. (1978). A Data Envelopment Analysis Approach to Evaluation of the Program Follow through Experiment in US Public School Education. Carnegie-Mellon Univ Pittsburgh Pa Management Sciences Research Group.

9. Del Barrio-Tellado, M. J., Gómez-Vega, M., Gómez-Zapata, J. D., & Herrero-Prieto, L. C. (2021). Urban public libraries: Performance analysis using dynamic-network-DEA. Socio-Economic Planning Sciences, 74, 100928.

10. Del Barrio-Tellado, M. J., & Herrero-Prieto, L. C. (2022). Analysing productivity and technical change in museums: A dynamic network approach. Journal of Cultural Heritage, 53, 24-34.

11. Dictionary of current museum terms. Museum, 2009, no. 5, p. 55.

12. Epstein, M. J., & Manzoni, J. F. (1997). The Balanced Scorecard and Tableau de Bord: a global perspective on translating strategy into action (Vol. 63). Fontainebleau: Insead.

13. Frumkin, P., & Kim, M. T. (2002). The effect of government funding on nonprofit administrative efficiency: An empirical test. Institute for Government Innovation, John F. Kennedy School of Government, Harvard University.

14. Gong Liang. (2021). High-Quality Development of the Museum: Quality, Performance and Evaluation.

15. Gori, E., & Fissi, S. (2013). From cash to accrual accounting: A model to evaluate the performance of public museums. Revista de Management Comparat International, 14(4), 519.

16. Haldma, T., & Lääts, K. (2012). The Balanced Scorecard as a performance management tool for museums. In Best Practices in Management Accounting (pp. 232-252). Palgrave Macmillan, London.

17. HU Hui-yuan. (2020). Regional Differences in Operation Efficiency of Provincial Museums in China: Trend, Reasons, and Implications. Journal of Shen Zhen University (Humaninities & Social Sciences). Vol.37 No.6.

18. Kaplan, R. S. (2001). Strategic performance measurement and management in nonprofit organizations. Nonprofit management and Leadership, 11(3), 353-370.

19. Kaplan, R. S., & Norton, D. P. (2005). The balanced scorecard: measures that drive performance. Harvard business review, 83(7), 172.

20. Kaplan, R. S., & Norton, D. P. (1996). Using the balanced scorecard as a strategic management system.

21. KULEMZIN, Anatoly M. Ideological aspects of mseology. Bulletin of Kemerovo State University of Culture and Arts, 2012, no. 18, p. 31.

22. Lebas, M., & Euske, K. (2002). A conceptual and operational delineation of performance. Business performance measurement: Theory and practice, 65-79.

23. Linfeng Tian, Aiyun Zhang. (2018). A Review on Studies of Library Efficiency Evaluation by Using DEA Method.

24. Lin, Y. N. (2006). Leisure-A function of museums? The Taiwan perspective. Museum Management and Curatorship, 21(4), 302-316.

25. Maddison, D., & Foster, T. (2003). Valuing congestion costs in the British Museum. Oxford Economic Papers, 55(1), 173–190.

26. Milovanov, K. Y., Nikitina, E. Y., Sokolova, N. L., & Sergeyeva, M. G. (2017). The creative potential of museum pedagogy within the modern society. Espacios, 38(40), 27.

27. Morkovkin, Y. V. Development strategy for the cultural institution. Market models of economic activity, case study of Ryazan historical and architectural museum-reserve. Handbook for head staff of the cultural institution, 2004, no. 3, p. 33.

28. Paulus, O. (2003). Measuring museum performance: A study of museums in France and the United States. International journal of arts management, 50-63.

29. Pop, I. L., & Borza, A. (2016). Factors influencing museum sustainability and indicators for museum sustainability measurement. Sustainability, 8(1), 101.

30. Prokůpek, M. (2016). Možnosti využití nástroje Balanced Scorecard v řízení muzeí. Museum: Museum & Regional Studies, 54(2).

31. Yue Nan，Liu Shu-guang. (2019). Performance Evaluation: Strong Method to Improve Museum Management-Case Study of Central Local Construction of National Museum.

32. Sofia Bollo & Yu Zhang. (2017). Policy and Impact of Public Museums in China: Exploring New Trends and Challenges, Museum International, 69:3-4, 26-37.

33. Sotnikova, Svetlana I. Natural history museum: from scientific factology to formation the bases of ecological culture (historical journey). In Abstracts of the scientific conference, November 25–26, 1997. Moscow, 1997, pp. 20–22.

34. Tang, J., & Qiu, C. (2015). Research on motivation, experience, satisfaction and behavioral intention of museum tourism—A case of Macau Museum. In Tourism and hospitality development between China and EU (pp. 137-153). Springer, Berlin, Heidelberg.

35. Yue Nan. (2017). Research on the Performance Evaluation of Chinese State-owned Museum

36. Zhang, F., & Courty, P. (2021). The China Museum Boom: soft power and cultural nationalism. International Journal of Cultural Policy, 27(1), 30-49.

37. Zorloni A. Designing a strategic framework to assess museum activities. Int J Arts Manag 2012;14(2):31–47.

Appendix

Appendix 1.   Relative technical efficiency of museum affair in 31 provinces 2015 - 2019
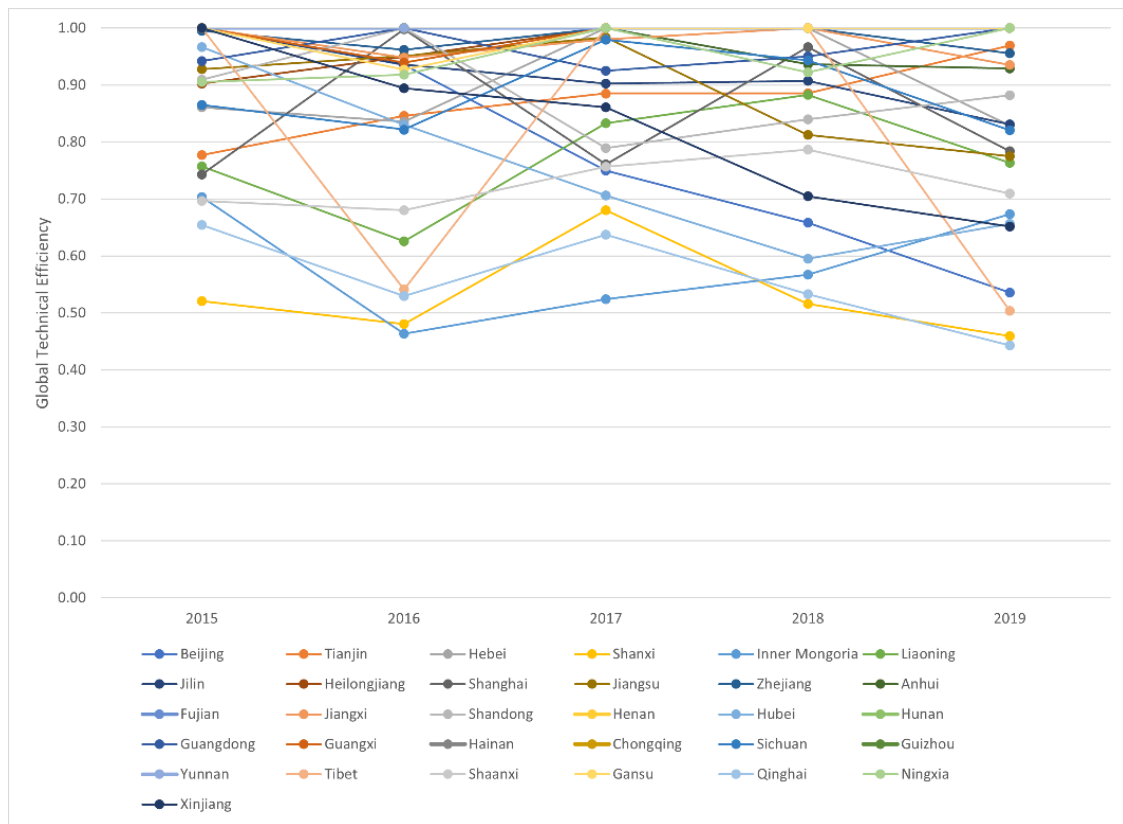
Appendix 2.   Efficient DMUs in 155 observations.

DMU	Score
Beijing-15	1
Jilin -15	1
Heilongjiang -18	1
Heilongjiang -19	1
Anhui-16	1
Fujian -16	1
Fujian -18	1
Fujian -19	1
Henan -16	1
Henan -18	1
Hunan -15	1
Hunan -17	1
Hunan -18	1
Hunan -19	1
Guangdong -19	1
Guangxi -15	1
Guangxi -17	1
Hainan -15	1
Hainan -16	1
Hainan -18	1
Hainan -19	1
Chongqing -16	1
Chongqing -17	1
Chongqing -18	1
Guizhou -15	1
Guizhou -16	1
Guizhou -19	1
Yunnan-15	1
Tibet-15	1
Tibet-17	1
Gansu-19	1