Master's Science in Engineering

Analysis for Cross-border Relation Between Base Interest Rate and Construction Investment

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Abstract

Analysis for Cross-border Relation Between Base Interest Rate and Construction Investment

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The world economy is focusing on interest rate fluctuations as the zero interest rate era is closing in line with the end of quantitative easing. In this case, the interest rate, which is regarded as a measure of the change in the value of money with the passage of time, tends to have a negative correlation with the construction investment. In particular, base interest rate, which is representative of each national interest rate, is determined by reflecting the policy intentions.

This study suggests the necessity of cross - border analysis in analyzing the relation between interest rate and construction investment considering characteristics of interest rate and construction investment variables. Differences among base interest rates of each country are determined by

influencing each other, since they affect the flow of capital in the global economy. In the case of construction investment, relevant policies or investment decision makers consider the situation both the inside and outside situations of the country. Therefore, this study analyzed the relation between the base rate and the construction investment beyond the border.

The period of each variable was checked by autocorrelation analysis, and the correlation strength and time difference between the variables were confirmed through cross correlation analysis. Based on this, the necessity of cross-border relation analysis is confirmed. Moreover, the result of the relation analysis itself will contribute to decision makers of construction related policies or investment to respond to the construction industry.

Keyword: Interest Rate, Base Interest Rate, Base Rate, Construction Market Condition, Construction Investment, Cross-correlation Analysis, Correlation

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Chapter 1. Introduction

1.1. Background: Termination of Quantitative Easing

Interest rate, which is a measure of change in the value of money over time(Yi, 2010), is a key economic and financial variable that affects substantially all other economic factors(Tan, 1988; Kim & Lee, 2014). In 2008, the global economy suffered from the US financial crisis. In 2010, quantitative easing was implemented in major countries around the world in response to the financial crisis.

As a result, the world has reached an unprecedented low interest rate era. As the global economy recovers, the US has raised interest rates four times since the end of 2015. Furthermore, it is expected to gradually increase interest rates in the future.

That is, as the zero interest rate period ends and the interest rate movement normalizes, this situation is observed not only by governments, industries, and companies of each country, but also by the bond market, the stock market, and the real estate market

1.2. Interest Rate and Construction Project

In particular, it is important to consider interest rates in construction investment(Wang et al., 2004). In fact, interest rates have a both large and small impact on the entire process from the early stages of the construction project to construction phases. Also, interest rates affects the phase of selling.

For example, if the interest rate increases during the fund raising process, the interest expense increases. Moreover, if the interest rate increases, the expected profit decreases from the net present value(NPV) analysis. In the case of inflation with a high inflation rate, the government increases interest rates to calm the overheated economy. In case of the contrary, the government decreases the interest rate to stimulate the economy. This change in interest rates generally affects the rate of change in direct costs of construction projects.

In addition to this, the construction sector is a major part of the national economy(Tan, 1988; Lee et al,. 2016) as a backbone industry. For construction-related policies or project, the massive funds are mobilized over a long period of time. Therefore, it is necessary to take into consideration the precise recognition of the current phase of the construction industry and future prospects when making the decisions of related parties(Moon et al., 2005; Kim et al., 2010). In order to help decision-making, interest rates have been centered on the fact that raising interest rates can shrink construction

investment and lowering interest rate would lead to construction investment activation(Tan, 1988; Kim et al., 2007 ; Yi, 2010; Kim et al, 2013).

Based on this, research has been conducted on the relationship between interest rates and the construction industry(Park et al., 2008; Kim et al., 2010). At this time, construction investment, housing price, and unsold housing were set as variables for the construction industry. Then the relationship between interest rate and the each factor for finding precedence relation or positive-negative relation. In addition, the need for additional research on relationship analysis has been continuously proposed(Wang et al., 2004; Moon et al., 2005; Park et al., 2008; Yi, 2010).

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1.3. Problem Statement

Previous research on interest rates and construction has focused on the analysis of variables within a single country. However, it did not reflect two points. One is that the interest rates of each country are substantially influencing each other(Huh et al., 2014). And the other is that changes in interest rates affect other countries' economic situation or investment direction. While some depend on national credit, global investors who operate funds tend to move funds to countries that can earn higher interest rates at the macro and long-term perspective.

In other words, the spread of interest rates among different countries represents fiscal soundness, which has a large impact on international money transfers and creates a possibility of massive outflow of funds. Therefore, each country's interest rate is determined by mutual influence(Park, 2016).

At the same time, interest rates are often politically determined at the national level in order to control the economy. In many cases, interest rate cuts are in line with policies to stimulate the construction industry. In the construction sector, companies in many developed countries also develop strategies and make decisions for markets around the world.

Given the nature of interest rates and the construction sector, there is a limit to the analysis of the relationship between specific internal variables in one country. Therefore, it is necessary to study the relationship between interest

rates and construction investment beyond the borders. In addition, when a cross-border analysis is conducted, if we find a relationship between the leading indicator as a more advanced signal or a variable with a higher correlation strength, it could be contributable.

As for the variable setting, the interest rate variable is set as the base rate representing the interest rate of each country. And the construction market condition is the construction investment as the proxy variable(Wang et al., 2004; Moon et al., 2005; Kim et al., 2010; Kim, 2012; Lee, 2017).

In short, considering the characteristics of variables, there is the need to analyze the relationship between interest rates and construction market condition across, which is absent.

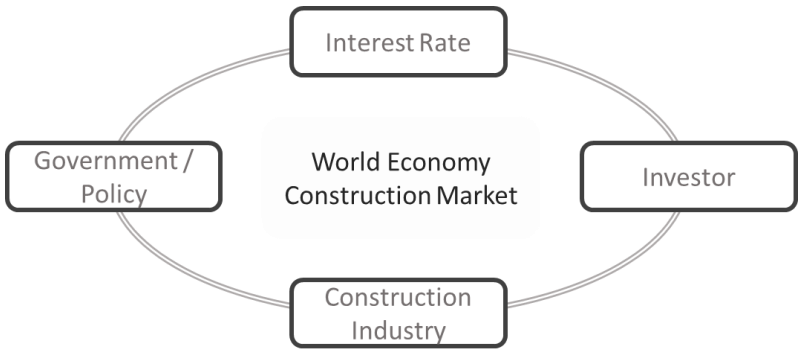


Figure 1-1. Construction Market in the World Economy

With Key Factors

1.4. Research Purpose and Scope

The purpose of this study is to analyze the relation between the base interest rate and the construction investment beyond the border, and to consider the external variables. For this purpose, this study examines the correlation between the base rate and the construction investment and the correlation strength. Furthermore, this research observes the differences among the countries and draws implications on existing theories and research.

The analysis period for the relationship between variables in this study is from 1977 to 2014. This period includes major internal and external events such as the second oil shock in 1979, the Asian economic crisis in 1997, the September 11, 2001 terrorist attacks in 2001, the US financial crisis in 2008, and the subsequent European financial crisis. Also, it was considered to be a sufficiently long enough to allow macro-economic analysis.

The US base rate and the EU base rate are selected as variables of interest rates. In the case of the US base rate, it is representative in the world, and its influence is substantial(Turner, 2014). Therefore, the analysis of the relationship between variables that transcend national boundaries centered on the US base rate is meaningful.

Next, in the case of EU base rate, considering the fact that the majority of the countries analyzed are members of the European Union and the influence of the Euro Zone economy, EU base rate needs to be considered as a

representative interest rate variable. However, since the analysis period has been since 1977, it is difficult to use EU base rate that is established in 1993. Thus, this study substitute EU base rate with Germany's base rate, which has been leading the Eurozone economy and is representative of the European Union.

The analysis of construction investment is conducted in 11 countries(USA, Japan, France, Italy, Korea, Netherlands, Austria, Norway, Denmark, Finland, Czech Republic) which are members of the Organization for Economic Cooperation and Development. The period of accumulation of construction investment data officially in the OECD was not long enough, and there was a limit in selecting countries with sufficient data for the period.

However, representative countries of different continents (America, Asia, and Europe) are included. If data of other countries are sufficiently accumulated and secured in the future, apply the method of this study to the analysis of other countries, results could be enlarged.

1.5. Research Method

The analysis of the relationship between the selected interest rate and the construction investment focuses on the understanding precedence relation, time lag, positive-negative relation, or strength of relation. First, cross-correlation analysis is performed. IBM SPSS Statistics 23 is used as the analysis tool. Then, based on the characteristics of the interest rate variable and the construction investment variable, the cross-correlation analysis result is analyzed, and some relation analysis is performed.

The analysis procedure is shown in Figure 1-2, and the contents at each step are as follows.

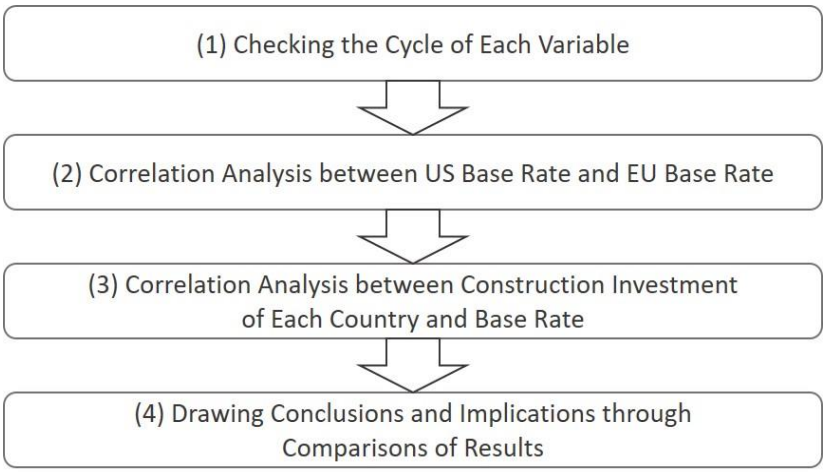


Figure 1-2. A Procedure for Analyzing Correlation between Base Rate and Construction Investment

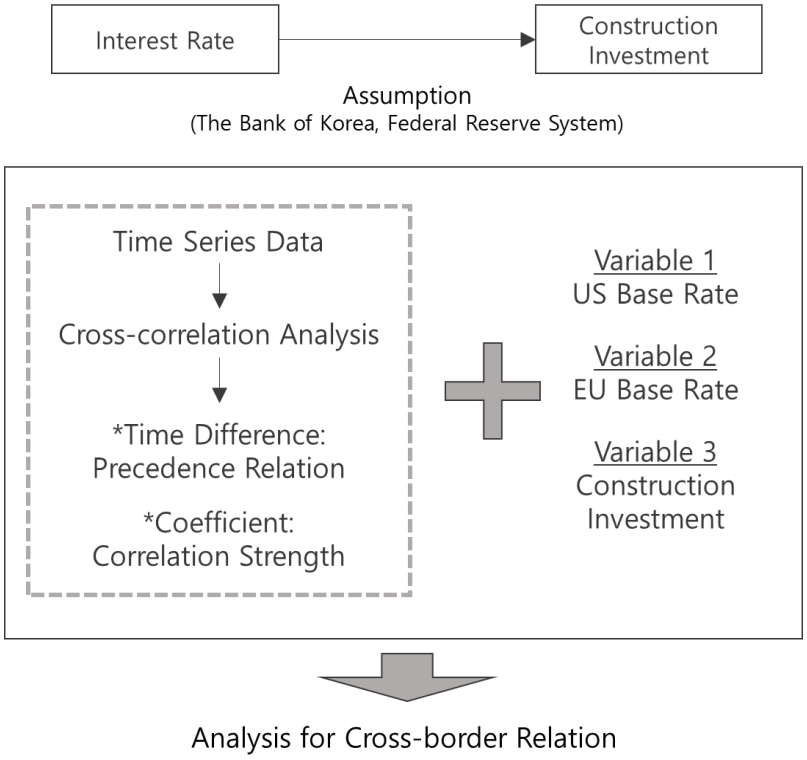


Figure 1-3. Statistical Meaning of Correlation Analysis for This Study

The overall statistical analysis flow of this study is as shown in Figure 1-3. First, it was assumed that construction investment is affected by interest rates in accordance with basic economic theory. Next, cross-correlation analysis was conducted to analyze the relation between variables. At this time, cross-correlation analysis is a method of analyzing time-series data. Precedence relation could be verified by the time difference from the results. Furthermore, the correlation coefficient value means the correlation strength. As a result,

according to the assumption and the characteristics of cross-correlation analysis, the relation between variables across borders was analyzed. Then the implications were derived from the results

Chapter 2. Preliminary Study

In this chapter, contents of preliminary studies for base rate and construction investment are described. In detail, the definition of each variable, basic theory, and analysis method for construction business are suggested. Moreover, related existing studies are analyzed to emphasize the need for this study.

2.1. Definition of Base Interest Rate and Construction Investment

Base Rate is the policy rate that represents each country's interest rate. Therefore, when the base rate is set according to the policy objective, the interbank transactions are made with the short-term interest rates which are almost the same as the corresponding days. In this study, this short-term interest rate is used as the surrogate variable of the base rate for a quantitative analysis.

Construction investment is the classification of total capital formation by expenditure items of Gross Domestic Production(GDP) by capital goods type. The amount of construction investment refers to all goods and services that form fixed capital due to construction activities such as facility construction(Statistics Korea). That is, all of the expenses(labor, materials, expenses, etc.) entered into the construction of social overhead capital(SOC), land improvement business, and building construction such as roads built on the land for one year(Construction & Economy Research Institute of Korea).

2.2. Basic Relation Between Interest Rate and Construction Investment

Interest rates and general investment are in negative relation that the decline in interest rates induces investment stimulation, and the rise in interest rates has a negative correlation with investment shrinkage(Yi, 2010). It is known that interest rates and construction investment also have a negative correlation(Tan, 1988; Kim et al., 2013; Yi, 2010). In particular, looking at NPV analysis(see Equation 2-1), which is the basis of profitability analysis when construction investment is made, it can be seen that the interest rate and NPV are negatively correlated.

$$NPV = -E + \sum_{t=1}^{n} \frac{Y(t)}{(1+i)^t} \quad \text{.....Equation 2-1.}$$

E = initial cash equity
$Y(t)$ = cash-flow profile for year t
i = interest rate
n = investment period

2.3. Analysis Method for Construction Business

Table 2-1. Method of Analyzing Construction Market Condition(Moon et al, 2005; Park et al., 2008)

Analysis Method	Content
Individual Indicators	Based on theories or past empirical facts, the most basic market condition analysis method using individual indicators
Survey	Survey on market condition from economic agents such as Business Survey Index or Consumer Survey Index
Composite Indexes of Business Indicators	Understanding overall movement of market condition by selecting economic indicators, processing and synthesizing
Metric Model	Modeling the causal relationship or correlation between economic variables into equation system to grasp the whole flow

In general, there are four methods for analyzing the construction industry, as shown in Table 2-1, by individual indicators, by survey, by composite indexes of business indicators, and by metric model. It is known that the method based on the individual indicators using the construction and statistical indicators is one of the main methods (Moon et al., 2005; Park et al., 2008).

The purpose of this study is to analyze the relationship between the existing interest rate and the construction industry by analyzing individual indicators for adding meaning beyond the border. If we analyze additional individual

indicators and accumulate the results in the future including this study, it is thought that it will be useful for constructing construction index or building model.

2.4. Literature Review

Research on the analysis of the relationship with various macroeconomic factors has been carried out in order to identify trends of construction industry and to diagnose the construction industry. It has been confirmed that the construction industry has various economic variables.

For example, Kim, S.(2010) analyzed the relationship between macroeconomic changes(GDP, exchange rate, interest rate, household consumption expenditure, consumer price index). Park J.(2008) analyzed the proportion of construction industry and construction industry in GDP and analyzed the increase-decrease of growth rate of construction industry using Markov Switching Model which is a part of the transition model. Moon H.(2005) analyzed the indicators that are considered to represent the construction industry, evaluated its characteristics and performance, and presented more systematic index selection criteria for the construction industry. As such, the construction industry is perceived to be closely related to the economy and its relationship with economic variables has been analyzed.

Table 2-2. Summary of Literature Review

References on the Relationship between Interest Rate and Construction Sector			
Researcher	Construction Variable (Correlated Subject)	Precedence Relation Analysis	Positive-Negative Correlation Analysis
Kim & Jeong (2012)	Price of Apartment	X	(-)
Yi (2010)	Construction Contract	0	(-)
Kim, Song, & Nam (2007)	Price of Seoul Apartment	0	(-)
Jung & Kim (2005)	Unsold Rate	X	(+)
Akintoye, Bowen, & Hardcastle (1998)	Construction Contract Price of UK	0	(-)
Harris (1989)	Housing Market Volume of US	X	(-)
Akintoye & Skitmore (1994)	Private Sector Construction Demand of UK	X	(-)

Especially, interest rate is one of the macroeconomic factors, and prediction and diagnosis of the construction industry was attempted based on the correlation with the construction industry(such as the construction order amount, apartment price, unsold housing). Some studies have also analyzed the parallax between correlated variables. The interest rate of the Republic of Korea has a negative correlation with the construction contract amount of the Republic of Korea and the Seoul apartment price as a leading indicator(Kim et

al., 2007; Yi, 2010). In Korea, interest rates and apartment prices generally have a negative correlation(Kim et al., 2012). Interest rates have been positively correlated with unsold housing units(Jung et al, 2005).

In the United Kingdom, base rate is regarded as a leading indicator of construction contract prices in a negative correlation preceding 1-2 quarters(Akintoye et al, 1998). Also, private sector construction demand is negatively responsive to interest rate(Akintoye & Skitmore, 1994). In the United States, interest rate has negatively correlated with volume of housing market(Harris, 1989). Table 2-2 summarizes these findings.

It is considered that this is useful information when the construction-related entities are to respond to the pre-emptive or to evaluate and supplement existing policies or strategies. However, the absence of an analysis for the relationship between the construction industry of any country and the interest rates of other countries, reflecting the characteristics of interest rates that transcend national boundaries and have significant impacts across countries.

Therefore, this study analyzes the correlation strength, precedence relationship, and time difference between base rate and construction business condition transcending borders. In this study, the construction investment was set up as the proxy variable of the construction business condition, which was mentioned in many studies(Wang et al., 2004; Moon et al., 2005; Kim et al. 2010; Kim, 2012; Lee, 2017), the following two are assumed.

First, in each country, raising or lowering interest rates is decided

considering the US, EU, and other world events. Second, changes in US interest rate or EU base rate, which is representative in the world economy, affects each country's industry or economy.

2.5. Summary

Base rate is the representative variable of interest rate. It is set as construction investment as proxy variable of construction business condition. Based on the basic theory, there is a negative correlation between base rate and construction investment, and the related precedent studies were analyzed. However, when the characteristics of each variable are taken into consideration, it is necessary to analyze the relationship across borders.

Chapter 3. Correlation Analysis between Base Interest Rate and Construction Investment

In this chapter, correlation between base rate and construction investment is analyzed. First, specific value of each variable is set for quantitative analysis. Then, analysis procedure is introduced. The analysis is performed with autocorrelation analysis and cross-correlation analysis. The principle and method of each analysis is suggested in this chapter.

3.1. Variable Setting

Before the cross-correlation analysis, base rate and construction investment variables were set and the data were collected. The contents are shown in Table 3-1.

Table 3-1. Variable Setting

	Variable 1 US Base Rate	**Variable 2 EU Base Rate**	**Variable 3 Construction Investment**
Data Selection	Effective Federal Funds Rate	Germany Overnight Inter-bank Rate	YoY*** Growth Rate of Yearly Construction Investment Amount of Each Country
Collection Period (year)	1977-2014 (As of December of Each Year)		
Source	FRB*	OECD.STAT**	OECD.STAT
Unit	%		

*Federal Reserve Board of Governors

**OECD Statistics

***Year on year

In the case of base rate variable, the short term interest rate(call rate), which is used for the actual interbank transaction and has almost the same value according to the base rate, is used as the proxy variable of base rate having the nature of the policy objective. The effective Federal Funds Rate was used as proxy for the US base rate and the German Overnight Inter-bank Rate, which

represents the Eurozone economy, was used as proxy for EU base rate.

In the case of construction investment variables, the values derived from the Volumes based on the Structural Analysis provided by OECD.STAT were used to calculate the real GDP of each country. At this time, the annual construction investment amount worldwide has tended to grow together with each other as the national economy grew since 1977. Therefore, it is natural that rising of the annual amount of construction investment itself is a natural phenomenon, and the relationship between YoY growth rate of yearly construction investment amount and the change rate in base rate is analyzed.

3.2. Role of Base Interest Rate and Assumption

(1) Role of Base Interest Rate on Construction Investment

The base rate increase causes interest rate increase. Then interest rate increase leads to financing cost increase, shrinkage of investment, and shrinkage of market. Construction market including real estate market, which is sensitive to both domestic and overseas economies, also contracts. In the case of base rate decrease, opposite situation is occurred.

(2) Assumption: Base Rates Regarded as a Signal That Causes Construction Investment Fluctuation

Base interest rate is determined by examining the circumstances of each country or global economy. In other words, considering the internal and external economic situation, it is adjusted with the intention of controlling the economy at the national level. Saying that again, the change in base interest rate is determined by expecting investors to move in the direction they want.

For example, base interest rate of Korea is determined by the Monetary Policy Committee of the Bank of Korea. At this time, base rate will be determined eight times a year considering the inflation trend, domestic and overseas economic conditions, and financial market conditions. This immediately affects the call rate. This leads to fluctuations in short-term and long-term market interest rates, deposits and loan interest rates, and ultimately

affects real economic activity(The Bank of Korea).

The same is true for US base interest rate as determined by the FOMC. Changes in the federal funds rate trigger a chain of events that affect other short-term interest rates, foreign exchange rates, long-term interest rates, the amount of money and credit, and, ultimately, a range of economic variables, including employment, output, and prices of goods and services. The FOMC holds eight regularly scheduled meetings per year. At these meetings, the Committee reviews economic and financial conditions, determines the appropriate stance of monetary policy, and assesses the risks to its long-run goals of price stability and sustainable economic growth(Federal Reserve System).

3.3. Analysis Procedure of Correlation

(1) Checking the Cycle of Each Variable

Prior to cross-correlation analysis, each cycle of each variable that can affect the analysis results should be checked. If the results of cross-correlation analysis are related to the cycle of each variable, it should be checked whether the result is due to correlation between variables or by self-cycle. Therefore, first-order autocorrelation analysis was performed to check the self-cycle of each variable.

Since the first-order analysis was performed in the cross-correlation analysis, the autocorrelation analysis was also performed as the first-order analysis. In the first-order analysis, it means analyzing the difference between the variables, not the absolute value of the variable in the time-series data. This study refers to an analysis comparing the previous year variables with the year variables.

(2) Correlation Analysis between US Base Rate and EU Base Rate

Cross-correlation analysis was used to determine the relationship between US base rate and EU base rate. Unlike construction investment, which has been steadily increasing for decades, base rate has been fluctuating and has been performing the adjustment function for economy situation. When discussing the results, the characteristics of base rate was reflected.

(3) Correlation Analysis between Construction Investment of Each Country and Base Rate

First-order cross-correlation analysis between construction investment and base rate was conducted to find precedent relation including time lag and relation strengths. Executing the first-order analysis is to see how the change in base rate and the change in the growth rate(change ratio) of construction investment change. In other words, this is not a relation between the base interest rate itself and the growth rate itself, but the relationship between the rise and fall of interest rates and the activation or inactivation of construction investment.

(4) Drawing Conclusions and Implications through Comparisons of Results

The conclusions and implications are derived by comparing and analyzing the correlation results among countries or variables.

3.4. Autocorrelation Analysis

(1) Autocorrelation Analysis

Time-series variables often have past values that affect the current value. When autocorrelation analysis is performed, it is possible to know whether the value at the time before the specific period has a positive or negative relation with the present value. In this case, the intensity is the absolute value of the autocorrelation coefficient, and the positive or negative relation could be known through the sign of the autocorrelation coefficient.

(2) Meaning of Time Difference in Autocorrelation Coefficient

The autocorrelation coefficient of lag k is shown in Equation 3-1 below.

$$\rho_k = \frac{\sum_{i=1}^{N-k} [x(i) - \bar{x})]\,[x(i+k) - \bar{x}]}{\sum_{i=1}^{N} [x(i) - \bar{x}]^2} \quad \text{.....Equation 3-1}$$

For example, in the time series data {x(t)}, the following correlation coefficient as shown in Table 3-2 is called a lag 2 autocorrelation coefficient or a second-order autocorrelation coefficient ρ_2.

Table 3-2. Second-Order Autocorrelation Coefficient ρ_2

…		$x(t-1)$	$x(t)$	$x(t+1)$	$x(t+2)$	…
…		$x(t-3)$	$x(t-2)$	$x(t-1)$	$x(t)$	…

3.5. Cross-correlation Analysis

Cross-correlation analysis is an analytical method that is used to find the relation between two different time series variables with a certain degree of intensity and a positive or negative correlation. In the cross-correlation coefficient, the absolute value means the correlation strength and the sign determines the positive or negative correlation. In this study, we estimate a normal population with 95% confidence. In this case, the standard deviation is $1/\sqrt{n-|k|}$ (n : the number of observations, k : time lag)

3.6. Summary

First, the data used for each variable are presented in detail. Base rate value was obtained by using short-term interest rate data. Construction Investment value was obtained by the YoY growth rate of yearly construction investment amount of each country. Correlations were derived from the year-to-year rate of change rather than absolute value.

Then, the procedure of the correlation analysis was suggested with details for each step. Lastly, autocorrelation analysis and cross-correlation analysis were described respectively.

Chapter 4. Result of Correlation Analysis

All the variables, which are US base rate, EU base rate, and construction investment of each country, were checked to find self-cycle through autocorrelation analysis. Then, cross-correlation analysis between US base rate and EU base rate was conducted. After that, cross-correlation analysis between base rate of US or EU and construction investment of each country. The result of each analysis were derived as coefficient with time lag, sign, and strength.

4.1. Cycle Check 1: Base Interest Rate of US and EU

In Figure 4-1, the values of the Auto Correlation Function(ACF) on the Y axis are the autocorrelation coefficients. The value that is greater than the upper limit of confidence or lower than the lower limit of confidence means that the bar graph has a valid correlation within the error range if it exceeds the upper or lower confidence limits.

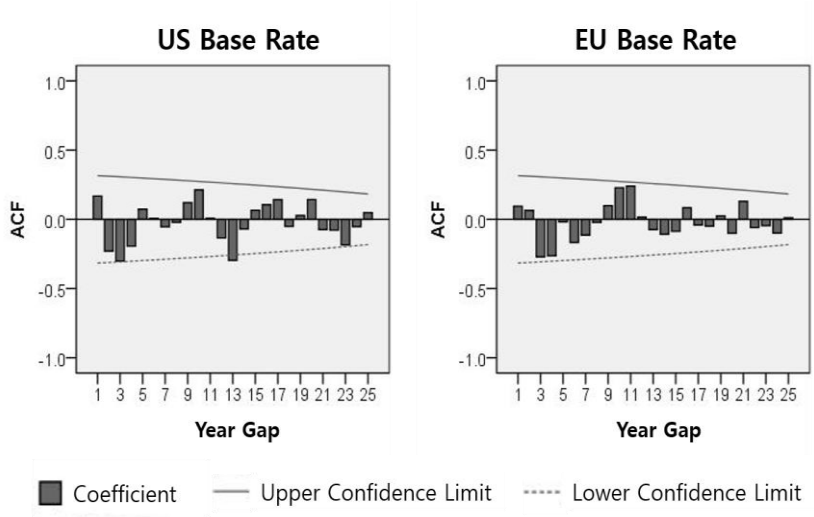


Figure 4-1. Auto Correlation Function of US Base Interest Rate and EU Base Interest Rate

Figure 4-1 shows the distribution of autocorrelation coefficients according to the time lag between the US base rate and the EU base rate. The US base rate had an autocorrelation coefficient of -0.30 with a time lag of 3 years, and

a -0.30 with a time lag of 13 years. Moreover, the autocorrelation coefficient of -0.19 with a 23-year time difference. On the other hand, the EU base rate did not have a valid autocorrelation coefficient.

The meaning of autocorrelation coefficient was examined at this time. For example, if the US benchmark interest rate has a negative autocorrelation coefficient with a time lag of three years, the current US base rate change means negative correlation with the change of the US base rate three years later.

In terms of the cycle, the fact that the US base rate has a negative autocorrelation coefficient that is valid for time lag of 3 years, 13 years, and 23 years, that is, repeating every 10 years means that the US base rate has a self-cycle of 10 years.

4.2. Cycle Check 2: Construction Investment

The autocorrelation analysis of the year-to-year growth rate of the annual construction investment amount by each country was conducted with the same principle as in chapter 4.1. above, and the result is shown in Figure 4-2. The year-to-year change in annual construction investment has been found to have significant autocorrelation coefficients in some countries(Austria, Czech Republic, Italy, Korea, and the Netherlands).

Therefore, when cross-correlation analysis related to these variables is performed, if the cross-correlation is related to the autocorrelation of the related variables, the interpretation of the result should be noted. Table 4-1 summarizes the autocorrelation results of all variables.

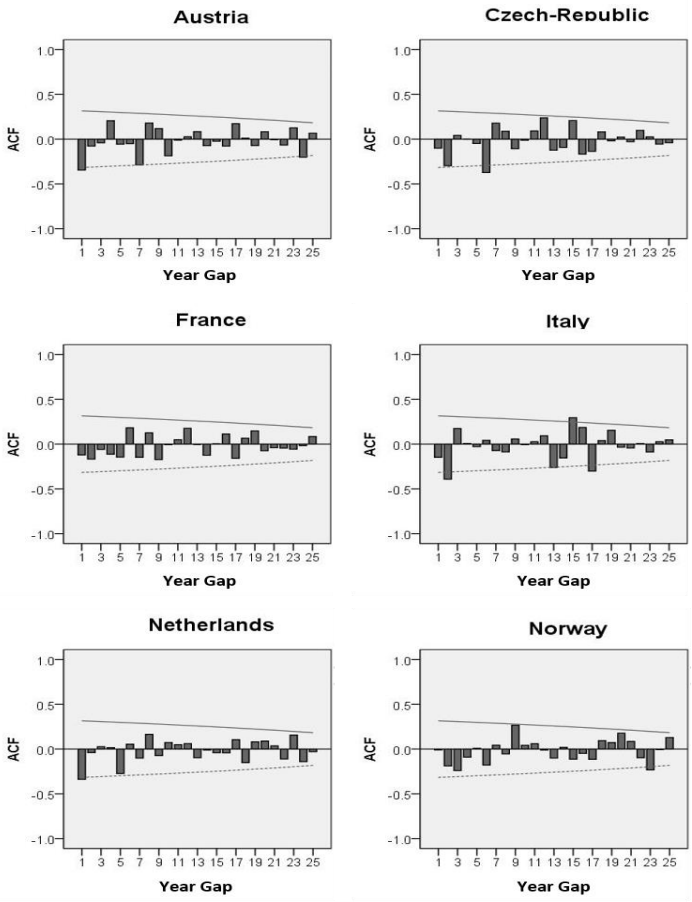
Table 4-1. Result of Autocorrelation Analysis

Variable	Contents	Subject	AC**	Year Gap	Cycle (year)
Variable 1	Base Rate	US	-0.301	3	10
Variable 2	Base Rate	EU	-	-	-
Variable 3	YoY Growth Rate of Yearly Construction Investment Amount	Austria*	-0.346	1	-
		Czech Republic*	-0.374	6	-
		Denmark	-	-	-
		Finland	-	-	-
		France	-	-	-
		Italy*	-0.392	2	-
		Japan	-	-	-
		Korea*	-0.329	9	-
		Nether-lands*	-0.338	1	-
		Norway	-	-	-
		US	-	-	-

* Subjects that have meaningful AC

** Autocorrelation Coefficient

'-' means that there is no effective value within a valid range


Austria
Czech-Republic
France
Italy
Netherlands
Norway
ACF
1.0
0.5
0.0
-0.5
-1.0
1 3 5 7 9 11 13 15 17 19 21 23 25
Year Gap

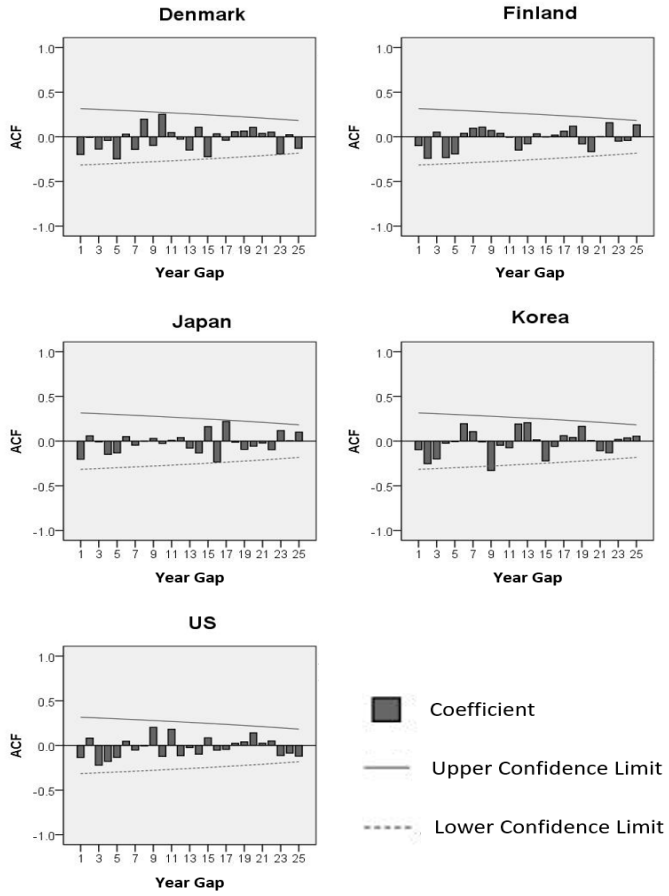


Figure 4-2. ACF of YoY Growth Rate of Yearly Construction Investment Amount of Each Country

4.3. Result of Cross-correlation Analysis between US Base Interest Rate and EU Base Interest Rate

Table 4-2 shows the results of cross-correlation analysis between the US base rate and the EU base rate. In the statistical results, the US base rate preceded and lagged the EU base rate at the same time. Although there was a difference in the correlation strength, both values were found to be meaningful within the error range.

Table 4-3. shows P-values of each correlation between US base rate and EU base rate. If P-value is lower than 0.05, the null hypothesis is rejected. It means that relation is effective.

Table 4-2. Result of Cross-correlation Analysis between US Base Interest Rate and EU Base Interest Rate

CC* 1	Year Gap**	CC 2	Year Gap
0.630***	1	(-)0.362****	(-)2

*: Cross-correlation coefficient

**: It means that how many years the US Base Rate leads to EU Base Rate (negative value means lagging)

***: The largest value among the effective CCs

****: The second largest value among the effective CCs

Figure 4-3 shows the result of autocorrelation analysis and cross-correlation analysis. Here, 'statistical meaning' is merely a relation with statistical result. While 'real meaning' reflects the result of autocorrelation analysis about precedence relation according to time lag and the meaning of cause and result.

Table 4-3. P-value of Pearson Correlation Between US Base Interest Rate and EU Base Interest Rate

P-value 1	Year Gap*	P-value 2	Year Gap
0.000**	1	0.017***	(-)2

*: It means that how many years the US Base Rate leads to EU Base Rate (negative value means lagging)

**: P-value of the largest cross-correlation coefficient

***: P-value of the second largest cross-correlation coefficient

The result for cross-correlation analysis of the US base rate and the EU base rate in Table 4-2 shows that even if the correlation coefficients are different, the relation seems to be contradictory since the US base rate not only precedes but also follows up. However, applying the fact that the US base rate as identified in chapter 4.1. has an autocorrelation with a 3-year time lag, the relationship between the European base rate and the US base rate, shown in dashed lines in Figure 4-3, is a statistical result due to the real relationship indicated by the solid line..

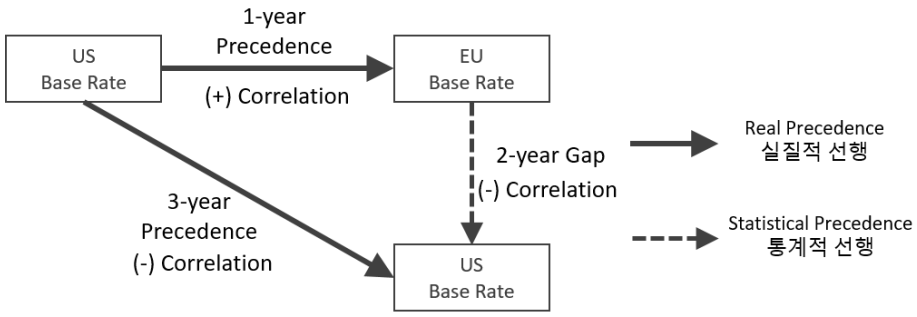
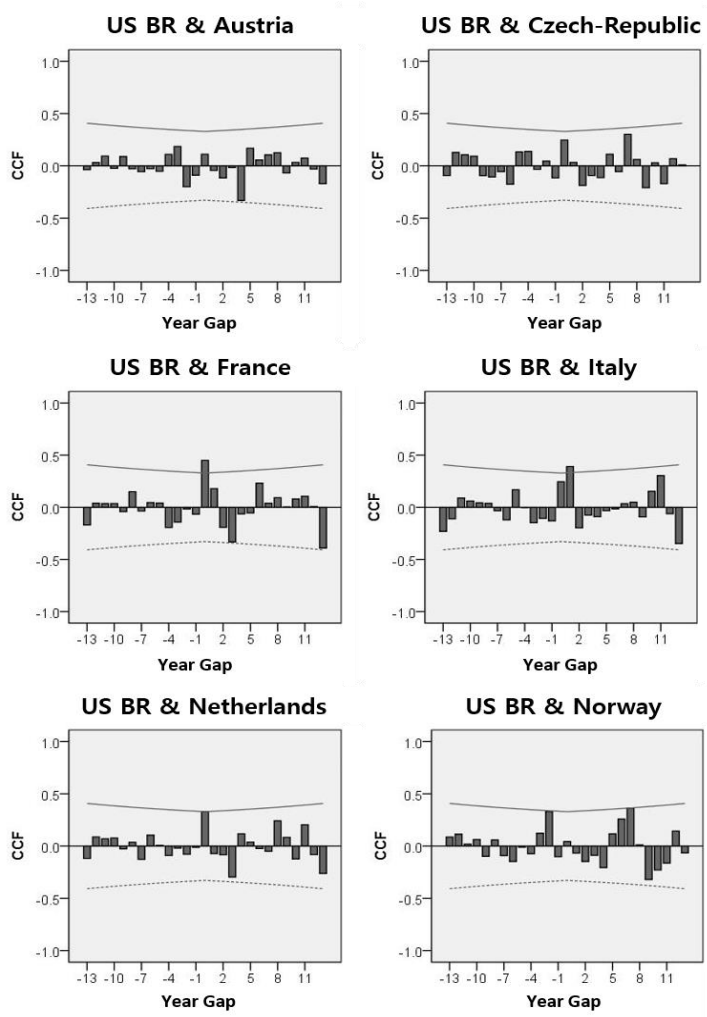


Figure 4-3. The Relation Between US Base Interest Rate and EU Base Interest Rate as Result of Correlation Analysis

4.4. Result of Cross-correlation Analysis between Base Interest Rate(US&EU) and Construction Investment of Each Country



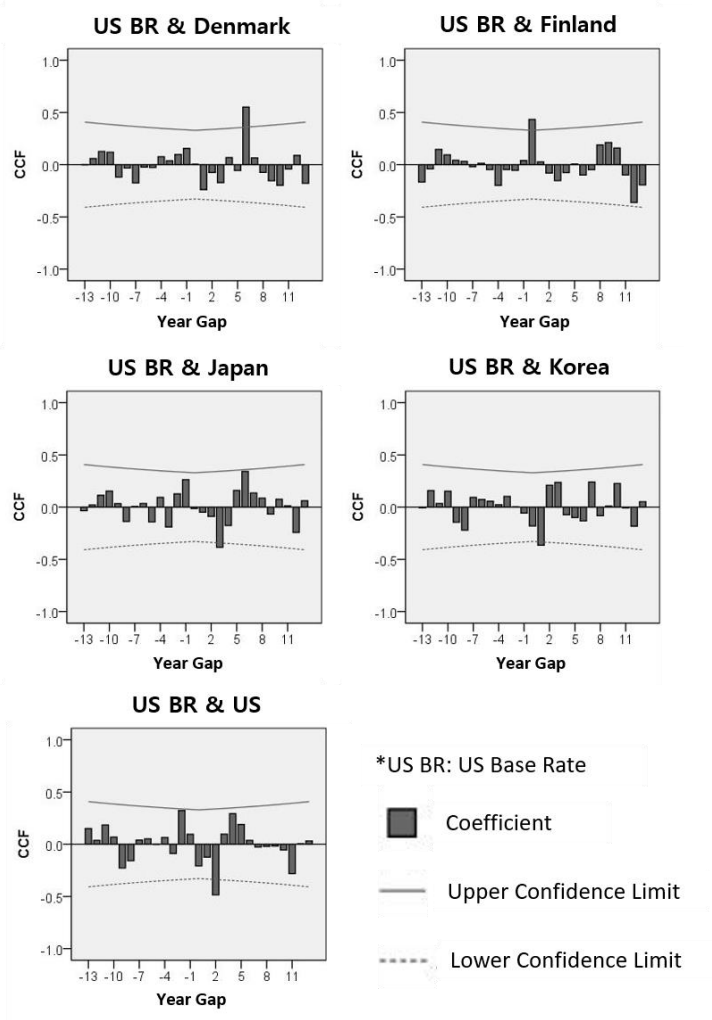


Figure 4-4. Cross-Correlation Coefficient between Construction Investment of Each Country and US Base Interest Rate

Figure 4-4 shows the cross-correlation coefficient between the US base rate and construction investment of each country. In the same way, the cross correlation coefficient between the EU base rate and each country's

construction investment was calculated. In Figure 4-4, the bars above the upper or lower confidence limits are valid cross-correlation coefficients within the error range in each relationship, and are summarized in Table 4-4.

Table 4-4. Coefficient of Cross-Correlation Analysis Between Construction Investment and Base Interest Rate

	Analysis with US Base Rate		**Analysis with EU Base Rate**	
Subject of Construction Investment	CC*	Year Gap**	CC	Year Gap
Austria	-	-	-	-
Czech Republic	-	-	-	-
Denmark	0.552	6	(-)0.358	2
Finland	0.433	0	(-)0.356	2
France	0.450	0	(-)0.429	2
Italy	0.391	1	0.335	0
Japan	(-)0.409	3	-	-
Korea	(-)0.365	1	(-)0.531	0
Netherlands	0.328	0	(-)0.428	2
Norway	-	-	-	-
US	(-)0.485	2	(-)0.472	1

*: Cross-correlation coefficient

**: It means that how many years the Base Rate precedes (negative value means lagging)

'-' means that there is no effective value within a valid range

Table 4-5. shows P-values of each correlation between construction investment and base interest rate. If P-value is lower than 0.05, the null hypothesis is rejected.

Table 4-5. P-value of Pearson Correlation Between Construction Investment and Base Interest Rate

	Analysis with US Base Rate		**Analysis with EU Base Rate**	
Subject of Construction Investment	P-value	Year Gap*	P-value	Year Gap
Austria	-	-	-	-
Czech Republic	-	-	-	-
Denmark	0.000	6	0.034	2
Finland	0.007	0	0.035	2
France	0.005	0	0.010	2
Italy	0.018	1	0.043	0
Japan	0.016	3	-	-
Korea	0.029	1	0.001	0
Netherlands	0.047	0	0.010	2
Norway	-	-	-	-
US	0.003	2	0.004	1

*: It means that how many years the Base Rate precedes (negative value means lagging)

‘-’ means that there is no effective value within a valid range

As a result, construction investment in Austria, Czech Republic and Norway did not have a significant correlation with the US and EU base rates.

In the case of other countries, the characteristics that are identified by dividing into precedence relationship and the positive-negative relationship are summarized as follows.

First, in terms of precedence relations, both the US base rate and the EU base rate were confirmed to precede or be accompanied by construction investment in most countries, except for countries that do not have some correlation with each other. Mostly, base rate precedes construction investment. However, in terms of construction investment in the same country, the time lags with the US base rate and EU base rate were different. For example, Japanese construction investment did not have a correlation with the EU base rate. While, it had a correlation with the US base rate.

Next, in terms of positive-negative correlations, the US base rate was negatively correlated with the construction investment in Japan(-0.409), Korea(-0.365), and the US(-0.485). Construction investment in Denmark(-0.358), Finland(-0.356), France(-0.429), and the Netherlands(-0.428) was negatively correlated with EU base rate and positively correlated with US base rate . Construction investments in Austria, the Czech Republic, Italy and Norway did not have a significant correlation with the US base rate or EU base rate. Japanese construction investment has a negative correlation with the US base rate, but not with the EU base rate.

4.5. Summary

Through autocorrelation analysis for each variables of base rate and construction investment, self-cycle was checked. US base rate had a 10-year self-cycle. It means that if correlation coefficients for cross-correlation analysis are related to self-cycle, additional cause analysis should be performed.

After that, cross-correlation coefficients were derived through cross-correlation analysis between US base rate and EU base rate and between each base rate and each construction investment. Most results were within valid range. Each coefficient had different value by country with different time-lag.

Chapter 5. Discussion and Implications

In this chapter, there are four topics for discussion and implications. First, classification of countries subject to construction investment was analyzed. Second, feasibility of cross-border relationship analysis between base rate and construction investment was checked. Third, the necessity of considering the characteristics of base rate itself while analyzing the correlation was confirmed. Fourth, difference in impact of increasing base rate and decreasing base rate was verified.

5.1. Classification of Countries Subject to Construction Investment Analysis

According to the cross-correlation analysis, 11 countries for construction investment analysis are divided into three groups having similar characteristics. The theoretical background that interest rates and construction investment have a negative correlation is set as a standard. In other words, it first sought to find out what kind of base interest rate the construction investment of each country has a negative correlation with. The countries that have a negative correlation with the US base rate and the EU base rate are classified into groups A and B, respectively. The remaining countries were classified as Group C.

With the similarities, US base rate precedes in a negative correlation with construction investment of countries(Japan, Korea, and the United States) as group A. US base rate accompanies in a positive correlation by, and EU base rate precedes in a negative correlation with construction investment of countries(Denmark, Finland, France, and the Netherlands) as group B. Other countries (Austria, Czech Republic, Italy, and Norway) were classified as group C

Group A countries that have a negative correlation with the US base rate have an economic alliance with the United States. On the other hand, Group B countries, which have a negative correlation with the EU base rate, belong to

the European Union. That is, the results of the grouping are valid from the viewpoint of economic market.

5.2. Feasibility Check of Cross-border Relation Analysis Between Base Interest Rate and Construction Investment

(1) Comparison Between This Study and Theoretical Background

This study confirms that there is a significant correlation between interest rates and construction investment across borders. At this time, base rate, which directly affects the economies in each country, has a negative relation with construction investment as in the background theory. For example, construction investment in European countries has a negative correlation with EU base rate, and US construction investment has a negative correlation with US base rate.

In addition, Korea, which has a significant influence from the US base rate and belongs to the Emerging Market where the monetary policy affects, has a negative correlation with the US base rate. Furthermore, when negative correlation is observed, it is confirmed that the change in the base rate precedes the growth rate of construction investment

(2) The Validity of Sample Number

Degree of Freedom(N-2) is about 35 when the data collection period is from 1977 to 2014 and when the time difference is taken into account during cross-correlation analysis. According to the Table of Critical Value of Pearson Correlation, the critical value is 0.325 based on 95% confidence level. In

other words, if the cross correlation coefficient derived from this study is 0.325 or more, it means that it has a significant correlation strength. The correlation coefficients derived from this study were satisfactory.

5.3. The Necessity of Considering the Characteristics of Base Interest Rate Itself While Analyzing the Correlation

Base rate is a variable used as a national policy tool to control the economy. Base rate has been fluctuating between 0 and 10% as the economy and the recession have repeated over the past several decades. In this case, it is possible to have a meaningful relationship by repeating the fluctuation between base rates of each country.

The cross-correlation analysis result of this study is as shown in Figure 5-1. This result is a clue as to which of the US base rate and EU base rate are more likely to lead the construction investment in each country. Arrows represent causal relation. This follows the assumption presented in Section 3.2 that construction investment is affected by base interest rates The following is an example.

In Figure 5-1, Case 1 and Case 2-1 illustrate the correlation of Table 4-3 with the US base rate ahead of the EU base rate in Figure 4-3. In Case 1, the line-and-posterior relationship was appropriate, but Case 2-1 had contradictory results. Case 2-1 shows that the US base rate precedes the EU base rate by one year and the EU base rate leads the French construction investment two years ahead. There is a contradiction in the relationship between the two.

In Case 2-2, the contradiction in Case 2-1 is solved by reflecting the case in

which the EU base rate precedes the US base rate in Figure 4-3. Based on this, it can be seen that France's construction investment is a leading indicator of EU base rate rather than the US. In other words, it is possible to give meaning to the simple statistical result value confirmed in Table 4-3 as a substantial relation.

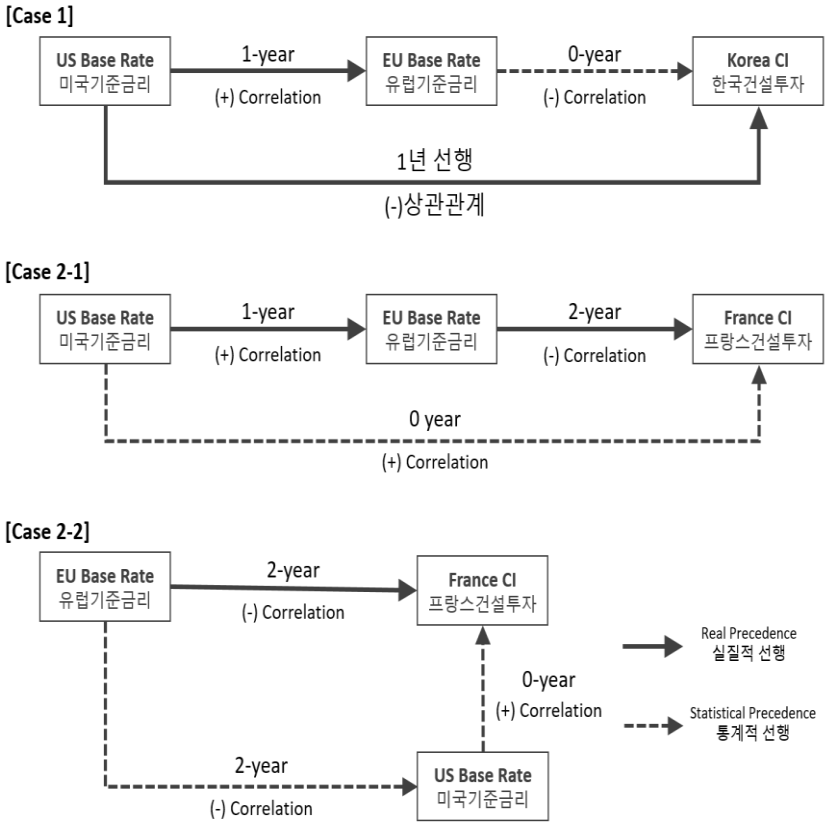


Figure 5-1. Three Cases of the Correlation Between Base Interest Rates and Construction Investment

As a result, from the standpoint of finding leading indicators, the US base rate was a leading indicator of construction investment in group A countries including the Republic of Korea. On the other hand, we can see that the EU base rate has been a leading indicator for the construction investment of group B, which includes European countries including France.

In addition, this study confirmed the correlation that could be found only through the analysis of the construction investment and the base rate beyond the border, which could not be explained by the stepwise relationship between variables. Table 4-2 shows that the relationship strength between the EU base rate and the French construction investment(-0.429) and the correlation coefficient between the EU base rate and the US base rate(-0.362). However, from these coefficients, the correlation strength(0.450) between the US base rate and the French construction investment could not be derived.

In other words, in order to know the correlation strength of the desired relationship, it is necessary to directly analyze the relationship between the base rate and the construction investment beyond the border. It is assumed that base rate and construction investment are directly or indirectly influenced by a number of economic variables in the macroeconomic world.

5.4. Difference in Impact of Increasing and Decreasing Base Interest Rate Respectively

Group A had a negative correlation with the US base rate, and group B had a negative correlation with the EU base rate. In this case, cross-correlation coefficients were compared for the three countries with the highest correlation strengths when base rate rises and when base rate declines. The values are shown in Table 5-1 below.

Table 5-1. Impact Comparison of Increase and Decrease of Base Rate

Base Rate	Construction Investment	Base Rate Increase	Base Rate Decrease
US Base Rate	US	(-)0.263	(-)0.644
	Japan	(-)0.412	(-)0.409
	Korea	(-)0.336	(-)0.369
EU Base Rate	Netherlands	(-)0.519	(-)0.333
	France	(-)0.521	(-)0.348
	Denmark	(-)0.338	(-)0.433

The fact that the base rate precedes construction investment and has a negative correlation implies that the rise in base rate will affect the contraction in construction investment and the decline in the base rate will affect the expansion of construction investment. However, depending on the country, the influence of rising and falling base rate on the construction investment differs as shown in Table 5-1. In other words, in each country, the

construction market had different sensitivities to interest rate rises and interest rate declines, respectively.

In particular, among the countries analyzed in this study, US construction investment was more than twice as sensitive to the base rate decrease(-0.644) than the base rate increase(-0.263), while construction investment in the Netherlands and France was lower than the base rate , which is more than 1.5 times higher than the base rate.

This means that the decision makers of construction investment in the global construction market need to be aware that the impact of the base rate increase and decrease may vary depending on the country when considering the base rate variable. For example, US construction investment means more attention should be paid to economic growth due to base rate decrease than the economic downturn following the rise in the US base rate.

5.5. Summary

This chapter can be summarized in four ways. First, depending on the relationship with base rate, countries subject to construction investment analysis are divided into three groups. Second, in analyzing the relationship between the base rate and the construction investment, the significance of cross-border analysis was confirmed. Third, when analyzing the correlation between base rate and construction investment, it was necessary to consider the cycle of base rate. Fourth, by countries, the impacts of each of the decreases and increases in base rate were different

Chapter 6. Conclusion

In this chapter, firstly, the entire study was briefly summarized. Then, two contributions were offered. One is about base rate as a leading indicator in the global construction market. The other is about drawing implications for future study about making corresponding model or diagnosing construction market condition. Finally, limitations were checked, and some future studies were proposed.

6.1. Research Summary

In order to respond to the construction industry, research has been conducted on the negative relationship between construction investment and interest rate with time lag. However, this study suggested the necessity of cross-border analysis when considering the characteristics of interest rate and construction investment variables. The correlation analysis was carried out through cross-correlation analysis between construction investment in major OECD countries and the US base rate or EU base rate.

At this time, it was confirmed that base rate and construction investment have a correlation with the time difference and form a correlation across the border. It is considered that this could be used in two major ways, and details are described in the next chapter

6.2. Contribution 1: Base Interest Rate as a Leading Indicator in the Global Construction Market

In the global construction market, base rate could be used as a leading index across borders. Policy makers who decide on construction investment might not only refer to the interest rate that is a leading indicator of construction investment in the country, but also to suggest that the policy evaluation should be carried out about several years later.

In addition, decision-makers of construction investment can establish a strategy by referring to the fact that when the base rate serves as a leading indicator, the timing of influencing each country's construction investment differs. For example, in the case of the US base rate decrease, it could be noted that construction investment has been expanded in the order of Korea, the United States, and Japan. Moreover, when the US base interest rate is cut, it could be guessed how strongly construction investment in the country will expand in a few years.

With the results of this study, the tendency of the change in the size of the construction market of major countries in the OECD due to the changes in the US base rate and the EU base rate could be guessed. This will help to establish a long-term strategy for decision-makers in construction investment in the target country of OECD.

6.3. Contribution 2: Drawing Implications for Future Study about Making Corresponding Model or Diagnosing Construction Market Condition

This study has left the possibility of contributing to rescue models in the future in response to the construction industry. First, it can contribute to the preemptive response by looking for the relationship as a leading indicator rather than the case of not crossing the border. For example, Korea's construction investment is affected by the US base rate one year earlier than EU base rate.

Therefore, we can refer to the US base rate as a leading indicator for the construction investment of Korea and to see the change in the US base rate as a preemptive measure. Secondly, it has been confirmed that there is a higher intensity relationship. This might be seen from the fact that construction investment in the euro zone countries has a higher correlation with the US base rate than the EU base rate.

Significant relations between variables across borders were identified for major OECD countries. If data for other countries are acquired in the future, it will be possible to establish a correlation model with economic variables for the global construction market. This could contribute to the response and prediction of the construction industry.

6.4. Contribution 3: Extensibility of Research

One of the contributions of this study is extensibility. The relation analysis method in this study can be applied to other objects to derive the meaning of relations between objects. This can be divided into two broad categories. One is the subdivision of the construction industry and the other is the application to other industries.

First, it is scalability in the construction industry. This study analyzed the construction investment of the whole construction market in each country. However, if future data is secured, the construction market can be analyzed by region or by detailed market (real estate, infrastructure, plant, etc.). If base rates have a different correlation with each detailed market, the stakeholders will be more responsive. If the housing sector is sensitive to changes in base rates, it should be more actively prepared to invest in the housing sector when the base rate is cut.

Next, it is extensibility to other industries. If this research mechanism is applied to an industry that can respond sensitively to domestic and foreign economic variables such as manufacturing and shipbuilding, a meaningful relationship can be derived. It would help in the process of establishing strategies for related industries. For example, if base rate affects the operating rate of manufacturing factories, it would contribute to the planning of facility investment or other factors.

6.5. Limitation

This study has a limitation that it depends on the data. There were limitations in selecting the target countries for analysis or subdividing the time unit for time-analysis into quarterly or monthly units. Furthermore, there was a difficulty in verifying whether the analyzed relationships had similar correlations in the future.

6.6. Future Study

In the future, related decision-makers will be able to respond more closely to the construction industry if research to analyze the relationship that takes into account the variables reflecting the internal and external economic conditions is conducted. Ultimately, a more sophisticated model of construction response will be established if the various relationships between the economic variables including the interest rate and the construction industry beyond the border are established, which will help to make more accurate decisions.

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Appendix

A. Input Variables for Correlation Analysis

A.1. Variables of Construction Investment

	STAN Database for Structural Analysis (ISIC Rev. 4, SNA08)		
Country	Austria	Czech Republic	Denmark
unit	Euro, Millions, 2010	Koruna, Millions, 20	Krone, Millions, 201
1977	25,735.9	454,423.0	164,598.0
1978	25,470.2	465,753.0	165,851.0
1979	26,019.1	467,018.0	164,144.0
1980	26,140.2	481,857.0	153,935.0
1981	25,208.2	481,224.0	131,318.0
1982	24,161.5	467,033.0	134,939.0
1983	24,454.2	481,129.0	136,392.0
1984	23,164.3	477,602.0	146,533.0
1985	24,197.9	501,667.0	156,525.0
1986	24,761.1	504,618.0	182,169.0
1987	25,641.2	514,629.0	188,990.0
1988	26,553.9	527,416.0	182,135.0
1989	27,574.4	514,551.0	175,040.0
1990	29,340.7	518,106.0	165,394.0
1991	30,858.0	500,205.0	151,662.0
1992	31,882.8	524,759.0	152,843.0
1993	32,322.3	550,331.0	150,001.0
1994	34,355.5	580,002.0	154,823.0
1995	36,121.0	651,341.0	164,982.0
1996	37,609.6	688,030.0	179,868.0
1997	37,597.0	660,757.0	189,392.0
1998	38,088.1	639,403.0	194,954.0
1999	38,463.5	614,767.0	194,119.0
2000	38,920.7	600,486.0	203,667.0
2001	37,531.3	609,127.0	205,306.0
2002	37,739.9	646,598.0	205,065.0
2003	39,683.4	694,890.0	212,682.0
2004	40,714.5	711,884.0	216,588.0
2005	41,536.9	740,175.0	227,697.0
2006	42,807.5	822,542.0	252,784.0
2007	45,126.6	934,978.0	247,857.0
2008	47,768.2	926,293.0	236,876.0
2009	45,144.9	845,380.0	206,415.0
2010	43,654.1	836,485.0	191,242.0
2011	43,504.0	802,245.0	196,904.0
2012	44,001.0	734,648.0	194,690.0
2013	43,321.8	713,160.0	193,025.0
2014	43,205.5	730,996.0	198,403.0

	STAN Database for Structural Analysis (ISIC Rev. 4, SNA08)		
Country	Finland	France	Italy
unit	Euro, Millions, 2010	Euro, Millions, 2010	Euro, Millions, 2010
1977	17,448.0	202,099.0	203,546.0
1978	17,180.0	203,036.0	204,305.9
1979	17,219.0	203,164.0	206,084.2
1980	18,517.0	209,506.0	211,999.7
1981	18,187.0	207,184.0	218,516.6
1982	19,045.0	203,451.0	215,825.0
1983	19,884.0	194,718.0	220,826.9
1984	19,244.0	191,302.0	220,120.9
1985	19,396.0	189,780.0	218,190.4
1986	19,075.0	197,738.0	219,609.6
1987	19,277.0	204,330.0	220,403.3
1988	20,788.0	218,840.0	225,977.1
1989	23,698.0	230,506.0	234,400.0
1990	23,616.0	235,707.0	241,854.5
1991	20,846.0	234,201.0	246,855.2
1992	18,152.0	234,891.0	245,401.5
1993	16,245.0	217,218.0	232,418.1
1994	16,001.0	213,403.0	221,756.4
1995	16,274.0	214,867.0	230,196.7
1996	17,842.0	206,990.0	232,795.6
1997	19,821.0	203,308.0	232,223.0
1998	21,852.0	208,131.0	233,098.6
1999	22,925.0	219,315.0	239,968.5
2000	24,386.0	238,741.0	249,932.0
2001	23,857.0	244,209.0	260,253.1
2002	23,990.0	244,645.0	267,694.5
2003	24,281.0	248,268.0	272,891.0
2004	25,605.0	255,857.0	279,058.2
2005	26,936.0	266,596.0	286,912.8
2006	27,752.0	278,923.0	292,356.2
2007	30,144.0	292,188.0	295,673.4
2008	30,455.0	288,834.0	287,652.2
2009	26,806.0	268,703.0	262,493.0
2010	27,998.0	264,969.0	253,788.7
2011	29,042.0	269,124.0	245,247.0
2012	27,728.0	263,141.0	217,095.6
2013	26,852.0	264,275.0	200,268.4
2014	25,865.0	259,102.0	188,302.3

	STAN Database for Structural Analysis (ISIC Rev. 4, SNA08)		
Country	Japan	Korea	Netherlands
unit	Yen, Millions, 2010	Won, Millions, 2010	Euro, Millions, 2010
1977	26,764,900.0	28,646,383.0	59,608.0
1978	29,994,300.0	35,881,524.0	60,114.0
1979	32,748,500.0	37,489,023.0	58,108.0
1980	33,690,700.0	36,461,629.0	60,316.0
1981	35,390,400.0	34,193,370.0	53,917.0
1982	36,292,500.0	40,514,486.0	50,515.0
1983	36,361,900.0	49,082,138.0	49,290.0
1984	37,469,100.0	52,354,342.0	51,364.0
1985	41,398,000.0	55,425,942.0	52,695.0
1986	45,864,900.0	57,407,539.0	55,487.0
1987	51,797,700.0	66,277,871.0	58,125.0
1988	59,523,100.0	74,700,173.0	64,431.0
1989	66,615,200.0	87,307,393.0	67,083.0
1990	75,595,000.0	113,198,462.0	68,343.0
1991	80,237,200.0	127,690,966.0	69,319.0
1992	82,656,000.0	127,163,719.0	69,362.0
1993	86,396,300.0	140,941,264.0	67,445.0
1994	90,516,600.0	147,758,597.0	69,288.0
1995	90,203,400.0	160,728,457.0	70,587.0
1996	94,275,100.0	172,530,153.0	73,058.0
1997	87,958,700.0	176,952,387.0	75,571.0
1998	84,356,900.0	155,761,807.0	78,873.0
1999	82,321,000.0	150,900,758.0	84,248.0
2000	80,024,200.0	148,428,405.0	88,530.0
2001	76,839,900.0	156,665,685.0	91,016.0
2002	73,081,400.0	164,823,333.0	88,475.0
2003	69,845,000.0	180,689,505.0	86,194.0
2004	67,287,100.0	181,492,802.0	85,767.0
2005	65,668,900.0	179,416,663.0	88,921.0
2006	64,155,100.0	181,930,023.0	92,847.0
2007	59,561,400.0	189,258,280.0	99,098.0
2008	55,698,500.0	183,511,601.0	103,442.0
2009	52,723,000.0	187,232,238.0	98,296.0
2010	50,687,200.0	181,057,735.0	87,521.0
2011	52,201,000.0	171,643,904.0	90,695.0
2012	54,289,100.0	167,437,440.0	82,971.0
2013	59,561,400.0	175,751,368.0	78,177.0
2014	59,979,000.0	176,129,256.0	79,975.0

	STAN Database for Structural Analysis (ISIC Rev. 4, SNA08)		
Country	Norway	United States	
unit	Krone, Millions, 201(	US Dollar, Millions,	
1977	137,212.0	792,032.0	
1978	150,031.0	855,666.0	
1979	149,286.0	872,265.0	
1980	150,996.0	788,326.0	
1981	150,022.0	776,386.0	
1982	149,803.0	724,102.0	
1983	162,335.0	801,098.0	
1984	165,443.0	916,210.0	
1985	179,101.0	985,630.0	
1986	203,651.0	1,029,952.0	
1987	218,363.0	1,055,916.0	
1988	213,283.0	1,046,396.0	
1989	193,475.0	1,033,312.0	
1990	180,230.0	1,011,785.0	
1991	162,065.0	925,038.0	
1992	164,085.0	957,191.0	
1993	164,296.0	988,596.0	
1994	175,326.0	1,035,815.0	
1995	187,301.0	1,049,968.0	
1996	199,709.0	1,127,305.0	
1997	218,107.0	1,170,400.0	
1998	230,687.0	1,236,692.0	
1999	238,236.0	1,289,000.0	
2000	236,045.0	1,345,138.0	
2001	242,955.0	1,356,124.0	
2002	248,271.0	1,337,465.0	
2003	259,240.0	1,380,677.0	
2004	276,633.0	1,436,051.0	
2005	302,095.0	1,472,519.0	
2006	334,916.0	1,437,804.0	
2007	376,254.0	1,359,269.0	
2008	383,456.0	1,257,213.0	
2009	335,700.0	1,090,682.0	
2010	327,969.0	1,008,294.0	
2011	354,638.0	978,571.0	
2012	390,255.0	1,012,466.0	
2013	396,353.0	1,049,339.0	
2014	406,447.0	1,094,119.0	

A.2. Year on Year Growth Rate of Yearly Construction Investment of Each Country

1. Volume based(price inflation correction applied)

Country	Austria	Czech Republic	Denmark	Finland
unit	%	%	%	%
1977	8.06	-0.41	-1.35	1.01
1978	-1.03	2.49	0.76	-1.54
1979	2.16	0.27	-1.03	0.23
1980	0.47	3.18	-6.22	7.54
1981	-3.57	-0.13	-14.69	-1.78
1982	-4.15	-2.95	2.76	4.72
1983	1.21	3.02	1.08	4.41
1984	-5.27	-0.73	7.44	-3.22
1985	4.46	5.04	6.82	0.79
1986	2.33	0.59	16.38	-1.65
1987	3.55	1.98	3.74	1.06
1988	3.56	2.48	-3.63	7.84
1989	3.84	-2.44	-3.90	14.00
1990	6.41	0.69	-5.51	-0.35
1991	5.17	-3.46	-8.30	-11.73
1992	3.32	4.91	0.78	-12.92
1993	1.38	4.87	-1.86	-10.51
1994	6.29	5.39	3.21	-1.50
1995	5.14	12.30	6.56	1.71
1996	4.12	5.63	9.02	9.64
1997	-0.03	-3.96	5.29	11.09
1998	1.31	-3.23	2.94	10.25
1999	0.99	-3.85	-0.43	4.91
2000	1.19	-2.32	4.92	6.37
2001	-3.57	1.44	0.80	-2.17
2002	0.56	6.15	-0.12	0.56
2003	5.15	7.47	3.71	1.21
2004	2.60	2.45	1.84	5.45
2005	2.02	3.97	5.13	5.20
2006	3.06	11.13	11.02	3.03
2007	5.42	13.67	-1.95	8.62
2008	5.85	-0.93	-4.43	1.03
2009	-5.49	-8.74	-12.86	-11.98
2010	-3.30	-1.05	-7.35	4.45
2011	-0.34	-4.09	2.96	3.73
2012	1.14	-8.43	-1.12	-4.52
2013	-1.54	-2.92	-0.86	-3.16
2014	-0.27	2.50	2.79	-3.68

Country	France	Italy	Japan	Korea
unit	%	%	%	%
1977	0.66	0.98	7.01	25.51
1978	0.46	0.37	12.07	25.26
1979	0.06	0.87	9.18	4.48
1980	3.12	2.87	2.88	-2.74
1981	-1.11	3.07	5.05	-6.22
1982	-1.80	-1.23	2.55	18.49
1983	-4.29	2.32	0.19	21.15
1984	-1.75	-0.32	3.04	6.67
1985	-0.80	-0.88	10.49	5.87
1986	4.19	0.65	10.79	3.58
1987	3.33	0.36	12.94	15.45
1988	7.10	2.53	14.91	12.71
1989	5.33	3.73	11.91	16.88
1990	2.26	3.18	13.48	29.66
1991	-0.64	2.07	6.14	12.80
1992	0.29	-0.59	3.01	-0.41
1993	-7.52	-5.29	4.53	10.83
1994	-1.76	-4.59	4.77	4.84
1995	0.69	3.81	-0.35	8.78
1996	-3.67	1.13	4.51	7.34
1997	-1.78	-0.25	-6.70	2.56
1998	2.37	0.38	-4.09	-11.98
1999	5.37	2.95	-2.41	-3.12
2000	8.86	4.15	-2.79	-1.64
2001	2.29	4.13	-3.98	5.55
2002	0.18	2.86	-4.89	5.21
2003	1.48	1.94	-4.43	9.63
2004	3.06	2.26	-3.66	0.44
2005	4.20	2.81	-2.40	-1.14
2006	4.62	1.90	-2.31	1.40
2007	4.76	1.13	-7.16	4.03
2008	-1.15	-2.71	-6.49	-3.04
2009	-6.97	-8.75	-5.34	2.03
2010	-1.39	-3.32	-3.86	-3.30
2011	1.57	-3.37	2.99	-5.20
2012	-2.22	-11.48	4.00	-2.45
2013	0.43	-7.75	9.71	4.97
2014	-1.96	-5.98	0.70	0.22

Country	Netherlands	Norway	United States
unit	%	%	%
1977	2.44	4.74	7.91
1978	0.85	9.34	8.03
1979	-3.34	-0.50	1.94
1980	3.80	1.15	-9.62
1981	-10.61	-0.65	-1.51
1982	-6.31	-0.15	-6.73
1983	-2.43	8.37	10.63
1984	4.21	1.91	14.37
1985	2.59	8.26	7.58
1986	5.30	13.71	4.50
1987	4.75	7.22	2.52
1988	10.85	-2.33	-0.90
1989	4.12	-9.29	-1.25
1990	1.88	-6.85	-2.08
1991	1.43	-10.08	-8.57
1992	0.06	1.25	3.48
1993	-2.76	0.13	3.28
1994	2.73	6.71	4.78
1995	1.87	6.83	1.37
1996	3.50	6.62	7.37
1997	3.44	9.21	3.82
1998	4.37	5.77	5.66
1999	6.81	3.27	4.23
2000	5.08	-0.92	4.36
2001	2.81	2.93	0.82
2002	-2.79	2.19	-1.38
2003	-2.58	4.42	3.23
2004	-0.50	6.71	4.01
2005	3.68	9.20	2.54
2006	4.42	10.86	-2.36
2007	6.73	12.34	-5.46
2008	4.38	1.91	-7.51
2009	-4.97	-12.45	-13.25
2010	-10.96	-2.30	-7.55
2011	3.63	8.13	-2.95
2012	-8.52	10.04	3.46
2013	-5.78	1.56	3.64
2014	2.30	2.55	4.27

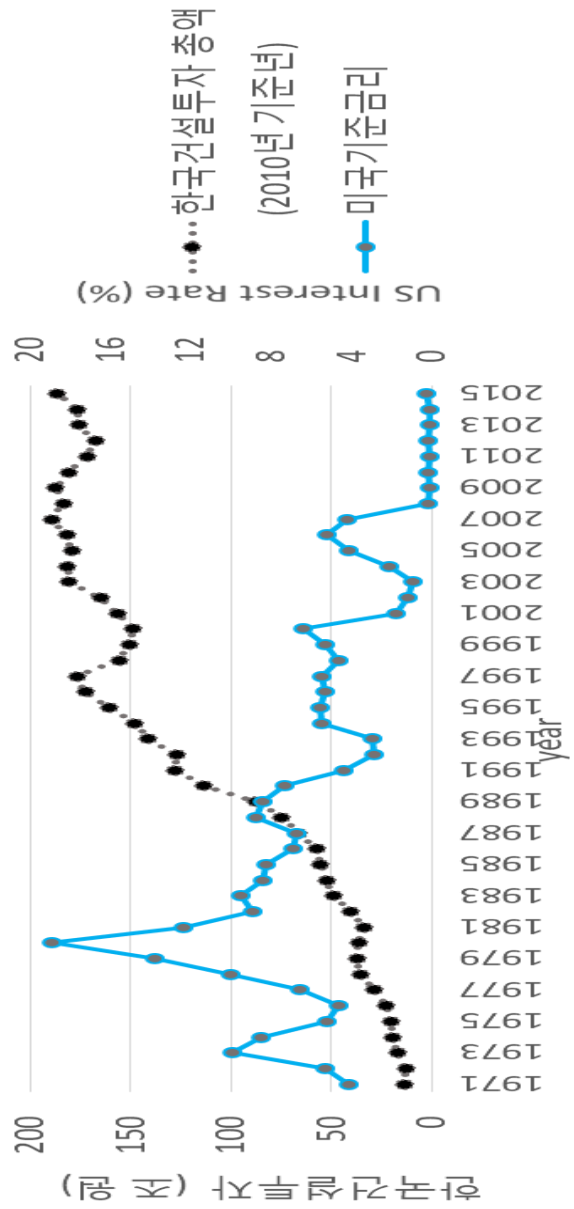
A.3. Variables of Base Interest Rate

1. US Base Rate: Effective Federal Funds Rate

2. EU Base Rate: Overnight Interbank Rate of Germany

	Base Rate	
unit	%	%
Country	US	EU
1977	6.56	3.2
1978	10.03	3.6
1979	13.78	9
1980	18.90	9.2
1981	12.37	10.6
1982	8.95	6.2
1983	9.47	5.6
1984	8.38	5.6
1985	8.27	4.6
1986	6.91	5
1987	6.77	3.2
1988	8.76	4.9
1989	8.45	7.7
1990	7.31	8.4
1991	4.43	9.2
1992	2.92	8.9
1993	2.96	6.2
1994	5.45	4.9
1995	5.60	4.1
1996	5.29	3.1
1997	5.50	3.4
1998	4.68	3.1
1999	5.30	3
2000	6.40	4.8
2001	1.82	3.3
2002	1.24	3.1
2003	0.98	2.1
2004	2.16	2.1
2005	4.16	2.3
2006	5.24	3.5
2007	4.24	3.9
2008	0.16	2.5
2009	0.12	0.4
2010	0.18	0.5
2011	0.07	0.6
2012	0.16	0.1
2013	0.09	0.2
2014	0.12	0
2015	0.24	-0.2

B. Variation Trend of Korea Construction Investment and US Base Interest Rate



C. Table of Critical Value of Pearson Correlation

	Confidence Level		
N	**90%**	**95%**	**99%**
1	0.988	0.997	0.999
2	0.9	0.95	0.99
3	0.805	0.878	0.959
4	0.729	0.811	0.917
5	0.669	0.754	0.875
6	0.621	0.707	0.834
7	0.584	0.666	0.798
8	0.549	0.632	0.765
9	0.521	0.602	0.735
10	0.497	0.576	0.708
11	0.476	0.553	0.684
12	0.458	0.532	0.661
13	0.441	0.514	0.641
14	0.426	0.497	0.623
15	0.412	0.482	0.606
16	0.4	0.468	0.59
17	0.389	0.456	0.575
18	0.378	0.444	0.561
19	0.369	0.433	0.549
20	0.36	0.423	0.537
21	0.352	0.413	0.526
22	0.344	0.404	0.515
23	0.337	0.396	0.505
24	0.33	0.388	0.496
25	0.323	0.381	0.487
26	0.317	0.374	0.479
27	0.311	0.367	0.471
28	0.306	0.361	0.463
29	0.301	0.355	0.456
30	0.296	0.349	0.449
35	0.275	0.325	0.418
40	0.257	0.304	0.393
45	0.243	0.288	0.372
50	0.231	0.273	0.354
60	0.211	0.25	0.325
70	0.195	0.232	0.303
80	0.183	0.217	0.283
90	0.173	0.205	0.267
100	0.164	0.195	0.254
150	0.134	0.159	0.208
300	0.095	0.113	0.148

*source: Statistics Solutions

D. Data Access for Construction Investment at OECD.Stat

OECD.Stat

→ [Industry and Services]

→ [Structural Analysis (STAN) Databases

→ STAN Database for Structural Analysis (ISIC Rev. 4, SNA08)

(or) STAN Database for Structural Analysis (ISIC Rev. 4, SNA93)

국 문 초 록

세계경제는 양적완화 종료에 따라 제로 금리 시대가 막이 내리면서 금리 변동에 주목하고 있다. 이 때 금리는 시간의 흐름에 따른 돈의 가치 변화에 기준이 되는 척도로 건설투자와 음의 상관관계를 갖는 경향이 있다. 특히 각 국가 금리의 대표성을 갖는 기준금리는 정책적인 의도가 반영되어 결정된다.

본 연구에서는 금리와 건설투자 변수의 특성을 고려했을 때 금리와 건설투자 간의 관계 분석 시 국경을 넘어선 분석의 필요성을 제시하였다. 국 국가 기준금리의 차이는 세계 경제에서 자본의 흐름에 영향을 주기 때문에 서로 영향을 주고받으며 결정된다. 건설투자의 경우, 관련 정책이나 투자 결정권자들은 국내외 상황을 고려한다. 따라서 본 연구에서는 국경을 넘어선 기준금리와 건설투자 간의 관계를 분석하였다.

자기상관분석을 통해 각 변수의 주기를 점검하였고, 교차차상관분석을 통해 각 변수간 상관강도와 시차를 확인했다.

이를 바탕으로 국경을 넘어선 관계 분석의 필요성을 확인하였고, 관계 분석 결과 자체는 건설 관련 정책이나 투자의 의사결정권자들이 건설경기에 대응하는데 기여할 것으로 사료된다.

키워드: 금리, 기준금리, 건설경기, 건설투자, 교차상관분석, 상관관계

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