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Exploring the Impact of Quantitative Easing Policy on the Business Performance of Construction Companies with the Debt Ratio as a Moderator

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Abstract: During the 2008 financial crisis, central banks (such as the Fed) adopted a quantitative easing (QE) policy to stimulate their countries' economies and overcome severe economic and financial recessions. However, apart from stimulating the economy by issuing a substantial amount of currency to purchase long-term bonds and suppress interest rates, QE policy also contributed to a boom in the real estate and construction sectors. Therefore, this study employs data envelopment analysis to measure the business performance (BP) of construction companies, and explore the impact of QE policy on the BP of construction companies, between 2004 and 2015, using hierarchical regression. We also examine the moderating role of the debt ratio on the relationship. Focused on publicly listed construction companies in Taiwan, this research reveals three encouraging findings. Firstly, QE policy indeed enhanced the BP of Taiwanese construction companies. Secondly, performance improvements in construction companies due to QE policy show a time-diminishing trend, suggesting the importance of seizing the initial policy benefits of QE implementation. Lastly, construction companies with appropriate financial leverage may exhibit better BP. These findings can provide valuable insights for relevant government entities and decision-makers in the industry for policy and investment decisions.

Keywords: quantitative easing policy; construction companies; data envelopment analysis; time lag; moderator

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1. Introduction

After the 2008 financial crisis, in an attempt to combat what was emerging as the most severe recession since 1937, the Federal Open Market Committee (FOMC) lowered the federal funds rate to almost zero, as described by Blinder [1]. As a result, the Federal Reserve began implementing a quantitative easing (QE) policy, which involved the purchasing of long-term bonds through the creation of new money. This move aimed to increase the prices of long-term bonds and lower interest rates, thereby reducing mortgage rates and supporting the real estate market [2]. Mukerji, Saeed, and Tan [3] analyzed the expansive monetary policy by the Federal Reserve, which indirectly influenced the prosperity of, and decline in, the real estate market by impacting the savings decisions and determinations of household units.

According to the report by the Central Bank of the Republic of China [4] on QE policy, this policy can support asset prices, leading to an economic boost through a rise in asset prices. By directly purchasing medium- and long-term assets from the private sector and setting purchase targets, the central bank can directly influence medium- and long-term interest rates (and real interest rates). This effect is transmitted through various channels, including inflation expectations, wealth, credit, and exchange rates (as shown in

Figure 1). As a result, stock and property prices also increase, contributing to an overall improvement in economic efficiency. Many studies also support the finding that QE policies have a positive impact on the economy [5–7].

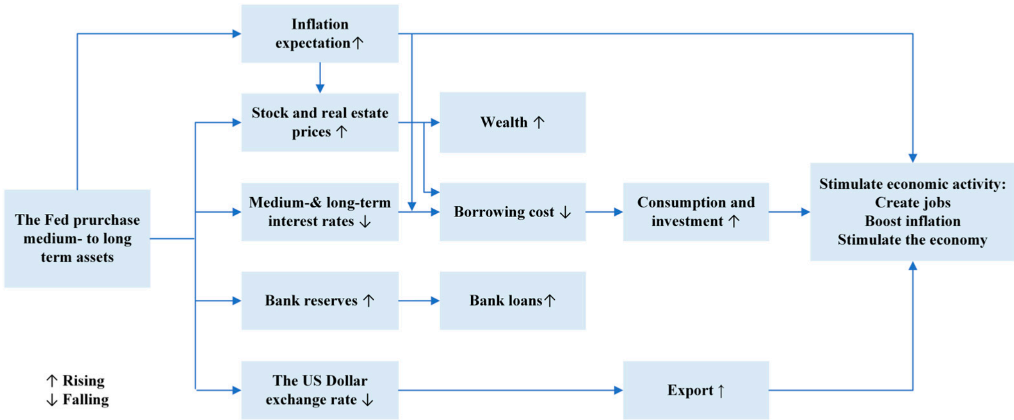

Figure 1. The transmission channels of QE policy: the case of the United States. Source: [4].

According to Cho and Rhee's [8] findings, the implementation of QE policy has aimed to support Asian economies by reducing financial risks and stabilizing long-term policy rates, leading to a decrease in interest rates in the region. Following the global financial crisis, asset prices, including real estate prices, have risen amid favorable liquidity conditions in certain countries. In Taiwan, for instance, this study also indicates a steady 57% increase in real estate prices from 2008 to 2012. Many studies also mention the impact of QE policy on the performance of the construction and real estate industries [9–11].

This study investigates the impact of QE policy on the business performance (BP) of construction and real estate development companies listed on the Taiwan Stock Exchange (TWSE). The motivation behind this research is to explore how the implementation of QE policy affects the performance of these companies.

Farrell [12] introduced the concept and method of efficiency boundaries and efficiency measurement, respectively, for the first time. Subsequent research building upon this idea led to the development of various methods to measure efficiency levels in production. These methods are also known as data envelopment analyses (DEA). Therefore, there have been many studies in the past that have used the DEA method to measure the BP of the real estate industry.

Some studies have used real estate investment trusts (REITs) as decision making units (DMUs) [13,14], while others have used real estate and construction companies as their research DMUs [15–18]. There have also been many studies that have used provinces, states, or countries as DMUs to conduct efficiency research on the real estate and construction industries [19–22].

The construction sector significantly impacts the gross domestic product (GDP) and socio-economic development objectives, including employment, the monetary system, and inflation [23]. Taking various countries as examples, the contribution of the construction sector to their respective GDP is as follows: in Taiwan, it accounted for 3.3% in 2021 [24]; in the United States, it was 4.1% in 2019; and in the European Union, it was 9% in 2019 [25]. Therefore, the construction industry is a significant component of a country's economy and a crucial pillar for economic growth and development [26]. Hence, this study focuses on the performance of the construction industry as its research subject.

However, despite the importance of QE policy, there is only limited research that explores its influence and importance in the construction industry before and after the 2009 financial crisis in Taiwan. Thus, it is important to determine what effect QE has had on the time lagging of Taiwan's construction industry performance. In addition, there is insufficient research on the implementation of debt ratio as a moderator. To begin with, this research employs the DEA method to assess the performance of construction companies from 2004 to 2015, based on financial data extracted from their reports in the *Taiwan Economic Journal* (TEJ). The results indicate that most companies have experienced some degree of performance growth.

Building on these findings, this study further analyzes the differences between the pre-QE period (2004–2009) and the post-QE period (2010–2015) to understand the impact of QE on the performance of construction companies. The study reveals that the implementation of QE has had a more significant impact on the performance of the construction industry compared to the past. This indicates the influence of QE on the industry's BP. The results of this research can serve as valuable references for policymakers and decision-makers in relevant government departments and industries when making policy decisions and creating investment strategies.

This study aims to provide a comprehensive investigation into the impact of QE policy on the BP of construction companies using hierarchical regression. By offering relevant data, research conclusions, and response strategies, this study aims to serve as a resource for decision making within the construction industry. It aims to enable companies to grasp and address the effects and potential challenges posed by QE policy, ultimately enhancing the efficiency of their BP.

2. Literature Review

2.1. Data Envelopment Analysis

Farrell [12] first proposed the concept of efficiency boundaries and the method of efficiency measurement. This method does not need to set the function form, but uses the mathematical programming formula to find the efficiency boundary composed of the most efficient production combination points to measure the relative efficiency among DMUs. Later studies began to use this to develop different methods to measure efficiency levels with production efficiency. These methods are roughly divided into two types, namely methods that use linear programming as a tool (for example DEA) and those that use econometrics to estimate production efficiency.

DEA, which is a nonparametric evaluated method for relative productive efficiency among DMUs, was first introduced by Charnes, Cooper, and Rhodes [27]. It was initially called the CCR model, and through mathematical programming, it was integrated with the method developed by Farrell and Fieldhouse, i.e., envelope theory, and has been widely utilized in performance and productivity assessment since.

Subsequently, Banker, Charnes, and Cooper [28] showed that the constant return to scale assumption is implied in the CCR model, and introduced the BCC model based on the variable return to scale assumption, and this modified model can be further separated into technical and scale efficiencies.

Tone [29] proposes a new measure of efficiency based on an input surplus and output shortage. The slacks-based measure of efficiency (SBM) is a method to measure non-radial efficiency, which complies with the unit invariant assumption and can measure the efficiency value by integrating the differential variables. In addition, the measurement is determined solely on the basis of the reference set of the DMU and is not impacted by statistics over the entire dataset. The new measurement closely connects with other methods proposed, e.g., the two models mentioned above. The dual side of this method can be interpreted as profit maximization, in contrast to the ratio maximization of the CCR model.

2.2. The Relation between Construction Company Efficiency and DEA

Previous studies have evaluated construction companies using several forms of DEA and through the implementation of various models. For example, Anderson, Fok, and Springer [13] employed the BCC method, which is one of the most popular forms of DEA, to measure technical efficiency and economies of scale for publicly traded REITs as listed in the NAREIT (National Association of Real Estate Investment Trusts) from 1992 to 1996. Topuz, Darrat, and Shelor [14] applied CCR and BCC input-oriented models and covered

280 equity REITs in the US to empirically study several aspects of the efficiency of REITs in the 1990s. You and Zi [16] applied DEA to measure the cost of South Korea's efficiency, configuration efficiency, and technical efficiency differences before and after production in construction companies in crisis.

In addition, Xue, Shen, and Wang [22] used the DEA-based Malmquist productivity observation method to continuously improve the efficiency of China's construction industry from 1997 to 2003. Zheng, Chau, and Hui [18] used the 2009 annual financial statement of the Listed Real Estate Companies in the Chinese stock market with the CCR, BCC, and Super-Efficiency-DEA models to investigate the efficiency and performance of these companies. Kapelko and Lansink [30] adopted the DEA method to estimate technical efficiency in the construction sector before and after the start of the financial crisis, and examine the impact of socio-economic factors on technical efficiency in Spain.

Moreover, Hu and Liu [31] used the two-stage DEA model to create a tool for measuring the construction industry's performance, showing its effectiveness and efficiency in China. Chen, Song, and Pan [32] adopted the DEA data package analysis method to analyze the execution efficiency of the evolution of the performance of China's construction companies. Yang and Fang [33] applied the SBM model and the Malmquist index model to examine the green productivity of 15 real estate firms in China.

Furthermore, Horta, Kapelko, and Oude Lansink [34] aimed to examine the dynamics in the performance of the construction industry in Portugal, assessed the factors that promote excellence and innovation within an industry using the CCR model, which is a type of DEA method, and also proposed a new DEA method to evaluate innovation in this field. Wong, Gholipour, and Bazrafshan [35] used the SBM model to investigate different efficiency fields in 12 real estate and construction companies in Iran in the last few years.

Generally speaking, in order to measure productivity and efficiency, studies on the construction industry have shifted from the appraisal of a single region or country to the appraisal of multiple companies, regions, and nations. For instance, Horta, Camanho, and Johnes [36] collected data from 118 construction companies in Europe, Asia, and North America from 1993 to 2005, then applied DEA and Malmquist indicators for the purpose of evaluating efficiency and changes in efficiency. This study was conducted as an international benchmarking study on the construction industry, and the authors also observed the impact of the level of efficiency on the location. However, we can assume that if they were to observe the differences in technology sets between companies and focus only on location, their work would improve.

In addition, Park, Yoo, and Lee [37] analyzed efficiency and productivity in Taiwanese, Japanese, and Korean construction companies, adopting the Malmquist method based on DEA. Horta, Kapelko, and Oude Lansink [34] aimed to research how diversification and internationalization strategies impacted the performance of multiple companies in the Spanish and Portuguese construction industry through the DEA model.

According to the literature, the DEA method has industrial value and provides a basis for decision-making regarding construction companies' performance. Various specific studies have used DEA-based methodologies to assess the performance of construction companies (see Table 1).

Table 1. A summary of the methodology used for measuring the performance of construction companies in the selected literature.

Study	Main Issuees Addressed	Region/Country	Decision-Making Units	Method
[13]	This study measures technical efficiency and economies of scale for REITs.	US	All REITs as listed in the NAREIT	BCC
[14]	This paper explores various efficiency aspects of REITs in light of their remarkable growth in the 1990s.	US	235 equity REITs	CCR, BCC
[16]	This article gauges and analyses different types of efficiency for the period 1996 to 2000.	Korea	Listed construction firms	CCR

Table 1. *Cont.*

Study	Main Issuees Addressed	Region/Country	Decision-Making Units	Method
[22]	This paper measures the productivity changes of the Chinese construction industry from 1997 to 2003.	China	4 regions construction industry	Malmquist index
[18]	This study measures the performance and efficiency of the listed real estate companies.	China	94 listed real estate companies	CCR, BCC, Super-efficiency DEA
[15]	This paper examines trends in the performance of the construction industry and identify the factors that promote excellence and innovation in the sector.	Portugal	110 major contractors laboring on public works	CCR
[35]	This paper explores various efficiency aspects of real estate and construction companies in Iran in light of their remarkable growth in recent years.	Iran	12 real estate and construction companies	SBM
[36]	This paper assesses construction companies' efficiency levels, exploring in particular the effect of location and activity in the efficiency levels.	Worldwide	118 construction companies	CCR, Malmquist index
[30]	This paper estimates technical efficiency in the construction sector before and after the start of the financial crisis and examines the impact of socio-economic factors on technical efficiency.	Spain	construction industry	DEA
[37]	This study aims to compare the efficiency and productivity of Chinese, Japanese, and Korean construction firms between 2005 and 2011.	China, Japan and Korea	32 construction firms	Malmquist index
[34]	This paper investigates the impact of internationalization and diversification strategies on the financial performance of construction companies.	Spain, Portugal	90,875 construction companies	CCR
[31]	This paper aims to develop a simultaneous measurement of overall performance and its two dimensions of efficiency and effectiveness.	China	31 provinces	Two-stage DEA
[32]	This paper aims to measure the evolution of the destocking performance of the real estate industry.	China	62 central cities and other regions	Malmquist index
[33]	This paper evaluates the green productivity of real estate companies statically and dynamically.	China	15 real estate companies	SBM, Malmquist index

2.3. The Effect of QE Policy on Performance of Construction Companies

After the 2008 financial crisis, in an attempt to combat what was emerging as the most severe recession since 1937–1938, the Federal Open Market Committee (FOMC) lowered the federal funds rate to almost zero, as described by Blinder [1]. As a result, the Federal Reserve began implementing QE policies, which involved the purchasing of long-term bonds through the creation of new money. This move aimed to increase the prices of long-term bonds and lower interest rates, thereby reducing mortgage rates and supporting the real estate market [2]. According to CBC [4], QE can support asset prices. Through asset price increases, the economy is boosted, such as through the direct purchasing of medium- and long-term assets from the private sector, setting purchase targets to directly affect medium- and long-term interest rates (and real interest rates), as well as through inflation expectation channels, wealth channels, credit channels, and exchange rate channels, etc., to convey the effect of monetary policy. Therefore, stock prices and movable property prices also rise to drive economic efficiency.

Many previous studies have primarily been aimed at studying the impact of QE policies on the construction and real estate industries. Xu and Chen [11] aimed to investigate the effects of monetary policy, including long-term borrowing interest rates, money supply, and mortgage credit conditions, on house price growth in China from 1998 Q1 to 2009 Q4. The empirical outcomes showed that an expansionary monetary policy accelerated the growth of real estate prices. Cho and Rhee [8] pointed out that QE was implemented in the economies of East Asian countries in order to reduce financial risks and stabilize the long-term policy rate, decreasing the interest rate in the area. Since the global financial crisis, asset prices (including real estate prices) have increased in high-liquidity circumstances in some countries. In truth, this study also presents data which show that real estate prices steadily rose by 57% in Taiwan from 2008 to 2012.

According to the IMF [38], housing prices in Asian economies such as Hong Kong, Malaysia, Singapore, and Taiwan have risen rapidly since the 2008 crisis. This evidence supports the international spillover effects of QE policy; therefore, this study infers that QE will also have an impact on the promotion of Taiwan's construction companies.

In addition, Bénétrix, Eichengreen, and O'Rourke [39] pointed out that the FOMC has sought to reduce long-term federal interest rates and mortgage interest rates to support the real estate market by purchasing long-term government bonds. Füss and Zietz [40] explored whether the national monetary policy has had significantly different impacts on the growth of real estate prices across cities. Their empirical results demonstrated that real estate price boosts are associated with lower interest rates. Ho, Zhang, and Zhou [9] created a factor-augmented vector autoregression model to predict whether unexpected modifications and uncertainties in monetary and economic policy affect the real estate, loan, and stock market in China. The analysis results revealed a remarkable increase in real estate investment due to the decrease in the US federal interest rate.

Moreover, Rosenberg [41] used the Bayesian structural vector autoregressive model to explore the impact of monetary policy on real estate prices, including the interest rate and balance sheet policies of the central bank in 30 years. The empirical results demonstrated that the interest rates and the balance sheet have a positive correlation with the real estate prices in Scandinavian countries in response to an expansionary monetary policy. Ryczkowski [42] studied the relationship between credit loosening and the rise in house prices in twelve developed countries. The results found that the rise in money supply and credit condition, as tools for the QE policy in the US and the UK, were associated with the house price increase.

Furthermore, Miyakoshi, Li, and Shimada [10] indicated that the Hong Kong REIT (H-REIT) market can formulate and promote housing prices through QE policy. Zhang and Pan [43] developed a smooth transition vector autoregression model to study the monetary policy and economic output of the real estate market. The analysis indicated that whenever the real estate market suffers from low growth, the real estate market is successfully stimulated by means of QE in China.

To sum up, these studies show that the implementation of QE policy can help improve the operating performance of the construction or real estate industries. As mentioned above, QE policy can help the performance of enterprises, and some researchers have mentioned that QE policy leads to an increase in the company's financial leverage.

According to a study by Acharya and Plantin [44], the Federal Reserve, through its QE policy, kept its policy rate as low as possible due to the financial crisis in 2008. The results found that the financial condition of companies in the US has undergone great change thanks to QE policy, including a remarkable rise in leverage. Alter and Elekdag [45] examined the influence exerted on the financial leverage of a company by the financial crisis in emerging markets. The results indicated that the global financial crisis caused companies' financial leverage to grow faster due to the implementation of QE policy, including adjusting borrowing interest rates and loosening borrowing constraints in the emerging market. Koráb, Mallek, and Dibooglu [46] tested the implications of QE policy on companies' performance in the Eurozone during the implementation of the Corporate Sector Purchase Programme (CSPP) measure from the European Central Bank (ECB). The empirical evidence showed an increase in the leverage of the company owing to the CSPP.

Another study also focused on whether the real estate industry will have higher financial leverage due to QE policy. Frame and Steiner [47] explored whether mortgage REIT (MREIT) agencies tend to revise their financial investments in reaction to QE policy. The results showed that MREIT agencies increased their leverage in response to QE policy to attain returns.

In the following section of this study, some previous research that has explored whether the effect of QE policy diminishes after its implementation is described. After the financial crisis in 2008, the US Federal Reserve implemented QE policies three times. Lin, Batmunkh, and Moslehpour [48] investigated the effects of QE on emerging markets. The results found that the first stage of QE leads to extremely significant effects. Moreover, their study pointed out that leverage related to QE policy reduced and diminished over the course of the three implementations of the policy.

Also, Hauzenberger, Pfarrhofer, and Stelzer [49] examined the impacts of the conventional and unconventional monetary policies applied by the ECB. The results pointed out that the transmission mechanism of the monetary system is broken when economic and financial uncertainty levels rise. Moreover, the conventional monetary policy and forward guidance were comparatively less valid to overcome the financial crisis during uncertain times. Therefore, QE, an unconventional monetary policy, was more effective during this period. In other words, QE policies are less effective when uncertainty drops.

Some studies have also demonstrated that the effect of QE policy is very short-lived and temporal. When the Bank of Japan (BOJ) applied its QE policy, Girardin and Moussa [50] showed that the impact of this policy was short-lived, only lasting for a year in stimulating outputs and prices.

In addition, Bowman, Cai, and Davies [51] aimed to investigate the impacts of unconventional monetary policy measures from the BOJ in stimulating bank lending. The results supported the authors' belief that liquidity has a significantly powerful and positive impact on lending activity, which demonstrates that the extension of liquidity flow related to the QE's stream of credit is beneficial. However, the size and impacts of the boost were small and short during the first few years. Martin and Milas [52] pointed out that government bond rates decreased with large-scale asset purchases, a tool of QE policy. However, this effect can be temporary, and the initial stage of QE policy is more effective than the follow-up stage.

Based on the previous literature, numerous studies have indicated that the implementation of an expansionary monetary policy, specifically QE policy, by central banks has effects that are transmitted through the monetary mechanism to the economy, thereby influencing the performance of the construction industry. Furthermore, a positive correlation has been observed between QE policy and the performance of the construction industry.

Some studies have argued that the impact of QE policy transmission through the monetary mechanism on economic performance diminishes over time after the policy's implementation. In other words, the initial impact of QE policy on the economy is the most significant, but this impact gradually diminishes as time passes.

Additionally, some research works have suggested that the degree of impact of QE policy implementation on the economy depends on the level of financial leverage. It has been found that the overall economy experiences an increase in financial leverage following the implementation of QE policy. This suggests that in order to further expand the magnitude of performance growth, economic entities should enhance their financial leverage through borrowing, aiming to achieve better performance results thanks to QE policy. Based on these findings, this study proposes the following three hypotheses:

H1. *QE policy has a significantly positive impact on the BP of construction companies.*

H2. *The impact of QE policy on the BP of construction companies diminishes over time after its implementation.*

H3. *The debt ratio has a moderating effect on the relationship between QE policy and the BP of construction companies.*

3. Methodology

3.1. Research Framework

Figure 2 demonstrates a conceptual research framework to discuss the relevance of multiple variables related to Taiwanese construction companies under the implementation of QE policy. The effect of the QE indicators on the BP is examined; the QE is considered an independent variable in this framework. In this study, QE influences BP, which is the dependent variable in the framework. With the moderating variable being debt ratio, the main objectives of this study were to examine the relationship between QE and BP. Thus, a visual conceptual framework helped to clarify the links between variables. To avoid collinearity, size and ROA were used as control variables.

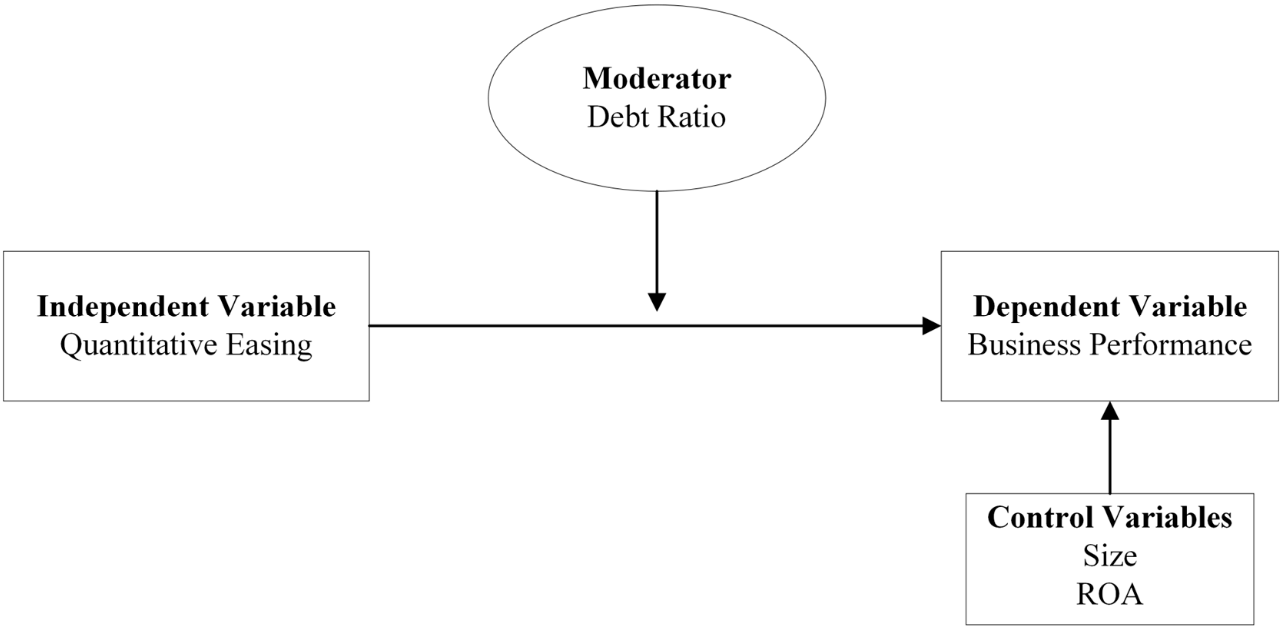

Figure 2. Conceptual research framework.

3.2. Sample and Data

This study investigated the 12-year financial report data of the Taiwan Economic Journal (TEJ), selecting 43 sets of data from 44 listed construction and real estate companies (because one of the companies, Fengding-KY, was established relatively late, the data could not be fully provided) in Taiwan. As shown in Appendix A, we employed data from 2004 to 2015 for listed Taiwan construction companies, comprising a total of 516 observations.

3.3. QE Measurement

In this study, we followed the CBC [4] report on QE policy to measure QE. After the 2008 financial crisis, QE was implemented. This study used 2004–2009 as the period before the implementation of QE, and the period of 2010–2015 as the period after QE. An indicator variable of 0 or 1 was used to indicate that the period was 2004–2009 or 2010–2015, respectively.

3.4. BP Measurement Using the Dynamic SBM (DSBM) Model

Regarding the formulation of the dynamic DEA approach described by Tone and Tsutsui [53], Figure 3 presents the dynamic processes that deal with n DMUs (p = 1, . . ., n) over T terms (t = 1, . . ., T). In each period, DMUs have o discretionary inputs (i = 1, . . ., o), j non-discretionary inputs (i = 1, . . ., j), u discretionary outputs (i = 1, . . ., u), and k non-discretionary outputs (i = 1, . . ., k). x_{ipt} (i = 1, . . ., o), x_{ipt}^{fix} (i = 1, . . ., j), y_{ipt} (i = 1, . . ., u), and y_{ipt}^{fix} (i = 1, . . ., k) represent the observed discretionary input, the non-discretionary input, and the discretionary output and non-discretionary output values of DMU p at term t, respectively. We represent the four class links as h^{good}, h^{bad}, h^{free} and h^{fix}. For the purpose of identifying them by term (t), DMU (p), and item (i), we utilize the notation h_{ipt}^{good} (i = 1, . . ., ngood; p = 1, . . ., n; t =1, . . ., T), demonstrating good link values where ngood is the number of good links up to the term T.

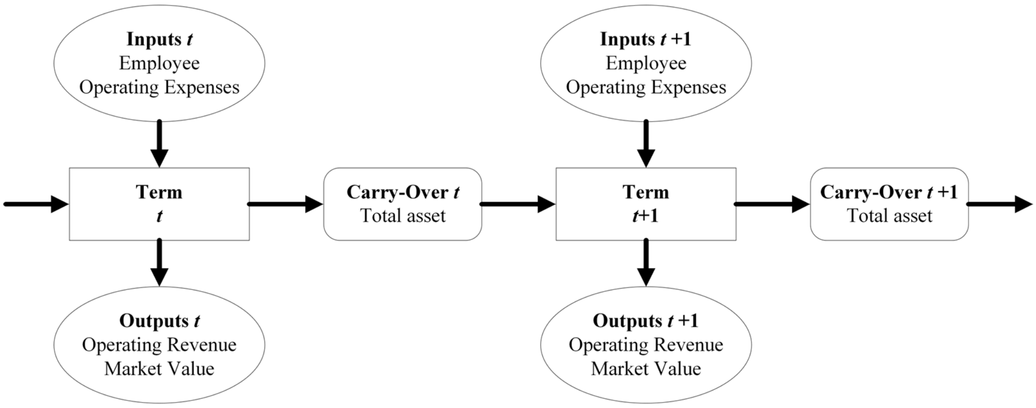

Figure 3. Dynamic structure.

The production expressions $\{x_{it}\}$, $\{x_{it}^{fix}\}$, $\{y_{it}\}$, $\{y_{it}^{fix}\}$, $\{h_{it}^{good}\}$, $\{h_{it}^{bad}\}$, $\{h_{it}^{free}\}$ and $\{h_{it}^{fix}\}$ are defined by

$$x_{it} \geq \sum_{p=1}^{n} x_{ipt}\lambda_p^t (i = 1, \ldots, o; t = 1, \ldots, T)$$

$$x_{it}^{fix} = \sum_{p=1}^{n} x_{ipt}^{fix}\lambda_p^t (i = 1, \ldots, j; t = 1, \ldots, T)$$

$$y_{it} \leq \sum_{p=1}^{n} y_{ipt}\lambda_p^t (i = 1, \ldots, u; t = 1, \ldots, T)$$

$$y_{it}^{fix} = \sum_{p=1}^{n} y_{ipt}^{fix}\lambda_p^t (i = 1, \ldots, k; t = 1, \ldots, T)$$

$$h_{it}^{good} \leq \sum_{p=1}^{n} h_{ipt}^{good}\lambda_p^t (i = 1, \ldots, ngood; t = 1, \ldots, T)$$

$$h_{it}^{bad} \geq \sum_{p=1}^{n} h_{ipt}^{bad}\lambda_p^t (i = 1, \ldots, nbad; t = 1, \ldots, T)$$

$$h_{it}^{free} : free(i = 1, \ldots, nfree; t = 1, \ldots, T)$$

$$h_{it}^{fix} = \sum_{p=1}^{n} h_{ipt}^{fix}\lambda_p^t (i = 1, \ldots, nfix; t = 1, \ldots, T)$$

$$\lambda_p^t \geq 0 (p = 1, \ldots, n : t = 1, \ldots, T)$$

$$\sum_{p=1}^{n} \lambda_p^t = 1 (t = 1, \ldots, T), \quad (1)$$

where $\lambda^t \in$ Rn (t = 1,. . ., T) is the intensity vector to the term t, with nbad, nfree, and nfix being the number of bad, free, and fixed links, respectively. The last limitation is related to the variable return-to-scale assumption. If this limitation has been deleted, we have a constant return-to-scale structure. Note that x_{ipt}, x_{ipt}^{fix}, y_{ipt}, y_{ipt}^{fix}, h_{ipt}^{good}, h_{ipt}^{bad}, and h_{ipt}^{fix} on the right are observed data, while x_{it}, x_{it}^{fix}, y_{it}, y_{it}^{fix}, h_{it}^{good}, h_{it}^{bad}, h_{it}^{free}, and h_{it}^{fix} on the left are variables connected by the intensity variable λ_p^t.

The continuity of linking flows between the terms t and t + 1 can be ensured by the following conditions:

$$\sum_{p=1}^{n} h_{ipt}^{\varepsilon}\lambda_p^t = \sum_{p=1}^{n} h_{ipt}^{\varepsilon}\lambda_p^{t+1} (\forall i; t = 1, \ldots, T-1), \quad (2)$$

where the symbol ε represents good, bad, free, or fix. This limitation is important to the dynamic structure, as it connects the term t and the term t + 1.

The expressions for the production of DMUq (q = 1, . . ., n) are as follows:

$$
\begin{gathered}
x_{iqt} = \sum_{p=1}^{n} x_{ipt}\lambda_p^t + s_{it}^{-}(i = 1, \ldots, o; t = 1, \ldots, T) \\
x_{iqt}^{fix} = \sum_{p=1}^{n} x_{ipt}^{fix}\lambda_p^t(i = 1, \ldots, j; t = 1, \ldots, T) \\
y_{iqt} = \sum_{p=1}^{n} y_{ipt}\lambda_p^t - s_{it}^{+}(i = 1, \ldots, u; t = 1, \ldots, T) \\
y_{iqt}^{fix} = \sum_{p=1}^{n} y_{ipt}^{fix}\lambda_p^t(i = 1, \ldots, k; t = 1, \ldots, T) \\
h_{iqt}^{good} = \sum_{p=1}^{n} h_{ipt}^{good}\lambda_p^t - s_{it}^{good}(i = 1, \ldots, ngood; t = 1, \ldots, T) \\
h_{iqt}^{bad} = \sum_{p=1}^{n} h_{ipt}^{bad}\lambda_p^t + s_{it}^{bad}(i = 1, \ldots, nbad; t = 1, \ldots, T) \\
h_{iqt}^{free} = \sum_{p=1}^{n} h_{ipt}^{free}\lambda_p^t + s_{it}^{free}(i = 1, \ldots, nfree; t = 1, \ldots, T) \\
h_{iqt}^{fix} = \sum_{p=1}^{n} h_{ipt}^{fix}\lambda_p^t(i = 1, \ldots, nfix; t = 1, \ldots, T) \\
\sum_{p=1}^{n} \lambda_p^t = 1(t = 1, \ldots, T) \\
\lambda_p^t \geq 0, s_{it}^{-} \geq 0, s_{it}^{+} \geq 0, s_{it}^{good} \geq 0, u_{it}^{bad} \geq 0 \text{ and } s_{it}^{free} : free(\forall i, t),
\end{gathered}
\tag{3}
$$

where s_{it}^{-}, s_{it}^{+}, s_{it}^{good}, s_{it}^{bad}, and s_{it}^{free} are slack variables demonstrating input excess, output shortfall, link shortfall, link excess, and link deviation, respectively.

In evaluating the efficiency of DMUq (q = 1,..., n), assuming ($\{\lambda^t\}$,$\{s_t^-\}$,$\{s_t^+\}$,$\{s_t^{good}\}$,$\{s_t^{bad}\}$,$\{s_t^{free}\}$) as variables, in our dynamic DEA model, we maximize relative slacks in outputs and desirable links.

The non-oriented models seek to decrease input-related factors and amplify output-related factors at the same time. In the combination of input- and output-oriented models, we define the non-oriented efficiency measure by solving the expression below:

$$
\delta_q^* = \min \frac{\frac{1}{T}\sum_{t=1}^{T} w^t [1 - \frac{1}{o+nbad}(\sum_{i=1}^{o} \frac{w_i^- s_{it}^-}{x_{iqt}} + \sum_{i=1}^{nbad} \frac{s_{it}^{bad}}{h_{iqt}^{bad}})]}{\frac{1}{T}\sum_{t=1}^{T} w^t [1 + \frac{1}{u+ngood}(\sum_{i=1}^{u} \frac{w_i^+ s_{it}^+}{y_{iqt}} + \sum_{i=1}^{ngood} \frac{s_{it}^{good}}{h_{iqt}^{good}})]}, \tag{4}
$$

subject to (2) and (3), where w^t and w_i^- are weights to term t and input i which are supplied exogenously in light of their significance and satisfy the criteria:

$$
\sum_{t=1}^{T} w^t = T \text{and} \sum_{i=1}^{o} w_i^- = o. \tag{5}
$$

If each of the weights is even, then we can input $w^t = 1(\forall t)$ and $w_i^- = 1(\forall i)$ subject to (2) and (3), where w_i^+ is the weight to output i and satisfies the criterion:

$$
\sum_{i=1}^{u} w_i^+ = u. \tag{6}
$$

This objective function is a stretching of the non-oriented SBM model. It deals with excesses in input resources and undesirable links, as well as shortfalls in output products and desirable links in a unitary formula. The numerator is the average input efficiency, and the denominator is the inverse of the average output efficiency. We define the non-oriented overall efficiency as a ratio that ranges between zero and one, and attains one when all slacks are zero. This objective function value is unit-invariant.

We employ an optimal solution ($\{\lambda_q^{t*}\}$, $\{s_{qt}^{-*}\}$, $\{s_{qt}^{+*}\}$, $\{s_{qt}^{good*}\}$, $\{s_{qt}^{bad*}\}$, $\{s_{qt}^{free*}\}$) to (4), subject to (2) and (3), then define the non-oriented term efficiency as follows:

$$\delta_{qt} = \frac{1 - \frac{1}{o+nbad}\left(\sum_{i=1}^{o} \frac{w_i^- s_{iqt}^{-*}}{x_{iqt}} + \sum_{i=1}^{nbad} \frac{s_{iqt}^{bad*}}{h_{iqt}^{bad}}\right)}{1 + \frac{1}{u+ngood}\left(\sum_{i=1}^{u} \frac{w_i^+ s_{iqt}^{+*}}{y_{iqt}} + \sum_{i=1}^{ngood} \frac{s_{iqt}^{good*}}{h_{iqt}^{good}}\right)} (t = 1, \ldots, T). \quad (7)$$

The definitions of the variables used in the dynamic structure are described in Table 2. This study was a compilation of previous research works that measured the efficiency of the real estate industry in a country using the DEA method. It has been observed that many studies in the literature have used operating expenses and the number of employees as inputs, the operating revenue as output, and the total assets as a carryover variable. The aggregation of individual variables used in previous research is summarized in Table 2. Furthermore, based on our knowledge, there are no existing research works that have used the DEA method with the market value as the output to measure the efficiency of the real estate industry. Therefore, this study collected research works that measure other industries as a basis for adopting market value as the output. The relevant literature is also summarized in Table 2.

Table 2. Definitions of variables used in the dynamic structure.

Variables	Description	Unit	References
Inputs			
Operating expenses	The expenses incurred through each construction company's operating activities within the statistical year.	1000 TWD	[13,14,18,35]
Employee	The human capital of each construction company within the statistical year.	Number of people	[15–18,20–22,31–33,35,37,54]
Outputs			
Revenue	The income received from the operating activities of each construction company within the statistical year.	1000 TWD	[15,16,18,20,21,30,33,35–37,54,55]
Market value	The value of each construction company within the statistical year, represented by the total outstanding shares multiplied by the price per share.	1000 TWD	[56–59]
Carryover			
Total asset	The resources controlled or owned by each construction company within the statistical year.	1000 TWD	[13,15,18,20–22,31–35,37,54]

3.5. Debt Ratio Measurement

The debt ratio measures the amount of leverage used by a company in terms of total debt to total assets. Debt ratio measurement follows the research of Frame and Steiner [47], which mentioned the impact of debt ratio on QE policy.

3.6. Control Variables

In accordance with the previous studies [33,59–62], we utilized control variables to account for their potential influence on BP. These control variables encompassed firm size (SIZE) [59,61,62] and return on assets (ROA) [59,61,62].

3.7. Hierarchical Regression

Following the research of Kuo, Lu, and Ganbaatar [59], we applied hierarchical regression to test the effect of QE on BP. Then, we examined the moderating role of the debt ratio on the relationship using the regression.

$$BP_i = \beta_0 + \beta_1 QE + \beta_2 DebtRatio + \beta_3 QE * DebtRatio + \beta_4 SIZE + \beta_5 ROA + \varepsilon_i$$

In the regression model, BP_i is the BP. The coefficient β_i explains how BP is related to the QE core. *QE* is a dummy variable, and we used "0" and "1" to represent before and after QE. *DebtRatio* is the ratio of total debt to total assets and *QE*DebtRatio* is the cross term. *SIZE* is the natural logarithm of total assets, and *ROA* is the ratio between total net income and total assets. ε_i is the error term and BP_i is the business performance of firm *i*.

4. Empirical Analysis

In the empirical analysis of this study, the purpose of the research was to first analyze the BP of construction companies. Secondly, we sought to discover the impact of QE on the BP of the construction companies before and after its implementation. Thirdly, we aimed to explore the results produced by comparing the effects of different time delays to understand the impact of QE policy on the performance fluctuations of construction companies to improve the reliability of this study. Lastly, we sought to establish whether the debt ratio of the enterprise during the QE period was the main influencing factor in the BP of construction companies.

4.1. Development Trend of Variables in Listed Construction Companies

This research was based on the data of 43 construction companies listed in Taiwan from 2004 to 2015. Total assets were used as a carryover variable, operating expenses and the number of employees were used as input variables, and the company's market value and operating income were used as output variables for analysis (Table 3). The input and output of each year were calculated separately. The number of DMUs was more than three times the input plus output variables, so it met the DEA research conditions (cite source). The K-S (Kolmogorov–Smirnov) test determined significance ($p < 0.01$), and it can be seen that all of the indicators were abnormally distributed. This shows that the DEA method is an authoritative research technique, because DEA research applies to the abnormal allocation of data [63]. Therefore, the multiple-input and multiple-output correlation analysis is particularly suitable for this research.

The average data for each company can be found in Figure 4, in which the indicators of various input and output variables show an upward trend from 2004 to 2015. In particular, the indicator of total assets shows a high growth trend. This helps us to further understand the upward development of construction companies over the course of this 12-year period, and we observed that the total assets increased significantly after the implementation of QE in 2010.

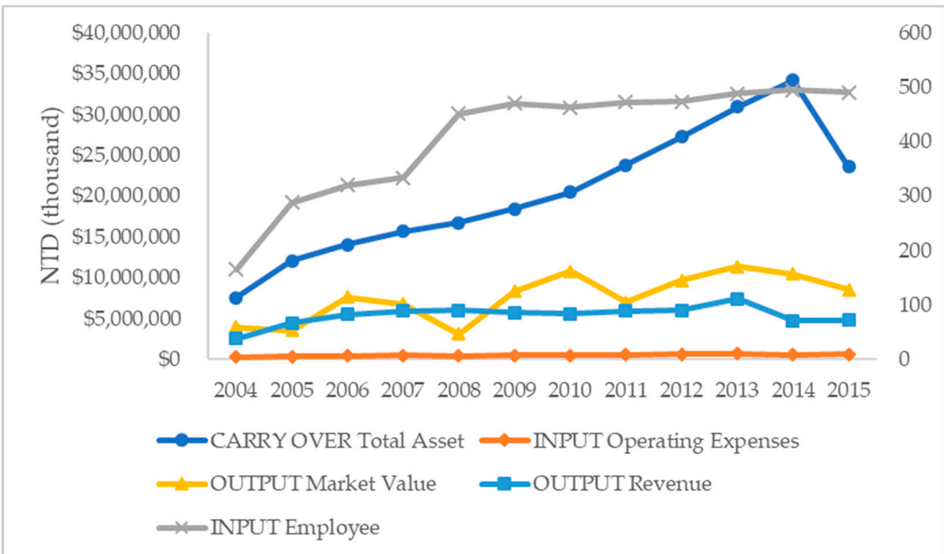

Figure 4. Trend average statistics of listed construction companies for 2004–2015.

Table 3. Annual statistics of 43 listed construction companies from 2004 to 2015.

Year		Variable Unit	Mean	Max.	Min.	SD.	K-S Test p-Value
2004–2015	CARRYOVER	Total assets	20,399,651	513,765,929	67,456	49,205,101	$p < 0.01$
	INPUT	Operating expenses	505,458	4,362,085	8255	677,382	$p < 0.01$
		Employees	409	8777	6	1081	$p < 0.01$
	OUTPUT	Market value	7,591,330	68,896,213	40,600	10,439,035	$p < 0.01$
		Revenue	5,375,358	93,388,930	447	10,610,906	$p < 0.01$
2004	CARRYOVER	Total assets	7,565,555	30,612,058	357,002	8,066,572	
	INPUT	Operating expenses	286,164	1,421,472	24,278	324,750	
		Employees	165	1130	9	259	
	OUTPUT	Market value	3,931,228	32,467,694	144,400	5,748,799	
		Revenue	2,564,752	14,682,404	8,910	3,449,044	
2005	CARRYOVER	Total assets	12,099,505	190,832,588	295,297	29,037,141	
	INPUT	Operating expenses	371,649	2,113,411	14,589	497,708	
		Employees	288	1788	7	498	
	OUTPUT	Market value	3,517,519	24,019,468	116,926	4,684,949	
		Revenue	4,421,445	59,952,117	7288	9,589,124	
2006	CARRYOVER	Total assets	14,073,131	217,834,482	333,846	33,196,029	
	INPUT	Operating expenses	440,388	2,219,759	20,576	579,230	
		Employees	320	2308	9	558	
	OUTPUT	Market value	7,613,964	38,762,451	119,799	9,224,576	
		Revenue	5,486,979	59,084,516	6849	10,027,593	
2007	CARRYOVER	Total assets	15,668,296	243,932,850	377,687	37,217,774	
	INPUT	Operating expenses	471,300	2,429,040	17,486	587,736	
		Employees	334	2364	9	599	
	OUTPUT	Market value	6,742,407	55,630,640	102,068	9,801,478	
		Revenue	5,905,852	71,902,022	4311	11,603,301	
2008	CARRYOVER	Total assets	16,704,320	256,563,380	565,971	39,304,494	
	INPUT	Operating expenses	451,394	2,461,484	18,642	582,777	
		Employees	451	7746	11	1245	
	OUTPUT	Market value	3,077,756	16,917,873	51,310	3,785,155	
		Revenue	5,974,117	93,388,930	6098	14,590,413	
2009	CARRYOVER	Total assets	18,424,987	298,661,093	314,939	45,762,671	
	INPUT	Operating expenses	473,080	2,884,978	17,404	657,306	
		Employees	470	8256	9	1325	
	OUTPUT	Market value	8,338,648	50,011,916	56,070	10,521,434	
		Revenue	5,728,271	77,054,529	7145	12,238,482	
2010	CARRYOVER	Total assets	20,499,210	332,823,105	260,662	50,962,571	
	INPUT	Operating expenses	522,998	2,786,296	15,539	726,323	
		Employees	463	8777	6	1386	
	OUTPUT	Market value	10,784,411	55,451,066	67,200	13,403,065	
		Revenue	5,577,582	50,892,148	10,189	9,370,187	
2011	CARRYOVER	Total assets	23,802,942	363,937,987	233,237	56,101,951	
	INPUT	Operating expenses	557,832	2,953,826	11,774	751,909	
		Employees	473	7815	7	1266	
	OUTPUT	Market value	6,988,937	36,643,068	48,090	8,818,972	
		Revenue	5,949,557	67,769,843	10,340	11,216,922	
2012	CARRYOVER	Total assets	27,289,835	421,631,217	67,456	65,125,582	
	INPUT	Operating expenses	612,433	4,362,085	13,233	910,910	
		Employees	473	7815	6	1266	
	OUTPUT	Market value	9,701,175	59,777,575	40,600	12,334,021	
		Revenue	5,973,852	91,043,785	447	14,342,822	
2013	CARRYOVER	Total assets	30,907,529	455,509,421	606,556	70,653,851	
	INPUT	Operating expenses	691,194	3,793,422	11,489	844,259	
		Employees	488	7815	6	1265	
	OUTPUT	Market value	11,370,469	68,896,213	521,272	13,316,573	
		Revenue	7,416,686	71,023,298	60,914	12,304,434	

Table 3. *Cont.*

Year		Variable Unit	Mean	Max.	Min.	SD.	K-S Test *p*-Value
2014	CARRYOVER	Total assets	34,193,889	513,765,929	609,515	79,155,427	
	INPUT	Operating expenses	590,493	2,927,776	8255	701,977	
		Employees	495	7815	6	1265	
	OUTPUT	Market value	10,454,865	60,105,226	662,599	12,874,811	
		Revenue	4,716,964	37,515,171	9850	6,783,894	
2015	CARRYOVER	Total assets	23,566,612	114,195,943	619,937	26,650,414	
	INPUT	Operating expenses	596,566	2,989,867	8795	741,252	
		Employees	491	7815	11	1254	
	OUTPUT	Market value	8,574,579	59,707,533	471,091	11,408,340	
		Revenue	4,788,241	34,638,039	23,596	6,819,592	

Unit: thousand NTD (total assets, operating expenses, market value, revenue); persons (employee). Data Source: TEJ database.

In the correlation statistics, it was found that the relationship between input and output variable items was significant, and the significant correlation between input and output variables was obvious, so it was inferred that the impact of input variables on output variables in this analysis was significant, and all variables were positively correlated, showing the isotonicity of the data (see Table 4).

Table 4. Correlation coefficient among all input and output factors.

	Total Asset	Operating Expenses	Employee	Market Value	Revenue
Total Asset	1.000				
Operating Expenses	0.657 **	1.000			
Employee	0.807 **	0.647 **	1.000		
Market Value	0.326 **	0.617 **	0.198 **	1.000	
Revenue	0.807 **	0.795 **	0.720 **	0.400 **	1.000

Note: ** $p < 0.05$.

4.2. Analysis of Performance Values before and after QE

In this study, Dynamic SBM (DSBM) [53] non-oriented-VRS was added to verify the performance value analysis before and after QE. The performance value results for each year are shown in Table 5. In addition, using the analysis of the lagging periods, we obtained the performance values for each year from 2004 to 2015 (Table 6).

Table 5. DSBM Model 2004–2015 BP.

Year	2004	2005	2006	2007	2008	2009	Pre QE Mean	2010	2011	2012	2013	2014	2015	Post QE Mean
Mean	0.445	0.442	0.526	0.571	0.585	0.628	0.535	0.625	0.670	0.641	0.589	0.587	0.559	0.612
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min	0.017	0.010	0.015	0.028	0.036	0.023	0.022	0.026	0.104	0.019	0.033	0.009	0.047	0.040
SD.	0.375	0.383	0.399	0.382	0.384	0.354	0.380	0.357	0.336	0.348	0.391	0.344	0.333	0.352

Table 6. One-, two- and three-year lagging periods to verify the performance value before and after QE.

DSBM in Different Time Effect	Before QE	After QE	Before QE	After QE	Before QE	After QE	K-S Test (Non-Parametric)	One-Way ANOVA (Parametric)
	Mean	**Mean**	**Std. Dev.**	**Std. Dev.**	**df**	**df**	***p*-Value**	***p*-Value**
QE One year lagging	0.533	0.612	0.382	0.350	258	258	$p < 0.01$	$p < 0.05$
QE Two years lagging	0.546	0.609	0.380	0.350	301	215	$p < 0.05$	$p < 0.10$
QE Three years lagging	0.562	0.594	0.376	0.353	344	172	$p > 0.10$	$p > 0.10$

This study finds that the trend of the DSBM model increased significantly after 2010, and the overall trend displays gradual upward development (Figure 5).

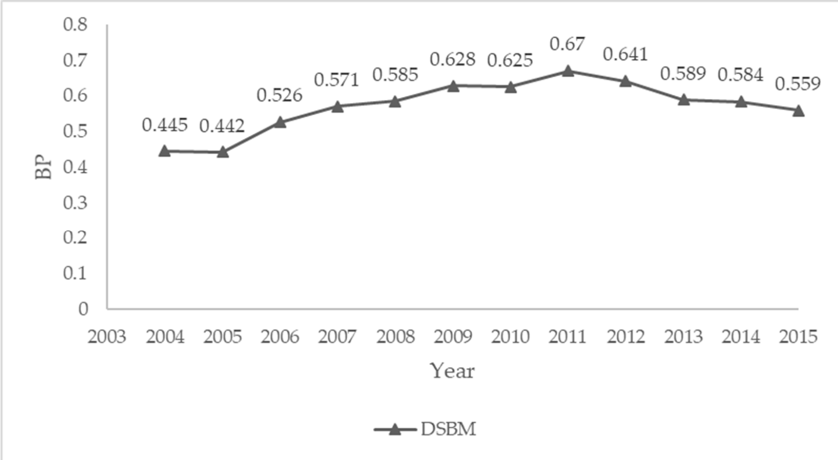

Figure 5. DSBM's average performance trend from 2004 to 2015.

According to DSBM [53], the DEA window model analysis and the Malmquist index usually neglect the carryover activity between two consecutive periods, focusing on a single time period and independently optimizing the local area within a single period. In order to cope with a long-term point of view, the DSBM incorporates the carry-over activities into the model and allows us to measure the period-specific performance based on the long-term optimization of the entire period.

We attempted to compare the situations in which the QE policy is delayed by one, two, or three years. We compared the average performance values with QE deferred by one year (before: 2004–2009; after: 2010–2015), QE deferred by two years (before: 2004–2010; after: 2011–2015), and QE deferred by three years (before: 2004–2011; after: 2012–2015) in DSBM models and through the K-S (Kolmogorov–Smirnov) test for significance, and applied one-way ANOVA to analyze the differences between different groups. We found that the performance with a one-year QE lag displayed significant growth. The one-year QE lag had a more significant effect than the two-year QE lag, but the three-year QE lag had no significant effect (Table 6).

According to the analysis of the one-, two- and three-year lagging periods, we found that the impact of QE policy on the performance of construction companies has diminishing benefits over time after the policy is implemented, and its effect decreases in significance, which provides support for Hypothesis 2.

However, from 2016 to 2023, the global economy and financial markets were significantly affected by other factors, such as the COVID-19 epidemic. The U.S. Federal Reserve Board launched the QE policy again in March 2020 [7]. To understand the subsequent impact of the QE policy on the construction industry, this study once again examines the impact of the quantitative easing policy from 2016 to 2022 on the business performance (BP) of Taiwan's listed construction and real estate development companies (Table 7). The DSBM model shows that with the implementation of the QE policy, the average BP of Taiwanese construction companies shows an upward trend (Figure 6). This finding is consistent with research conducted from 2004 to 2015. Please see Appendix B for information from 2016 to 2022.

Table 7. DSBM Model 2016–2022 BP.

Year	2016	2017	2018	2019	2020	2021	2022
Mean	0.429	0.401	0.433	0.462	0.504	0.541	0.483
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min	0.017	0.020	0.040	0.011	0.073	0.122	0.096
SD.	0.374	0.369	0.371	0.364	0.363	0.335	0.325

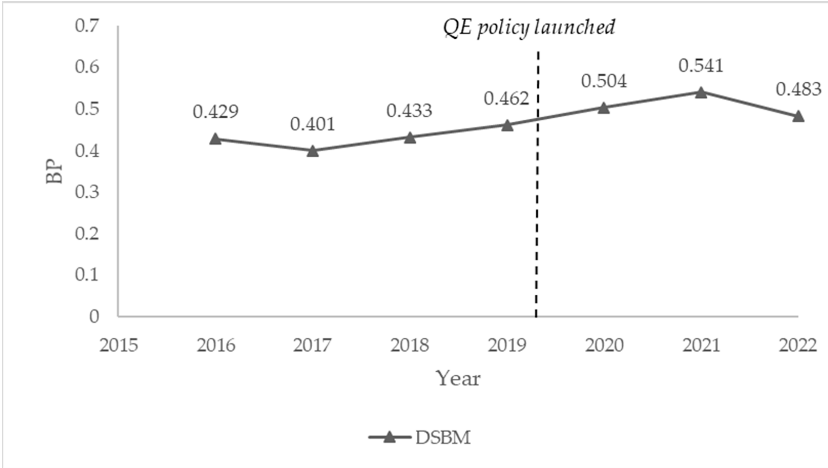

Figure 6. DSBM's average performance trend from 2016 to 2022.

4.3. Moderator and the Influence of Control Variables

The QE policy impact and performance value BP were assessed. In Model 1, two control variables, including SIZE and ROA, were included in the regression to test the effects of QE and debt ratio on BP. The analysis results are shown in Table 8. The analysis results show that the main effect of QE can explain 5.33% of BP variation, F = 14.33, $p < 0.01$, and SIZE is significantly correlated with BP (β = 0.224, $p < 0.01$).

Table 8. Prediction of BP according to QE policy.

	BP			
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Control variables				
SIZE	0.224 ***	0.215 ***	0.222 ***	0.245 ***
ROA	0.045	0.041	0.039	0.029
Independent variable				
QE		0.078 *	0.076 *	0.073 *
Moderator				
Debt Ratio			−0.022	−0.051
Interaction term				
QE x debt ratio				−1.18 ***
R-squared	0.053	0.059	0.059	0.072
ΔR^2	0.053 ***	0.006 *	0.000	0.013 ***
F-statistic	14.330 ***	3.225 *	0.228	7.078 ***

* $p < 0.10$; *** $p < 0.01$.

In Model 2, the independent variable QE and the control variables SIZE and ROA are included in the regression. As shown in Table 8, these two control variables explain significant variability (ΔR2 = 0.06, $p < 0.1$). The standardized regression weights are significant for QE (β = 0.078, $p < 0.1$). Therefore, Hypothesis 1 is supported.

In Model 3, a moderating variable, the debt ratio, is added to the regression. As shown in Table 8, the debt ratio explains insignificant variability (ΔR2 = 0.000, $p = 0.633$). The regression weights standardized by the debt ratio are not significant (β = −0.22, $p = 0.633$).

In Model 4, the interaction of the QE and debt ratio (i.e., QE × debt ratio) is added to the predictor variables. This interaction term explains a lot of unique variability in the QE policy impact and performance value BP (ΔR2 = 0.013, $p < 0.01$). As shown in Table 8, the QE × debt ratio interaction is significant (β = −1.18, $p < 0.01$), which provides support for Hypothesis 3.

According to Table 8, after excluding the factors of SIZE and ROA, QE still has a significant explanatory power for BP ($p < 0.1$), and QE x debt ratio has a significant explanatory power for the BP value ($p < 0.01$) under the interaction of QE x debt ratio. Tsai, Chen, and Chiu [64] pointed out that when the interaction has a significant effect, it can indicate that the moderator effect is significant.

The simple slope analysis results (Table 9) show that for the high debt ratio group, the debt ratio has significant explanatory power for the performance value BP (B = 0.45, $p < 0.01$). For the low debt ratio group, the debt ratio has significant explanatory power for the performance value BP (B = 0.61, $p < 0.01$). This finding implies that the interaction is significant. A diagram showing the interaction effect is presented in Figure 7, and it can be seen from the regression coefficient that in the high and low debt ratio groups, QE has a significant and positive correlation with the BP value [65].

Table 9. Debt ratio x QE simple slope verification results.

	Simple Slope (B)	Std. Error	*t*-Value	df	*p*-Value
High Debt Ratio	0.450	0.046	9.759	512	0.000
Low Debt Ratio	0.610	0.045	13.626	512	0.000

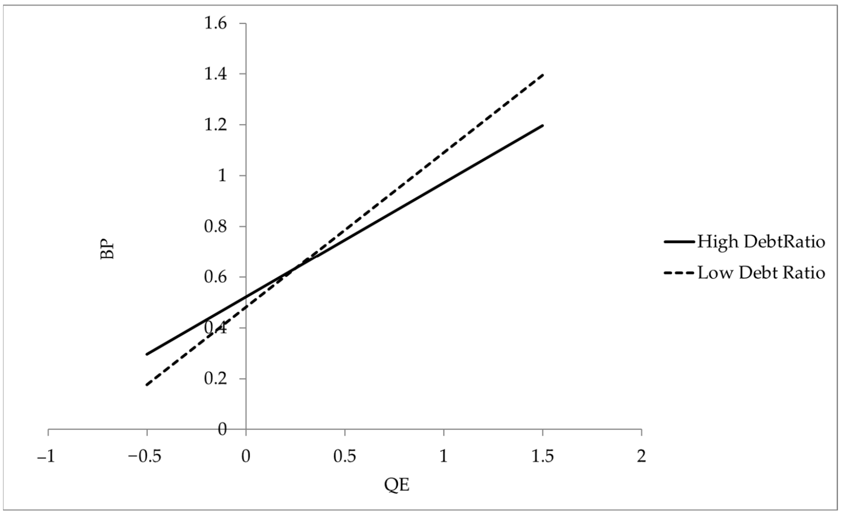

Figure 7. Two-way interaction effects for the simple slope of debt ratio x QE.

From the research results, the performance value of companies with a high debt ratio is higher than the performance value of companies with a low debt ratio in the initial stage, and then gradually slows down, while the performance value of companies with a low debt ratio gradually rises; in response to the above-mentioned QE lagging effect, the marginal effect gradually weakens, and the high debt ratio is in the period around QE implementation. The effect of increasing the performance value also weakens.

5. Discussion

As discussed by the IMF [38], housing prices in Asian economies have risen rapidly since the 2008 crisis. This evidence supports the international spillover effects of QE; therefore, this study infers that QE will also have an impact on the promotion of Taiwan's construction companies. The current research found that according to the trend of the dynamic DEA model, the performance value results for each year increased significantly after QE. The QE policy was implemented again in March 2020 due to the impact of the COVID-19 epidemic on the global economy [7]. This study re-evaluates the impact of the QE policy from 2016 to 2022. With the implementation of the QE policy, the average BP of Taiwanese construction companies shows an upward trend. This finding is consistent with research conducted from 2004 to 2015.

After the 2008 financial crisis, the U.S. Federal Reserve Board implemented three rounds of QE policies. Lin, Batmunkh, and Moslehpour [48] demonstrated that the first stage of this QE policy led to extremely significant effects on emerging markets. They pointed out that the leverage of the QE policy was diminished over the three implementations of the policy. According to the analysis of the one-, two- and three-year lagging periods, we found that the impact of QE policy on the performance of construction companies will have diminishing benefits over time after the policy is implemented, and its effects will decrease in significance.

A study by Alter and Elekdag [45] examined the influence of the financial crisis on the financial leverage of companies in emerging markets. The results demonstrated that the global financial crisis caused faster financial leverage growth in companies affected by QE policy, including adjusting borrowing interest rates and loosening borrowing constraints in emerging markets. From the present research results, the performance value for companies with a high debt ratio is higher than the performance value of companies with a low debt ratio in the initial stage, and then gradually slows down, while the performance value for companies with a low debt ratio gradually rises; in response to the above-mentioned QE lagging effect, the marginal effect gradually weakens, and the high debt ratio is in the period around QE implementation. The effect of increasing the performance value also weakens.

6. Conclusions and Implications

6.1. Conclusions

The current research indicates that the trend of the dynamic DEA model shows a significant increase in performance value results for each year following QE implementation.

Analyzing the impact over one-, two-, and three-year lagging periods, we observed that the effect of QE policy on construction companies' performance demonstrates diminishing benefits over time. As time progresses from the implementation of the policy, its significance diminishes.

The research findings suggest that initially, performance values with a high debt ratio surpass those with a low debt ratio, but this trend gradually slows down. Conversely, performance values with a low debt ratio gradually increase.

6.2. Implications

The results presented in this study show that expansionary monetary policies have a certain impact on the performance of construction industry companies in Taiwan. Based on these findings, construction companies can take advantage of this outcome when facing a new wave of QE policies in the future. They should seize this opportunity to enhance their financial performance, improving their revenue or net profit.

Due to the diminishing effects of its impact, the influence of QE policy on the financial performance of construction companies gradually decreases. Based on this conclusion, for the management and decision-makers of construction companies, it is even more important to promptly capitalize on the short-term operational performance benefits brought about by QE policies.

The impact of QE policy is particularly significant for construction companies with financial leverage. Therefore, corporate decision-makers need to consider leveraging financial policy operations, such as borrowing from banks or issuing corporate bonds, to further amplify the contribution of QE policy to the company's performance.

6.3. Future Direction

The scope of this study is limited to construction companies listed on the Taiwan Stock Exchange. In the future, based on the purpose and methods of this study, it is hoped that the research data will be extended to include construction companies in the Asia-Pacific region or on a global scale. In addition, the two-stage DEA and more variables will further explore the issue of corporate operation. This expansion aims to further enhance the coverage of, and contributions to, this research topic.

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Appendix A

Table A1. Listed Taiwanese construction companies' BP for the period 2004–2015.

DMU	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
On Yao	0.075	0.032	0.059	0.075	0.069	0.120	0.151	0.104	0.033	0.033	0.168	0.155
Huayoulian	0.421	0.113	0.094	1.000	1.000	0.665	0.026	1.000	1.000	1.000	0.685	0.474
Three Places	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mingxuan	1.000	1.000	0.393	0.923	0.665	0.610	0.611	0.932	0.717	0.664	0.735	0.633
General	0.058	0.073	0.026	0.125	0.221	0.410	0.363	0.437	0.310	0.199	0.315	0.268
Baolai	0.038	0.120	0.083	0.094	0.078	0.173	0.132	0.155	0.108	0.093	0.171	0.047
Runlong	0.257	0.397	0.299	0.282	0.385	0.255	0.361	0.382	0.407	0.121	0.648	0.446
Haiyatt	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
New Meiqi	0.948	0.979	0.989	0.984	0.871	0.942	0.495	0.235	0.177	0.076	0.175	0.123
Guojian	1.000	1.000	1.000	1.000	1.000	1.000	0.898	0.777	0.597	0.587	0.589	0.558
Guo Yang	0.146	0.345	0.474	0.354	0.363	0.218	0.437	0.377	0.354	1.000	0.317	0.370
Too Set	0.017	0.038	0.064	0.037	0.062	0.073	0.058	0.181	0.049	0.033	0.125	0.106
Q-K JP	0.320	0.210	0.197	0.467	0.222	0.305	0.301	0.318	0.463	0.060	0.017	0.333
Edward	0.284	0.300	0.371	0.194	0.233	0.240	0.251	0.227	0.818	0.251	0.277	0.238
Long Bang	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Guande	0.305	0.235	0.239	0.239	0.289	0.531	0.502	0.444	0.249	0.313	0.372	0.257
Capital	1.000	1.000	1.000	1.000	0.731	0.897	0.884	0.839	1.000	1.000	1.000	1.000
Hong Jing	0.086	0.180	0.388	0.200	0.161	0.201	0.152	0.113	0.405	0.216	1.000	0.432
Huangpu	1.000	0.187	1.000	1.000	1.000	0.823	1.000	1.000	0.771	0.834	0.474	0.328
Huajian	0.571	0.162	0.316	0.661	0.413	0.484	0.711	0.632	0.019	0.172	0.009	0.758
Hongsheng	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.999	1.000
Hongpu	0.585	0.776	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Announcement	0.218	0.159	1.000	1.000	1.000	1.000	1.000	0.714	0.613	0.486	0.778	0.690
Kitai	0.270	0.359	1.000	0.635	0.476	0.583	1.000	1.000	1.000	1.000	0.502	0.699
Sakura BL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mountain Forest	0.141	0.010	0.018	0.030	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.264
Hing Fu Fat	0.373	0.502	0.491	0.488	0.766	1.000	1.000	1.000	1.000	0.999	1.000	1.000
King Xiang	0.407	0.484	0.663	0.587	0.999	1.000	1.000	1.000	1.000	1.000	0.714	0.768
Nissatsu	0.333	0.251	0.550	0.393	0.236	0.395	0.315	0.263	0.079	1.000	0.188	0.108
Huagu	0.381	1.000	0.997	1.000	1.000	1.000	1.000	1.000	1.000	0.694	0.768	0.940
Scripture	0.085	0.096	0.115	0.279	0.166	0.257	0.194	1.000	0.417	0.538	0.420	0.368
Master	0.048	0.028	0.023	0.088	0.119	0.407	0.408	0.579	0.572	0.292	0.360	0.337
Rising Sun	0.076	0.085	0.056	0.139	0.155	0.206	0.572	1.000	1.000	1.000	1.000	1.000
Longda	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.696	0.857	0.406	0.406	0.321
Farglory	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Suncheon	0.276	0.365	0.569	0.427	0.276	0.359	0.436	0.462	0.458	0.255	0.423	0.463
Country Forest	0.183	0.289	0.310	0.544	0.299	0.483	0.371	0.324	0.406	0.231	0.364	0.260
Emperor Ding	0.388	0.275	0.249	0.528	0.486	0.852	0.519	0.612	0.399	0.129	0.433	0.354
Changhong	0.399	0.487	0.893	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dali	0.029	0.039	0.078	0.182	0.323	0.389	0.504	0.513	0.588	0.214	0.465	0.403
Shimbaba	0.024	0.015	0.016	0.028	0.036	0.023	0.027	0.150	0.361	0.152	0.030	0.213
Runtaixin	0.353	0.382	0.587	0.509	0.999	0.991	0.995	1.000	1.000	1.000	1.000	1.000
Sanfa RE	0.022	0.018	0.015	0.057	0.061	0.132	0.213	0.346	0.339	0.261	0.310	0.341

Appendix B

Table A2. Listed Taiwanese construction companies' BP for the period 2016–2022.

DMU	2016	2017	2018	2019	2020	2021	2022
On Yao	0.073	0.137	0.089	0.119	0.115	0.157	0.101
Huayoulian	0.235	0.206	0.191	0.310	0.225	0.253	0.288
Three Places	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Asent	1.000	1.000	1.000	1.000	1.000	1.000	0.528
Mingxuan	1.000	0.450	0.345	0.536	0.471	0.676	0.685
Honghe	0.227	0.198	0.171	0.273	0.165	0.300	0.179
General	0.078	0.110	0.041	0.128	0.350	0.142	0.261
I-HWA	0.115	0.132	0.139	0.264	0.281	0.307	0.212
Baolai	0.017	0.117	0.040	0.121	0.158	0.324	0.242
Runlong	0.314	0.337	0.526	0.308	0.425	0.613	0.387
Haiyatt	0.128	0.177	0.152	0.169	0.201	0.314	0.202
New Meiqi	0.045	0.052	0.077	0.081	0.073	0.187	0.201
Guojian	1.000	0.605	0.559	0.464	0.498	0.486	0.446
Guo Yang	0.211	0.293	0.124	0.360	1.000	0.552	0.324
Too Set	0.121	0.104	0.120	0.098	0.127	0.174	0.108
Q-K JP	0.151	0.218	0.288	0.313	0.284	0.292	0.098
Edward	0.150	0.173	0.108	0.146	0.134	0.212	0.195
Long Bang	0.305	0.020	1.000	1.000	1.000	1.000	0.517
Guande	0.191	0.176	0.158	0.227	1.000	1.000	0.999
Capital	0.380	1.000	1.000	1.000	1.000	1.000	0.604
Hong Jing	0.132	0.046	0.152	0.223	0.194	0.383	0.225
Huangpu	0.165	0.126	0.516	0.649	0.207	0.688	0.625
Huajian	0.732	0.089	0.381	0.013	0.958	0.963	0.550
Hongsheng	0.393	0.490	0.503	0.433	0.273	0.350	0.392
Hongpu	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Announcement	0.426	0.188	0.337	0.264	0.395	0.415	0.285
Kitai	0.259	0.151	0.062	0.056	0.186	0.125	0.192
Sakura BL	0.846	0.872	0.739	1.000	1.000	1.000	1.000
Mountain Forest	0.230	0.159	0.138	0.199	0.279	0.359	0.401
Hing Fu Fat	1.000	1.000	1.000	1.000	1.000	1.000	1.000
King Xiang	1.000	1.000	1.000	1.000	0.612	0.616	0.530
Nissatsu	0.083	0.164	0.384	0.130	0.101	0.122	0.104
Huagu	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Scripture	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Master	0.238	0.273	0.185	0.528	0.535	0.577	1.000
Rising Sun	0.202	0.179	0.204	0.284	0.323	0.252	0.277
Longda	0.145	0.166	0.212	0.298	0.340	0.343	0.264
Farglory	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Suncheon	0.205	0.193	0.287	0.315	0.218	0.208	0.383
Country Forest	0.228	0.149	0.141	0.190	0.233	0.165	0.096
Emperor Ding	0.143	0.135	0.137	0.179	0.237	0.256	0.301
Changhong	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Dali	0.149	0.222	0.126	0.241	0.214	0.346	0.290
Shimbaba	0.252	0.200	0.095	0.011	0.156	0.425	0.478
Runtaixin	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Sanfa RE	0.145	0.136	0.189	0.337	0.230	0.286	0.270

References

1. Blinder, A.S. Quantitative easing: Entrance and exit strategies. *Fed. Reserve Bank St. Louis Rev.* **2010**, *92*, 465–479. [CrossRef]
2. Neely, C.J.; Fawley, B.W. Four stories of quantitative easing. *Fed. Reserve Bank St. Louis Rev.* **2013**, *95*, 51–88.
3. Mukerji, P.; Saeed, K.; Tan, N. An examination of the influence of household financial decision making on the US housing market crisis. *Systems* **2015**, *3*, 378–398. [CrossRef]
4. CBC. *Quantitative Easing Monetary Policy*; Central Bank of the Republic of China: Taipei, Taiwan, 2013.
5. Bhattarai, S.; Chatterjee, A.; Park, W.Y. Effects of US quantitative easing on emerging market economies. *J. Econ. Dyn. Control* **2021**, *122*, 104031. [CrossRef]
6. Boehl, G.; Goy, G.; Strobel, F. A structural investigation of quantitative easing. *Rev. Econ. Stat.* **2022**, 1–45. [CrossRef]
7. Rebucci, A.; Hartley, J.S.; Jiménez, D. An event study of COVID-19 central bank quantitative easing in advanced and emerging economies. In *Essays in Honor of M. Hashem Pesaran: Prediction and Macro Modeling*; Emerald Publishing Limited: Leeds, UK, 2022; Volume 43, pp. 291–322.

8. Cho, D.; Rhee, C. *Effects of Quantitative Easing on Asia: Capital Flows and Financial Markets*; Asian Development Bank Economics Working Paper Series; Asian Development Bank: Mandaluyong, Philippines, 2013; Volume 50.
9. Ho, S.W.; Zhang, J.; Zhou, H. Hot money and quantitative easing: The spillover effects of US Monetary policy on the Chinese Economy. *J. Money Credit Bank.* **2018**, *50*, 1543–1569. [CrossRef]
10. Miyakoshi, T.; Li, K.-W.; Shimada, J.; Tsukuda, Y. The impact of quantitative easing and carry trade on the real estate market in Hong Kong. *Int. Rev. Econ. Financ.* **2020**, *69*, 958–976. [CrossRef]
11. Xu, X.E.; Chen, T. The effect of monetary policy on real estate price growth in China. *Pac. Basin Financ. J.* **2012**, *20*, 62–77. [CrossRef]
12. Farrell, M.J. The measurement of productive efficiency. *J. R. Stat. Soc. Ser. A Gen.* **1957**, *120*, 253–281. [CrossRef]
13. Anderson, R.I.; Fok, R.; Springer, T.; Webb, J. Technical efficiency and economies of scale: A non-parametric analysis of REIT operating efficiency. *Eur. J. Oper. Res.* **2002**, *139*, 598–612. [CrossRef]
14. Topuz, J.C.; Darrat, A.F.; Shelor, R.M. Technical, allocative and scale efficiencies of REITs: An empirical inquiry. *J. Bus. Financ. Account.* **2005**, *32*, 1961–1994. [CrossRef]
15. Horta, I.M.; Camanho, A.S.; Da Costa, J.M. Performance assessment of construction companies: A study of factors promoting financial soundness and innovation in the industry. *Int. J. Prod. Econ.* **2012**, *137*, 84–93. [CrossRef]
16. You, T.; Zi, H. The economic crisis and efficiency change: Evidence from the Korean construction industry. *Appl. Econ.* **2007**, *39*, 1833–1842. [CrossRef]
17. Wang, X.; Lai, W.; Song, X.; Lu, C. Implementation efficiency of corporate social responsibility in the construction industry: A China study. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2008. [CrossRef] [PubMed]
18. Zheng, X.; Chau, K.-W.; Hui, E.C. Efficiency assessment of listed real estate companies: An empirical study of China. *Int. J. Strateg. Prop. Manag.* **2011**, *15*, 91–104. [CrossRef]
19. Dinh, T.N.; Kuo, K.-C.; Lu, W.-M.; Nguyen, D.T. The effect of quantitative easing on Asian construction firms' performance. *Int. J. Constr. Manag.* **2023**, *23*, 38–47. [CrossRef]
20. Liu, X.-X.; Liu, H.-H.; Yang, G.-L.; Pan, J.-F. Productivity assessment of the real estate industry in China: A DEA-Malmquist index. *Eng. Constr. Archit. Manag.* **2021**, *30*, 1243–1270. [CrossRef]
21. Wang, X.; Chen, Y.; Liu, B.; Shen, Y.; Sun, H. A total factor productivity measure for the construction industry and analysis of its spatial difference: A case study in China. *Constr. Manag. Econ.* **2013**, *31*, 1059–1071. [CrossRef]
22. Xue, X.; Shen, Q.; Wang, Y.; Lu, J. Measuring the productivity of the construction industry in China by using DEA-based Malmquist productivity indices. *J. Constr. Eng. Manag.* **2008**, *134*, 64–71. [CrossRef]
23. Lewis, T.M. The construction industry in the economy of Trinidad & Tobago. *Constr. Manag. Econ.* **2004**, *22*, 541–549.
24. Textor, C. Contribution of the Secondary Sector to Overall GDP of Taiwan from 2011 to 2021, by Subsector. Available online: https://www.statista.com/statistics/706395/taiwan-gdp-share-across-industry-sectors/ (accessed on 3 April 2023).
25. Musarat, M.A.; Alaloul, W.S.; Liew, M. Impact of inflation rate on construction projects budget: A review. *Ain Shams Eng. J.* **2021**, *12*, 407–414. [CrossRef]
26. Ofori, G. Nature of the construction industry, its needs and its development: A review of four decades of research. *J. Constr. Dev. Ctries* **2015**, *20*, 115.
27. Charnes, A.; Cooper, W.W.; Rhodes, E. Measuring the efficiency of decision making units. *Eur. J. Oper. Res.* **1978**, *2*, 429–444. [CrossRef]
28. Banker, R.D.; Charnes, A.; Cooper, W.W. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Manag. Sci.* **1984**, *30*, 1078–1092. [CrossRef]
29. Tone, K. A slacks-based measure of efficiency in data envelopment analysis. *Eur. J. Oper. Res.* **2001**, *130*, 498–509. [CrossRef]
30. Kapelko, M.; Lansink, A.O. Technical efficiency and its determinants in the Spanish construction sector pre-and post-financial crisis. *Int. J. Strateg. Prop. Manag.* **2015**, *19*, 96–109. [CrossRef]
31. Hu, X.; Liu, C. Measuring efficiency, effectiveness and overall performance in the Chinese construction industry. *Eng. Constr. Archit. Manag.* **2018**, *25*, 780–797. [CrossRef]
32. Chen, K.; Song, Y.-Y.; Pan, J.-F.; Yang, G.-L. Measuring destocking performance of the Chinese real estate industry: A DEA-Malmquist approach. *Socio-Econ. Plan. Sci.* **2020**, *69*, 100691. [CrossRef]
33. Yang, Z.; Fang, H. Research on green productivity of chinese real estate companies—Based on SBM-DEA and TOBIT models. *Sustainability* **2020**, *12*, 3122. [CrossRef]
34. Horta, I.M.; Kapelko, M.; Oude Lansink, A.; Camanho, A.S. The impact of internationalization and diversification on construction industry performance. *Int. J. Strateg. Prop. Manag.* **2016**, *20*, 172–183. [CrossRef]
35. Wong, W.P.; Gholipour, H.F.; Bazrafshan, E. How efficient are real estate and construction companies in Iran's close economy? *Int. J. Strateg. Prop. Manag.* **2012**, *16*, 392–413. [CrossRef]
36. Horta, I.; Camanho, A.; Johnes, J.; Johnes, G. Performance trends in the construction industry worldwide: An overview of the turn of the century. *J. Product. Anal.* **2013**, *39*, 89–99. [CrossRef]
37. Park, J.-L.; Yoo, S.-K.; Lee, J.-S.; Kim, J.-H.; Kim, J.-J. Comparing the efficiency and productivity of construction firms in China, Japan, and Korea using DEA and DEA-based Malmquist. *J. Asian Archit. Build. Eng.* **2015**, *14*, 57–64. [CrossRef]
38. IMF. *Regional Economic Outlook, April 2014, Asia and Pacific: Sustaining the Momentum: Vigilance and Reforms*; International Monetary Fund: Washington, DC, USA, 2014.

39. Bénétrix, A.S.; Eichengreen, B.; O'Rourke, K.H. How housing slumps end. *Econ. Policy* **2014**, *27*, 647–692. [CrossRef]
40. Füss, R.; Zietz, J. The economic drivers of differences in house price inflation rates across MSAs. *J. Hous. Econ.* **2016**, *31*, 35–53. [CrossRef]
41. Rosenberg, S. The effects of conventional and unconventional monetary policy on house prices in the Scandinavian countries. *J. Hous. Econ.* **2019**, *46*, 101659. [CrossRef]
42. Ryczkowski, M. Money, credit, house prices and quantitative easing—The wavelet perspective from 1970 to 2016. *J. Bus. Econ. Manag.* **2019**, *20*, 546–572. [CrossRef]
43. Zhang, X.; Pan, F. Asymmetric effects of monetary policy and output shocks on the real estate market in China. *Econ. Model.* **2021**, *103*, 105600. [CrossRef]
44. Acharya, V.V.; Plantin, G. *Monetary Easing, Leveraged Payouts and Lack of Investment*; National Bureau of Economic Research: Cambridge, MA, USA, 2019.
45. Alter, A.; Elekdag, S. Emerging market corporate leverage and global financial conditions. *J. Corp. Financ.* **2020**, *62*, 101590. [CrossRef]
46. Koráb, P.; Mallek, R.S.; Dibooglu, S. Effects of quantitative easing on firm performance in the euro area. *N. Am. J. Econ. Financ.* **2021**, *57*, 101455. [CrossRef]
47. Frame, W.S.; Steiner, E. Quantitative easing and agency MBS investment and financing choices by mortgage REITs. *Real Estate Econ.* **2022**, *50*, 931–965. [CrossRef]
48. Lin, J.-Y.; Batmunkh, M.-U.J.; Moslehpour, M.; Lin, C.-Y.; Lei, K.-M. Impact analysis of US quantitative easing policy on emerging markets. *Int. J. Emerg. Mark.* **2018**, *3*, 185–202. [CrossRef]
49. Hauzenberger, N.; Pfarrhofer, M.; Stelzer, A. On the effectiveness of the European Central Bank's conventional and unconventional policies under uncertainty. *J. Econ. Behav. Organ.* **2021**, *191*, 822–845. [CrossRef]
50. Girardin, E.; Moussa, Z. Quantitative easing works: Lessons from the unique experience in Japan 2001–2006. *J. Int. Financ. Mark. Inst. Money* **2011**, *21*, 461–495. [CrossRef]
51. Bowman, D.; Cai, F.; Davies, S.; Kamin, S. Quantitative easing and bank lending: Evidence from Japan. *J. Int. Money Financ.* **2015**, *57*, 15–30. [CrossRef]
52. Martin, C.; Milas, C. Quantitative easing: A sceptical survey. *Oxf. Rev. Econ. Policy* **2012**, *28*, 750–764. [CrossRef]
53. Tone, K.; Tsutsui, M. Dynamic DEA: A slacks-based measure approach. *Omega* **2010**, *38*, 145–156. [CrossRef]
54. Yang, G.-L.; Fukuyama, H.; Chen, K. Investigating the regional sustainable performance of the Chinese real estate industry: A slack-based DEA approach. *Omega* **2019**, *84*, 141–159. [CrossRef]
55. Shin, J.; Kim, Y.; Kim, C. The perception of occupational safety and health (OSH) regulation and innovation efficiency in the construction industry: Evidence from South Korea. *Int. J. Environ. Res. Public Health* **2021**, *18*, 2334. [CrossRef]
56. Kuo, K.-C.; Lu, W.-M.; Nguyen, D.T.; Wang, H.F. The effect of special economic zones on governance performance and their spillover effects in Chinese provinces. *Manag. Decis. Econ.* **2020**, *41*, 446–460. [CrossRef]
57. Kuo, K.C.; Lu, W.M.; Dinh, T.N. Firm performance and ownership structure: Dynamic network data envelopment analysis approach. *Manag. Decis. Econ.* **2020**, *41*, 608–623. [CrossRef]
58. Kuo, K.-C.; Yu, H.-Y.; Lu, W.-M.; Le, T.-T. Sustainability and Corporate Performance: Moderating Role of Environmental, Social, and Governance Investments in the Transportation Sector. *Sustainability* **2022**, *14*, 4095. [CrossRef]
59. Kuo, K.-C.; Lu, W.-M.; Ganbaatar, O. Sustainability and profitability efficiencies: The moderating role of corporate social responsibility. *Int. Trans. Oper. Res.* **2023**, *30*, 2506–2527. [CrossRef]
60. Lu, W.-M.; Wang, W.-K.; Kweh, Q.L. Intellectual capital and performance in the Chinese life insurance industry. *Omega* **2014**, *42*, 65–74. [CrossRef]
61. Lu, W.-M.; Kuo, K.-C.; Tran, T.H. Impacts of positive and negative corporate social responsibility on multinational enterprises in the global retail industry: DEA game cross-efficiency approach. *J. Oper. Res. Soc.* **2023**, *74*, 1063–1078. [CrossRef]
62. Wu, W.; Liang, Z.; Zhang, Q. Effects of corporate environmental responsibility strength and concern on innovation performance: The moderating role of firm visibility. *Corp. Soc. Responsib. Environ. Manag.* **2020**, *27*, 1487–1497. [CrossRef]
63. Lin, F.; Lin, S.-W.; Lu, W.-M. Dynamic eco-efficiency evaluation of the semiconductor industry: A sustainable development perspective. *Environ. Monit. Assess.* **2019**, *191*, 1–16. [CrossRef]
64. Tsai, W.-C.; Chen, C.-C.; Chiu, S.-F. Exploring boundaries of the effects of applicant impression management tactics in job interviews. *J. Manag.* **2005**, *31*, 108–125. [CrossRef]
65. Aiken, L.S.; West, S.G.; Reno, R.R. *Multiple Regression: Testing and Interpreting Interactions*; Sage: Thousand Oaks, CA, USA, 1991.