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MASTER THESIS IN FINANCE

The impact of macroeconomic factors on the performance of European REIT markets

An empirical analysis of macroeconomic influences on the British, French and Belgian REIT indexes from 2007-2017

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Abstract:

The concept of real estate investment trust has been first introduced in the US market in 1960. However, it has not been until the last decade that we have seen the increased adoption of the concept around the world. Although REITs have become a highly discussed topic in Europe, given the limited historical data the topic is still lacking academic literature that would analyze REIT performance in the context of the region-specific environment. The study aims to investigate both short-term and long-term relationships between the European REIT markets and their respective macroeconomic factors that include short-term, long-term interest rate, inflation, GDP, money supply, industrial production and government expenditure. The data include REIT index price for the UK, France and Belgium and their macroeconomic variables in the period from Sep-2007 till Dec-2017. The integration between REIT performance and macroeconomic factors is examined through Johansen's cointegration test and Granger causality test. The results show that industrial production has proven to have a significant long-term relationship with REIT index in the UK and France, as well as a significant short-term relationship with Belgium REIT index. Furthermore, France and Belgium have shown country-specific short-term relationships, which include GDP and government expenditure for France, and long-term and short-term interest rate for Belgium.

Keywords: real estate investment trust (REIT), macroeconomic variables, developed markets, Europe, industrial production

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1. Introduction

Real estate investment trusts have become an integral part of the investment landscape over the last decade, worth around $1.3 trillion in June 2017 (EPRA, 2017). The market capitalization for the US REIT market has experienced growth of around 150 percent since 2010. In the same period, the non-US REIT market has more than doubled (EY, 2016). The increased interest in REITs has advanced around the world and has raised the importance of the research around REIT markets and their performance.

The concept of real estate investment trust has been first introduced in the US market in 1960. However, it has not been until the last decade that we have seen the increased adoption of the concept around the world. Real estate investment trust is a vehicle that allows investors to own real estate in a manner that mutual funds provide investment in a stock market. REIT would own and often manage real estate that generates regular income and would be obliged to pay out around 90[4] percent of their taxable income to investors in dividends each year. REITs are often publicly listed; as a result, real estate investors can have a benefit of liquidity and level of governance that cannot be found with direct investment in real estate. Furthermore, REITs are often granted tax breaks that are not provided to other types of investment. (Investopedia, 2018)

Real estate investment trusts traded on the Singapore Exchange have shown impressive performance with the average return of 10 percent for the last five-year period (Haoxiang, 2017). In 2017, SGX S-REIT 20 index delivered a return of around 27 percent (Dayani, 2018). Meanwhile in the wake of the Brexit vote, British real estate market and REIT companies have tumbled. The UK REITs priced a discount of around 20 percent (Coumarianos, 2016; Borchersen-Keto, 2016). That raises a question, which markets could be expected to overperform in the future? Are UK REIT companies a bargain at the current price? If economic growth, demographics and interest rates are considered as the main demand drivers for real estate sector growth, to what extent can macroeconomic environment explain the performance of REIT index?

Besides the Netherlands, which is in the group of the early adopters of REIT structure, the legislation that brought REITs to other countries in Europe has been introduced rather late, around

[4] The percentage varies across different legislations. For example, in Belgium required payout is 80 percent, in France 95 percent, in Netherlands 100 percent and in UK 90 percent.

a decade before. According to the latest data, the largest REIT markets in Europe by market capitalization are the UK, France, the Netherlands, Belgium, and Spain, all of which could be classified as developed. Apart from five countries mentioned, REIT markets in Europe can still be considered in growth and expansion stage. For the illustration of the largest REIT markets in Europe, please refer to Table 1. With REIT regime introduction in new markets, a positive investment climate and the significant growth in market capitalization, European REIT market becomes an attractive investment option for both domestic and foreign investor. The benefits of low interest rates, untapped potential in markets like Sweden, restored confidence in Central Europe and increased capital inflows in Europe, altogether result in a positive outlook for the years ahead. (Borchersen-Keto, 2017)

Table 1 The largest REIT markets in Europe by market capitalization. Source: Global REIT Survey 2017 (EPRA)

Countries	Number of REITs	Number in EPRA REIT index[5]	Mkt Cap (EURm)	% of Global REIT Index	Enacted
France	32	6	74,013	1.89%	2003
UK	44	28	60,828	5.23%	2007
Netherlands	5	5	26,695	2.57%	1969
Spain	5	4	11,682	0.64%	2009
Belgium	17	8	11,673	0.70%	1995/2014[6]
Turkey	25	4	6,363	0.17%	1995
Germany	4	2	2,852	0.22%	2007
Ireland	3	3	2,492	0.23%	2013
Italy	5	2	2,446	0.09%	2007
Greece	4	1	2,189	0.03%	1999

Although REITs have become a highly discussed topic in Europe, given the limited historical data the topic is still lacking academic literature that would analyze the region-specific environment and its effect on the REIT performance. Taking into consideration an insufficient research on European REIT markets, the study aims to answer: What is the relationship between the European REIT markets and their respective macroeconomic variables?

To examine the integration between European REIT markets and macroeconomic variables, authors focus on three key markets in Europe – the UK, France, and Belgium. The countries have been selected based on both market capitalization and number of registered real estate investment

[5] FTSE EPRA/NAREIT Global REITs Index (July 2017)
[6] The form of SICAFI, a type of REIT, was introduced in 1995, while the form of BE-REIT has been introduced by the Law since 2014.

trusts as of 2017. The results of the study will allow to compare the behavior of developed REIT markets in Europe with REIT markets in the US, Australia and developed REIT markets in Asia. In addition, it will be possible to compare results with similar studies that looked at public real estate market in Europe. Based on previous research, the correlation between REIT markets and property stocks varies from moderate to weak level; hence, the behavior of European REITs can be different in comparison to the property stock behavior.

The significance of macroeconomic determinants in the real estate market, or specifically REIT return performance, has been highlighted by several studies that have looked at the US and Asia Pacific REIT markets (Liow & Yang, 2005; Yunus, 2012; Loo, Anuar, & Ramakrishnan, 2016; Wong, 2017). The objective of our study is to determine which macroeconomic factors have a significant short-term or long-term linkage with European REIT markets; and for that reason, authors include seven factors that are tested using Johansen's cointegration technique and Granger causality test. The factors selected include short-term interest rate, long-term interest rate, consumer price index, money supply, gross domestic product (GDP), industrial production and government expenditure.

Performing such research would provide practical insights into the integration of European REIT markets and country-level macroeconomic factors. The research can be used by investors to make better-informed decisions, and to forecast REIT market response towards a potential change in the macro environment. Furthermore, the findings can be used to inform policymakers on the connection between government policies and REIT performance both in the short and long-term perspective, as well as show the impact of REIT market on the overall economic growth.

The remainder of the paper is organized as follows: Section 2 presents a relevant literature review and theoretical framework; Section 3 puts forward a brief description of the data; Section 4 walks through the methodology; Section 5 examines empirical results; and, finally, Section 6 contains conclusion and recommendation for future research.

2. Literature review

The recent introduction of a real estate investment trust as a financial instrument and their tremendous growth in terms of market capitalization has encouraged increased research about such type of investment and their performance. The question that the research aims to answer is what factors affect REIT performance and how much macroeconomic environment can explain REIT price variation.

The distinction between an emerging and developed market has proven to be important when we analyze the behavior of real estate investment trust markets, their linkage and consequential implication for potential diversification. For example, Pham (2012) reports that the dynamic link between developed markets in Asia will often show limited opportunities for diversification compared to the markets not developed that have a weaker correlation. In the literature, markets are often classified based on the size of the market capitalization. The REIT markets below 10 billion dollars are considered as emerging markets, while above 10 billion dollars are classified as developed (Loo, Anuar, & Ramakrishnan, 2016; EY, 2016). An alternative assessment includes an inspection of both quantitative and qualitative factors to determine whether the market is established or in the emerging stage. The emerging markets are described with risk, transparency, business environment and corporate governance that is adequate but not strong enough. Developed markets on the other hand would include liquid capital markets, as well as mature and open business environment (EY, 2016).

So far, there has been limited research performed on the integration between macroeconomic environment and European REIT index performance. The available research covers to the most extent REIT markets in the Asia Pacific and the United States, however, provides little or none information about REIT performance in Europe.

Macroeconomic factors that are often tested in previous studies include interest rates, inflation, industrial production, GDP, money supply and government expenditure. However, the impact of each variable seems to be discrepant between the markets tested. Hence, there is no straightforward indication how macroeconomic factors would affect European REIT markets like UK, France, and Belgium and whether these markets would follow a similar pattern as developed markets in Asia or US REIT market.

2.1 US REIT market

Approximately two-thirds of the global REIT market are registered in the US market, a place where REIT legislation has been first introduced. The sector has experienced a rapid growth after the crisis in the late 1980s and once again in the wake of the Global Financial Crisis (GFC). In fact, REIT structures appear to be a solution for real estate market to reduce the high levels of debt by transfer of shares to the public (Ng, 2017). For the illustration of US REIT performance versus US stock index for the last 15-year period, please refer to Appendix 1 Figure 1.

Table 2 The largest REIT markets in North America by market capitalization. Source: Global REIT Survey 2017 (EPRA)

Countries	Number of REITs	Number in EPRA REIT index[7]	Mkt Cap (EURm)	% of Global REIT Index	Enacted
US	227	134	926,316	65.20%	1960
Canada	47	16	48,957	3.02%	1994

Since REITs have existed for a long period in the US market, it is possible to find quite extensive research literature on the topic of REITs and their integration with macro-level factors in the US market. For example, Chen and Tzang (1988) looked at the effect of short-term and long-term interest rates as well as inflation. The findings showed that equity REITs[8] are not sensitive towards the variation in interest rates, but are reactive towards the expected inflation.

McCue and Kling (1994) have examined the relationship between REIT returns and the macroeconomic factors such as consumer price index, short-term nominal rate, industrial production, and investment. The study used the procedure to control for covariation with the overall stock market, and have found that almost 60 percent of the variation in real estate series can be explained by macroeconomic factors mentioned above. However, the majority of variation appeared to be a response to nominal interest rate variable.

The effect of interest rate movement has been further examined by Pauley and Mueller (1995). The authors found that REIT price and interest rates have low and negative correlation both in the period when rates are raised and reduced; as a result, the interest-rate movements could not sufficiently explain REIT price variation. The probable reason could be the insufficient magnitude

[7] FTSE EPRA/NAREIT Global REITs Index (July 2017)
[8] Equity REITs are type of REITs which own and operate real estate. In comparison, mortgage REITs invest in property mortgages and derive income from interest.

of the change in interest rate. In turn, Allen, Madura, and Springer (2000) argue that sensitivity towards interest rates depends on the leverage level of the firm. Finally, Cheong et al (2006) confirm cointegration between long-term interest rate and REIT returns in the US market for the period from 1990-2005.

Empirical evidence on the inflation factor and the capabilities of real estate investment trusts to hedge inflation is mixed. For example, Chatrath and Liang (1998) showed evidence that there is a long-run equilibrium between REITs and CPI, however, the outcome would differ based on the cointegration technique used. In short run, the results showed no possible hedge against inflation.

More recent authors, for example, Glascock, Lu, and So (2002) and Simpson, Ramchander, and Webb (2007), showed a positive relationship with inflation and argued that the suggested negative relationship in the previous studies resulted from the omission of significant explanatory variables in the model.

Building upon previous research, Yunus (2012) explored several factors together such as GDP, money supply, inflation, long-term interest rate and made a comparison with other international REIT markets in Europe, Australia, and Asia. Based on the number of cointegration ranks in the multivariate model, the author observes that well developed, large and mature REIT markets, such as US, Australia, are more integrated with the macroeconomic environment than markets that are small and not fully developed. The exclusion test reveals that each variable is a part of the long-term equilibrium. For the US market in short-term, factors such as GDP and long-term interest rate have proved to drive return performance for REIT market.

2.2 Asia Pacific REIT market

Besides Australia, which has adopted REIT structure in the 1980s following the crisis period, REIT structures in Asia first appeared around two decades before. Now, Japan and Singapore have become the market leaders in the region, and in addition, take 2nd and 6th place in the global market. In the last five years both Australia and Japan have been two markets with the fastest growth (EY, 2016). Furthermore, we are likely to see the first REIT to appear in China this year (Reuters, 2018).

For the illustration of Asia Pacific REIT performance versus Asia Pacific stock index for the last 12-year period, please refer to Appendix 1 Figure 2.

Table 3 The largest REIT markets in Asia-Pacific by market capitalization. Source: Global REIT Survey 2017 (EPRA); Global REIT Survey 2016 (EPRA). For Japan and Taiwan data presented as of 2016.

Countries	Number of REITs	Number in EPRA REIT index[9]	Mkt Cap (EURm)	% of Global REIT Index	Enacted
Japan	56	33	102,695	7.43%	2000
Australia	56	13	88,333	6.76%	1985
Singapore	36	9	43,204	1.79%	1999
Hong Kong	12	3	22,539	1.68%	2003
Thailand	63	0	10,212	0.00%	1992/2007
Malaysia	17	4	6,179	0.18%	2005
New Zealand	6	1	3,772	0.12%	2007
Taiwan	5	0	2,007	0.00%	2003
South Korea	6	0	1,403	0.00%	2001

To start with, a study by Reddy and Wong (2017) looked at the effect of interest rates on Australian REIT performance in the time period before, during and after the GFC. The findings indicate that before the GFC, medium and large size investment trusts showed a negative relationship with the long-term interest rate. The relationship has intensified in the period of GFC but has then diminished after. Following the GFC, long-term interest factor appeared significant only for the group of large investment trusts in Australia.

Regarding the inflation, Wong (2017) found that unexpected inflation would have a negative implication for Australian REIT, while expected inflation would have a positive effect on REIT performance. Besides, high leverage level proved to reinforce both the risk exposure for unexpected inflation, as well as benefit from an increase in expected inflation.

Loo, Anuar & Ramakrishnan (2016) have performed a comprehensive research on the interdependence of Asian REIT markets and macroeconomic variables, which included markets like Japan, Hong Kong, Singapore, Malaysia, Taiwan, Thailand and South Korea. By using Johansen's cointegration and Granger causality test, the authors tested seven different macroeconomic factors for their short-term and long-term relationship with REIT index performance. According to the paper, the emerging markets revealed a stronger link with the macroeconomic state in the long run as in comparison with developed markets in Asia. That implies that emerging markets are more sensitive towards the change in macroeconomic environment. Also, the higher number of long-run relationships identified shows that it requires a

[9] FTSE EPRA/NAREIT Global REITs Index (July 2017)

longer time horizon to observe the economic impact. For developed markets, the study finds a consistent co-integration evidence with CPI, which indicates that real estate trusts are used as a hedge for inflation. The other significant factors are specific to each market. For example, in Japan long-term interest, industrial production and money supply are factors cointegrated with REIT. In Singapore long-term dynamics are observed for industrial production, GDP, and government expenditure. Besides inflation, Hong Kong does not show cointegration for other factors tested. For emerging markets, the study revealed consistent co-integration with a short-term interest rate, money supply, and IP across the markets tested. In addition, the study found country-specific results, such as cointegration with a long-term interest rate in Taiwan and South Korea, GDP in Malaysia, inflation in Malaysia and Thailand. The short-term impact towards the Asian REIT performance overall has been marked as minimal.

Fang et al (2016) contribute to the discussion with the use of a different method to examine the long-run equilibrium between REIT and macroeconomic variables of interest, inflation, and stock index. The research uses ARDL bounds test, ECM, and Granger non-causality test and is focused on such developed markets as Japan, Singapore and China. The results indicate a cointegration with macroeconomic variables in Singapore and China, but none in Japan. Based on long-run ADL method, there is a positive impact of stock index on REIT index, a negative impact of inflation and a negative impact of interest rate, except for China where interest rate proved insignificant.

A research by Atchison and Yeung (2014) has analyzed how REIT market affects the economic development and has concluded that it can serve as a stimulus for the growth. The reason for that - the engagement of other related service providers like for law, financial management, and real estate services. Job opportunities and lessened reliance on bank loans to finance real estate result in a reduced risk for the financial system and facilitate economic growth.

2.3 Property stock behavior in Europe

The main difference between real estate investment trust and property stocks are restrictions that are imposed on REIT, the most pronounced of which is a minimum requirement for income distribution in dividends, as well as the proportion of income from real estate, i.e. rent, sale of real estate or interest from a mortgage. The main income source for REIT would be rental income rather than the income from capital gain, construction, property development, etc.

However, in consideration of similar features between REIT market and property stock market, we can form an initial expectation about European REIT market based on a similar research performed for real estate sector. For instance, with the use of Johansen's cointegration and Granger causality tests, Yunus (2012) has investigated the linkage between securitized real estate, stock index and four macroeconomic factors which include GDP, inflation, money supply and 10-year government bond yield. The countries researched included amid others France and the UK, and have shown a significant cointegration and short-term relationship with four macroeconomic variables. However, the extent is different across the countries tested. For example, in France, the authors identified a short-term relationship with GDP, whereas in the UK, stock index appeared significant. No other macroeconomic variable proved to be significant in short-term.

Liow and Yang (2005) performed a similar approach to investigate relationships between macroeconomic determinants and property stocks in Asia, which included Japan, Hong Kong, Singapore, and Malaysia. The authors employed multivariate Johansen's cointegration test and claimed at least one cointegration rank between factors like GDP, inflation, interest rates and money supply.

2.4 Conceptual framework

2.4.1 Long-term and short-term interest rate

The response to the changes in the level of interest rates often depends on the factor whether the assets have their future cash flows fixed. For example, if interest rates are to be increased, but future cash flows are locked, we would observe a negative effect on the present value of the cash flows and subsequently a lower valuation for the asset. If REIT has the ability to increase the rent of the underlying properties when interest rates rise, the effect should not be negative. Furthermore, increased interest rates are normally a response to stronger economic activity, which often includes a growth in demand for credit. A higher level of economic activity also has implication for increased demand for office, commercial, residential or other type of real estate which in fact can result in higher earnings for REIT.

The previous studies have shown that the importance of interest rates in explanation of REIT return variation differs between the markets tested, and might be dependent on such factors as size of the firm (Reddy & Wong, 2017), leverage level (Wong, 2017; Allen, Madura, & Springer, 2000) or period selected (Pauley & Mueller, 1995; Cheong, Gerlach, Stevenson, Wilson, & Zurbruegg, 2006). We construct Hypothesis 1 and Hypothesis 2 as follows:

H1: There is neither short-term nor long-term relationship between REIT index and long-term interest rate

H2: There is neither short-term nor long-term relationship between REIT index and short-term interest rate

2.4.2 Inflation

Real estate is often viewed as a good inflation hedge, which attracts capital when markets fear inflation and seek protection for purchasing power. In the US, long-term lease contracts are often linked to CPI factor that allows for a regular 'step up' mechanism. Also, inflation usually is a signal for economic growth, which in turn is a major demand driver for real estate.

In fact, the majority of studies performed have found a long-term equilibrium between inflation and REIT performance. We construct Hypothesis 3 as follows:

H3: There is a long-run equilibrium between REIT index and Consumer Price Index

2.4.3 GDP

GDP, which is an aggregate measure of the country-level output, is expected to affect REITs and property stocks in a similar manner that it affects the expected growth of future corporate cash flows. The economy in the expansion fosters the increased business activity, higher income for citizens and subsequently a higher demand for real estate. The studies in general show a short-term relationship with GDP (Yunus, 2012; Loo, Anuar, & Ramakrishnan, 2016) and in few cases a long-term cointegration (Loo, Anuar, & Ramakrishnan, 2016; Liow & Yang, 2005). We construct Hypothesis 4 as follows:

H4: There is a short-term relationship between REIT index and Gross Domestic Product

2.4.4 Money supply

The reason money supply is included in many of the above-mentioned research papers, is the impact that monetary policies have on overall economic state and inflation. Another important factor is a shift towards financial assets (e.g. REITs) as opposed to non-interest-bearing cash when money supply is increased. In the previous studies, money supply is a factor that has showed significance across emerging markets in the short-term, and occasional significance in the long-term for countries like Japan (Loo, Anuar, & Ramakrishnan, 2016). We construct Hypothesis 5 as follows:

H5: There is neither short-term nor long-term relationship between REIT index and money supply (M2)

2.4.5 Industrial production

Industrial production is as an indicator of output of the industrial sector, and is considered to have high sensitivity towards interest rates and consumer demand. Higher industrial demand should have a positive effect on the demand for warehouse facilities, industrial and office real estate.

Industrial production factor hasn't been researched as much, but we have seen evidence from Loo, Anuar & Ramakrishnan (2016) that industrial production seems to have short-term relationship with REIT markets; in particular, there is a consistent evidence throughout emerging REIT markets in Asia. Besides, in the long-run industrial production has shown significance in markets like Japan and Singapore. We construct Hypothesis 6 as follows:

H6: There is long-term cointegration between REIT index and industrial production

2.4.6 Government expenditure

Government expenditure is a factor that has been first introduced in the research by Loo, Anuar and Ramakrishnan (2016) and hence, has not been covered in other studies before. The government spending is used as a proxy for fiscal policy and is claimed to have potential effect together with monetary policy in the same manner it has proved to affect share markets in general. The results of the study showed that government expenditure is cointegrated with REIT performance in Singapore, but has no similar pattern in any other REIT market in Asia. We construct Hypothesis 7 as follows:

H7: There is neither short-term nor long-term relationship between REIT index and government expenditure

3. Data

The paper uses monthly historical price of FTSE REIT index for the UK, France and Belgium obtained from DataStream. The macroeconomic variables are collected either on monthly or quarterly basis depending on the availability. Monthly data are used for short-term interest rate, long-term interest rate, CPI, industrial production and money supply. Quarterly data are used for GDP and government expenditure. The variables are tested with the REIT index separately based on the frequency of data. The macroeconomic data are collected from the following sources: OECD, Eurostat and Economist Intelligence Unit (EIU). The sampling period is from Sep-2007 till Dec-2017. To avoid the effect from exchange rate fluctuation, all data are denominated in local currencies. Finally, for the purpose to remove potential non-linear behavior, the authors use the logarithm difference of data. The number of observations is N=124 for monthly data and N=41 for quarterly data.

This paper tests the long-run cointegrating relationship, of which the test requires time series integrated at 1. Differenced financial and economic data are often integrated at 0, therefore, instead of taking the return or growth of such variables, original index and macroeconomic data are employed. For detailed description of data, please refer to Table 4.

Table 4 Data description

Variable	Proxy	Source	Frequency
REIT Index	FTSE REIT Index	DataStream	Monthly; Quarterly
Short-term interest rate	3 months money market rate, % per annum	OECD	Monthly
Long-term interest rate	10 years government bond, % per annum	OECD	Monthly
Inflation	Consumer Price Index, Base year=2010	OECD	Monthly
Industrial production	Index of production excl. construction, Base year=2010	Eurostat	Monthly
Monetary policy	Money supply (M2), National Currency Units	EIU	Monthly
GDP	Real GDP, Chained 2010 National Currency Units	Eurostat	Quarterly
Fiscal policy	Government expenditure index, Base year=2010	OECD	Quarterly

4. Methodology

This section explains the research methodology throughout the paper. Overall, the first step is to test stationarity on the log-transformed data. For those macroeconomic variables and the REIT index in their corresponding market that are integrated at one, they are then paired to test long-term relationship with Johansen's test. The underlying Vector Error Correction Models (VECM) for those showing cointegrating relationship are set up for robustness and diagnostic check. The final part tests short-term relationship through Granger causality check for the non-cointegrated pairs using methodologies of Wald test and Likelihood Ratio test based on the underlying Vector Autoregressive (VAR) models, which are also evaluated by the robustness check.

4.1 Unit root test

A stochastic process can be considered as stationary if it has finite mean and variance for all t and t-s (Lütkepohl & Krätzig, 2004):

$$\mathrm{E}(\mathrm{y_t}) = E(y_{s-t}) = \mu$$

$$\mathrm{E}[(\mathrm{y_t} - \mu)^2] = \mathrm{E}[(\mathrm{y_{t-s}} - \mu)^2] = \sigma_y^2$$

$$\mathrm{E}[(\mathrm{y_t} - \mu)(\mathrm{y_{t-s}} - \mu)] = \mathrm{E}\big[(\mathrm{y_{t-j}} - \mu)(\mathrm{y_{t-j-s}} - \mu)\big] = \gamma_\mathrm{s}$$

Granger and Newbold (1974) argued that presence of a unit root can result in the issue called spurious regression. They found that a spurious regression has a high R^2 and t-statistics, leading to significant parameters, which would not be necessarily consistent. This means statistical inferences derived from such spurious regression do not hold. As a simplified illustration of their research method, they generated two individual series, $\{\mathrm{y_t}\}$ and $\{\mathrm{z_t}\}$, which are a random walk series with the formula:

$$\mathrm{y_t} = \mathrm{y_{t-1}} + \varepsilon_{\mathrm{yt}} \text{ and } \mathrm{z_t} = \mathrm{z_{t-1}} + \varepsilon_{\mathrm{zt}}, \text{ where } \varepsilon_{\mathrm{yt}} \text{ and } \varepsilon_{\mathrm{zt}} \text{ are white noise}$$

As these two series are independent, any conclusions of significance relationship will be spurious. However, running the regression below, one can reject the null that $\mathrm{a_1}$ equals zero.

$$\mathrm{y_t} = a_o + a_1\mathrm{z_t} + \mathrm{e_t}$$

Therefore, it is important to test stationarity for the original data. The REIT index, the development of which is similar to stock price, and macroeconomic variables are generally non-stationary at levels (Diba & Grossman, 1988). Therefore, direct use of these variables will probably provide no reliable inferences.

The Augmented Dickey-Fuller test (ADF test) and the Elliott, Rothenberg, and Stock test (ERS test) are employed to determine whether the series contains a unit root.

4.1.1 Augmented Dickey-Fuller test

The Augmented Dickey-Fuller test was proposed by Dickey and Fuller (1979) and considers three different regression equations, which can be used to test the existence of unit root, and are augmented by higher order lags:

$$\Delta \mathrm{y_t} = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{1}$$

$$\Delta \mathrm{y_t} = a_0 + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{2}$$

$$\Delta \mathrm{y_t} = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \tag{3}$$

These three equations try to model the true data-generating process. The equation (2) and (3) add deterministic elements a_0 and $a_2 t$ based on the equation (1). And the null hypothesis for each equation is as follows:

	$\mathrm{H_0}$ (Unit root)	$\mathrm{H_1}$
Equation (1)	$\gamma = 0, pure\ random\ walk$	$\gamma \neq 0, Stationary$
Equation (2)	$\gamma = 0, random\ walk\ with\ drift$	$\gamma \neq 0, Stationary$
Equation (3)	$\gamma = 0, random\ walk\ with\ drift\ and\ linear\ time\ trend$	$\gamma \neq 0, Trend\ Stationary$

Enders (2009) pointed out that it could be the drift or the linear time trend that result in the trend in the plotted series. A trend stationary series can be transformed to stationary by detrending while a unit can be transformed by differencing. Detrending a difference stationary model keeps the time-varying stochastic part. Differencing the trend-stationary model will introduce a non-invertible unit root into the equation. Therefore, it is important to find the true data-generating process, which ADF test three model specifications are used to differentiate.

Also, Enders (2009) pointed out that if we include too few lagged differenced items in the ADF test, there will be remaining serial correlations in the residuals, i.e. not white-noise. This basically means that the model does not sufficiently capture the true data-generating process and subsequent inference will be invalid. If we include too many lags, it will reduce the power of the test to reject the null of a unit root. Therefore, the optimal model of each variable is selected by AIC and BIC for equation (1)-(3). In presence of inconsistent conclusion of AIC and BIC, BIC is preferred because it penalizes the additions of lags more than AIC does, and hence it results in a more parsimonious model. A white noise check of residuals of the ADF model (1)-(3) will be conducted and the lag will be increase until the residuals are white-noise.

Model selection is performed for the equation (3) first. For the model where residuals are white noise, we check the significance of the linear trend parameter a_2. Significance here is defined as statistical and economic significance. Even if the t-statistics are large, i.e. statistically significant, if the value of a_1 is too small compared to the scale of the original series, the trend effects can mostly come from the drift, and therefore we still proceed to the equation (2). If the drift of equation (2) is neither statistically significant nor economically significant, equation (1) is used.

Once the fitted ADF model is identified, the ADF test is conducted with the specified number of lagged augmentations.

4.1.2 Elliott, Rothenberg, and Stock test

Elliott, Rothenberg, and Stock (1996) show that it is possible to further enhance the power of the test by estimating the model using something close to first differences. According to Schmidt and Phillips (1992), the slope of a trend and constant of ADF test specifications are often poorly estimated when a unit root exists. The underlying least squares principle cannot correctly differentiate the movements of the corresponding variables induced by the deterministic trend from those induced by the stochastic trend. Poor estimations of a_0 and a_1 can have large errors, and hence the estimation of γ can be unreliable. In such a case, one is less likely to reject the null hypothesis of a unit root even when the true value of γ is not zero (Elliott, Rothenberg, & Stock, 1996).

The procedure of ERS test dominates other existing unit root tests in terms of power. It detrends data with GLS to efficiently estimate the deterministic parameters of the series and tests the model with something close to first differences. The same lag selection is performed for ERS test. Therefore, ERS test is the benchmark for the unit root test.

4.2 Long-term relationship

The variables which have null rejected at equation (1) or (2), are integrated at one, or I (1). Such macroeconomic variables are paired with the REIT index (if also I (1)) to test a long-run relationship. Johansen's test is used for such evaluation. Johansen's test is powerful in multivariate cases (Johansen & Juselius, 1990). Stock and Watson (1988) found a way to use the rank of Π to determine if the tested pairs are cointegrated. Johansen's test examines the number of cointegrating relationships r out of n number of variables. To illustrate Π, consider a VAR (1) with two variables:

$$\mathrm{X_t} = A_1X_{t-1} + \varepsilon_t, \text{ where } \mathrm{X_{t-1}} = \{\begin{matrix} y_t \\ z_t \end{matrix}\}, \mathrm{X_{t-1}} = \{\begin{matrix} y_{t-1} \\ z_{t-1} \end{matrix}\}, \varepsilon_\mathrm{t} = \{\begin{matrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{matrix}\}, \mathrm{A_1} = [\begin{matrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{matrix}]$$

Then we have:

$$\Delta\mathrm{X_t} = (A_1 - I_2)\mathrm{X_{t-1}} + \varepsilon_t = \Pi\mathrm{X_{t-1}}$$

There are two tests for Johansen's test: Maximum Eigenvalue test and Trace test (Stock & Watson, 1988). The latter is more powerful than the former, and hence is used as the benchmark model. The rank of the matrix Π is the number of non-zero eigenvalues, which are the solutions of $\det(\Pi - \mathrm{I}\Lambda) = 0$. To identify the underlying VECM model to estimate the rank, similar procedure of finding the number of lags is used, i.e. starting from AIC and BIC suggested number of augmentations and then increasing the number until residuals of the underlying VECM are white-noise. Since BIC always shows a more parsimonious model than AIC, by checking remaining residual serial correlations to increase the number of lags starting from that suggested by BIC, one can find the fittest and most parsimonious model. Once the eigenvalues are identified, the test statistics of both tests are calculated as follows and are compared with critical values:

$$\lambda_{\mathrm{trace}}(r) = -T\sum_{i=r+1}^{n} \ln(1 - \widehat{\lambda_\imath})$$

$$\lambda_{\max}(r, r+1) = -T\ln(1 - \hat{\lambda}_{r+1})$$

Below are summarized hypotheses for both tests when the number of variables equals 2:

Trace test

r	H_0	H_1
r=0	r=0, no cointegrating relationship	r≥1, cointegrating relationship; one relationship
r=1	r≤1, one cointegrating relationship	r=2 no cointegrating relationship; stationary system

Maximum Eigenvalue test

r	H_0	H_1
r=0	r=0, no cointegrating relationship	r=1, cointegrating relationship; one relationship
r=1	r=1, one cointegrating relationship	r=2, no cointegrating relationship; stationary system

For the tested pairs that reject the null at r=1, the residuals are then tested on their unit root. Apart from ε_{1t} and ε_{2t}, $y_{t-1} - \beta z_{t-1}$ is then tested for stationarity. At least one of α_1 and α_2 should be stationary and β must be stationary in order to indicate cointegrating relationship.

The next step is to construct VECM model, which is a VAR model plus an error correction term, which corrects for the shocks that make the cointegrated variables to deviate from their long-term equilibrium. β describes such equilibrium. α_1 and α_2 represent the speed of adjustment parameters, and at least one of such parameters should be non-zero. The larger α_1 is, the greater the response of $LnMacroEcon_{t-1}$ to the previous period's deviation from long-run equilibrium. Extremely small absolute value of α_1 implies that the REIT index is unresponsive to last period's equilibrium error. Also, β defines the long run equilibrium to which α_1 and α_2 adjust.

$$\Delta y_t = -\boldsymbol{\alpha_1}(y_{t-1} - \boldsymbol{\beta} z_{t-1}) + lagged\ augmentations + \varepsilon_{1t}$$

$$\Delta z_t = \boldsymbol{\alpha_2}(y_{t-1} - \boldsymbol{\beta} z_{t-1}) + lagged\ augmentations + \varepsilon_{2t}$$

The robustness and diagnostic tests are performed in terms of VECM model serial correlation, disturbance normality, and VECM stability.

4.3 Short-term relationship

Granger causality test evaluates a short-term relationship. A variable x is said to Granger cause a variable y, given that the past values of x are useful for predicting y. Granger causality tests are valid for inferences when tested pairs are both stationary (Gujarati, 2003). However, Granger tests do not indicate causality but the existence of forecasting ability between tested variable pairs. Therefore, the test results are interpreted as one variable being helpful in predicting the other (Enders, 2009).

Granger causality test used in this paper is based on vector autoregressive model (VAR). The unit root test results determine whether level series or differenced series are modelled in the VAR. Again, Granger causality relationship is tested in pairs, for example, X and Y. Three relationship results are identified (Enders, 2009). If estimated coefficients for Y are statistically different from 0 and estimated coefficients for X are statistically not different from 0, unidirectional Granger causality is identified that Y Granger causes X. If estimated coefficients are both statistically different from 0, bilateral Granger causality is identified. If neither of the estimated coefficients is statistically different from 0, X and Y are independent (Gujarati, 2003). Therefore, we define the null hypothesis as follows:

For the VAR specified as:

$$\mathrm{Y_t} = \sum_{i=1}^{n} \alpha_{1,i} X_{t-i} + \sum_{i=1}^{n} \beta_{1,i} Y_{t-i} + \varepsilon_{1,t}$$

$$\mathrm{X_t} = \sum_{i=1}^{n} \alpha_{2,i} Y_{t-i} + \sum_{i=1}^{n} \beta_{2,i} X_{t-i} + \varepsilon_{2,t}$$

The null to test that X Granger causes Y:

$$\mathrm{H_0}: \alpha_{1,i} = 0$$

$$\mathrm{H_1}: \alpha_{1,i} \neq 0$$

For those pairs that show 0 rank or full rank and show non-stationarity in their log-transformation, difference VAR is fitted for unit root logged series and VAR for stationary series based on the unit root test in the first section.

The first step is to fit the VAR model. The optimal number of lags is again based on AIC and BIC, and then the number is increased until residuals are white noise. After the pairs are fitted in the corresponding VAR, Wald test (Lütkepohl, 1992) and Likelihood Ratio test (Enders, 2009) are conducted to test the above hypothesis. The decision is that if both tests are consistent, the existence of Granger causality relationship is concluded.

A common rationale for testing Granger causality is to construct the underlying VAR model and test the null hypothesis that the estimated coefficients on the lagged values of x are jointly zero. Failure to reject the null hypothesis means x cannot Granger cause y. The Wald test is integrated in STATA Granger command, but Likelihood Ratio test (Enders, 2009) is constructed as follows (when the number of variables equals 2):

$$LR = (T - c)(\ln|\Sigma_r| - \ln|\Sigma_u| \sim \chi^2(p)$$

Here, p equals the number of lags, T is the sample size and c is the number of unknown coefficients in each equation (unrestricted system). $|\Sigma_r|$ is the determinant of estimated covariance matrix with restrictions. $|\Sigma_u|$ is the determinant of estimated covariance matrix with no restrictions.

Finally, diagnostic and robustness tests are conducted on the VAR model serial correlation, disturbance normality, and VAR stability.

5. Result discussion

5.1 Descriptive statistics

Table 5 shows the means and standard deviations of REIT returns (natural logarithm transformed) and macroeconomic variables, including short-term interest rate (ST-IR), long-term interest rate (LT-IR), CPI, industrial production (IP), money supply (M2), GDP and government expenditure (Gov-Ex) for the UK, France, and Belgium.

Table 5 Descriptive statistics of REIT and macroeconomic variables in the United Kingdom, France(FR) and Belgium(BL). SD=Standard deviation, CV=Coefficient of variance

Market	Statistic	REIT return	ST-IR	LT-IR	CPI	IP	M2	GDP	Gov-Ex
UK	Mean	-0.004	1.34	2.70	106.06	99.58	2089.69	417.51	102.09
	SD	0.08	1.74	1.15	7.28	5.41	157.57	21.63	2.85
	CV	-20.00	1.30	0.43	0.07	0.05	0.08	0.05	0.03
FR	Mean	0.002	0.97	2.35	102.97	101.56	1563.96	514.09	103.12
	SD	0.07	1.55	1.31	3.25	9.80	221.77	14.41	4.28
	CV	35.00	1.60	0.56	0.03	0.10	0.14	0.03	0.04
BL	Mean	0.001	0.97	2.58	105.05	102.90	424.18	93.65	101.99
	SD	0.04	1.55	1.48	5.40	8.35	50.99	2.99	2.56
	CV	40.00	1.60	0.57	0.05	0.08	0.12	0.03	0.03

Note that period selected includes the Global Financial Crisis (GFC); hence, the returns of the REIT indexes across the markets average to zero return. The coefficient of variance allows comparing the extent of variation across UK, France, and Belgium. The UK has the lowest REIT return and the lowest variance compared to France and Belgium. The most of macroeconomic variables in the UK, which include long-term interest rate, short-term interest rate, industrial production and money supply, are the most stable variables among three markets.

5.2 Unit root tests

This section discusses the findings from the unit root test. The evaluation is based on the assessments of Augmented Dickey-Fuller test (ADF test) as the basic test. A more powerful test, Elliott, Rothenberg, and Stock test (e.g. ERS test), is also considered as the robustness test. The results of the unit root test indicate that all the variables except for industrial production in Belgium are integrated at order one (i.e. I (1) process).

5.2.1 Test results

For the UK, the null hypothesis that the tested variables are non-stationary is not rejected in the ERS test for each variable, i.e. they have a unit root. The ADF test also does not reject the null of non-stationarity for all variables except for short-term interest rate, industrial production, and money supply, which reject the null at 5% significance level. The τ test statistics of short-term interest rate and money supply are lower than the critical values at 1% significance level but higher than the critical values at 5% significance level. This means all tested variables are integrated at one, qualify for cointegration tests and should be differenced for VAR model.

Table 6 Unit root test results for UK

Variables (logarithm)	Augmented Dickey Fuller			The Elliott, Rothenberg, and Stock (ERS) test		
	τ test statistic	1% critical value	5% critical value	DF-GLS test statistic	1% critical value	5% critical value
REIT-M	-2.67	-3.50	-2.89	-0.74	-2.60	-2.08
REIT-Q	-2.47	-3.65	-2.96	-1.40	-2.63	-2.31
Short-term interest rate	-2.07**	-2.60	-1.95	-0.24	-2.60	-2.07
Long-term interest rate	-1.58	-2.60	-1.95	-0.12	-2.60	-2.08
CPI	-0.08	-3.51	-2.89	2.92	-2.60	-2.08
Industrial production	-3.49**	-3.51	-2.89	-1.24	-2.60	-2.02
Money supply	-3.19**	-3.50	-2.89	1.00	-2.60	-2.08
GDP	0.94	-2.64	-1.95	-0.31	-2.63	-2.31
Government expenditure	2.48	-2.64	-1.95	0.64	-2.63	-2.32

Note: ** and *** denotes coefficient significance at 5% and 1% significance level

For France (Table 7), the null hypothesis that the tested variables are non-stationary is not rejected in the ERS test for each variable. The ADF test also does not reject the null of non-stationarity for all variables except for the short-term interest rate, long-term interest rate, and industrial production, which reject the null at 5%. The τ test statistics of the short-term interest rate and long-term interest rate are lower than the critical values at 1% significance level but higher than the critical value at 5% significance level. However, industrial production rejects the null of a unit root at 1% significance level. In case of inconsistent results between ADF test and ERS, the more powerful ERS test results are prioritized. This means that all tested variables are integrated at one, qualify for cointegration tests and should be differenced for VAR model.

Table 7 Unit root test results for France

Variables (logarithm)	Augmented Dickey Fuller			The Elliott, Rothenberg, and Stock (ERS) test		
	τ test statistic	1% critical value	5% critical value	DF-GLS test statistic	1% critical value	5% critical value
REIT-M	0.24	-2.60	-1.95	-1.43	-2.60	-2.08
REIT-Q	-1.36	-3.65	-2.96	-1.30	-2.63	-2.31
Short-term interest rate	-2.27**	-2.60	-1.95	0.11	-2.60	-2.08
Long-term interest rate	-3.98**	-4.03	-3.45	-0.65	-2.60	-2.07
CPI	1.44	-2.60	-1.95	1.52	-2.60	-2.08
Industrial production	-5.64***	-3.51	-2.89	-2.40	-2.60	-2.08
Money supply	2.37	-2.60	-1.95	4.79	-2.60	-2.08
GDP	1.10	-2.64	-1.95	0.05	-2.63	-2.31
Government expenditure	3.59	-2.64	-1.95	-0.00	-2.63	-2.32
Note: ** and *** denotes coefficient significance at 5% and 1% significance level						

For Belgium, the null hypothesis that the tested variables have a unit root is not rejected in the ERS test for each variable except industrial production. The τ test statistic of the industrial production is lower than the critical values at 1% significance level but higher than the critical value at 5% significance level. The ADF test does not reject the null of non-stationarity for all variables except for the short-term interest rate.

Table 8 Unit root test results for Belgium

Variables (logarithm)	Augmented Dickey Fuller			The Elliott, Rothenberg, and Stock (ERS) test		
	τ test statistic	1% critical value	5% critical value	DF-GLS test statistic	1% critical value	5% critical value
REIT-M	0.21	-2.60	-1.95	-1.31	-2.60	-2.08
REIT-Q	0.14	-2.64	-1.95	-0.99	-2.63	-2.31
Short-term interest rate	-2.27**	-2.60	-1.95	0.11	-2.60	-2.08
Long-term interest rate	-1.54	-2.60	-1.95	-0.42	-2.60	-2.07
CPI	2.61	-2.60	-1.95	1.80	-2.60	-2.07
Industrial production	0.98	-2.60	-1.95	-2.24**	-2.60	-2.08
Money supply	3.68	-2.60	-1.95	2.65	-2.60	-2.08
GDP	1.15	-2.64	-1.95	-0.07	-2.63	-2.32
Government expenditure	4.91	-2.64	-1.95	0.77	-2.63	-2.31
Note: ** and *** denotes coefficient significance at 5% and 1% significance level						

5.2.2 Decisions under inconsistent results

It is noted that the short-term interest rates for the UK, Belgium and France, long-term interest rate, industrial production for France, and money supply for the UK are stationary at 5% significance level in ADF test, while ERS test shows non-stationarity at 1% level. ERS test shows more power than ADF test, which is weak at evaluating stationarity when the series has, in fact, a unit root.

According to Schmidt and Phillips (1992), the slope of a trend and constant of ADF test specifications are often poorly estimated when a unit root exists. The underlying least squares principle cannot correctly differentiate the movements of the corresponding variables induced by deterministic trend from those induced by the stochastic trend. Poor estimations of α_0 and α_1 can have large errors, and hence the estimation of γ can be unreliable. In such a case, one is less likely to reject the null hypothesis of a unit root even when the true value of γ is not zero. ERS test is more powerful, as it does not have such issues, and therefore where there is an inconsistency in results between these two methods, the conclusion considers ERS test results.

5.3. Long-term relationship

This section evaluates the long-term relationship between REIT and macroeconomic variables in all three markets. Firstly, Johansen's cointegration test is performed to identify potential cointegrations based on Maximum Eigenvalue test and Trace test for each pair of the macroeconomic variable and the corresponding REIT index. For those pairs indicating that the rank equals one, it suggests that there is one potential long-term relationship. Therefore, the following subsection will illustrate the stationarity results for residual series from the cointegrating relationship and the residuals from the estimated VECM (1) for robustness check. Lastly, for robustness check, other misspecification test results are displayed and discussed, including testing VECM residual serial correlation, multivariate normality, and stationarity of the underlying VECM.

Table 9 presents summarized results and overall show that industrial production has a long-term relationship with the REIT index in UK and France, while in Belgium, REIT index has shown no significant long-term relationship with any of tested factors. This also potentially suggests that developed REIT markets could have a similar relationship with their respective macroeconomic variables. The detailed results for each factor will be discussed further in the section.

Table 9 Summary result of long-term relationship between REIT index and macroeconomic variables

Country	ST-IR	LT-IR	CPI	IP	M2	GDP	Gov-Ex
UK				✓			
France				✓			
Belgium							
Note: ✓Denotes long-term relationship evidence with REIT market							

5.3.1 Johansen's cointegration test

Firstly, Johansen's cointegration test will be tested between each macroeconomic variable and the REIT index in the corresponding market. According to Maximum Eigenvalue test and Trace test, short-term interest rate, money supply, industrial production, GDP and government expenditure are potentially cointegrated with UK REIT index. The short-term interest rate, CPI, industrial production and money supply are potentially cointegrated with France REIT index. Money supply and government expenditure are potentially cointegrated with Belgium REIT index. The results are based on the significant evidence of one rank of Π of the following Johansen's test. One rank means one potential cointegrating relationship, which will be further tested on its residuals of its underlying VECM model for robustness check.

Table 10 Summary result of Johansen's cointegration test

Country	ST-IR	LT-IR	CPI	IP	M2	GDP	Gov-Ex
UK	✓			✓	✓	✓	✓
France	✓		✓	✓	✓		
Belgium					✓		✓
Note: ✓Denotes potential long-term relationship evidence with REIT market before the residuals test							

5.3.1.1. Short-term interest rate

Table 11 displays the cointegration test for UK short-term interest rate. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 24.54 and 21.27 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 3.27 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 11 Johansen test for cointegration for UK short-term interest rate

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	24.54*	19.96	r=0	r=1	21.27*	15.67
r=1	r≥2	3.27	9.24	r=1	r=2	3.27	9.24
Note: * Denotes reject the null at 5% significance level							

Table 12 displays the cointegration test for France short-term interest rate. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 21.13 and 16.57 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 4.56 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 12 Johansen test for cointegration for France short-term interest rate

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	21.13*	19.96	r=0	r=1	16.57*	15.67
r=1	r≥2	4.56	9.24	r=1	r=2	4.56	9.24
Note: * Denotes reject the null at 5% significance level							

Table 13 displays the cointegration test for Belgium short-term interest rate. The null hypothesis of no cointegrating vectors cannot be rejected, as the test statistics 14.26 and 10.88 are smaller than the 5% critical values under either Trace test or Maximum Eigenvalue test. This means the system of Belgium short-term interest rate and Belgium REIT index is I (1) but with no cointegrating relationship.

Table 13 Johansen test for cointegration for Belgium short-term interest rate

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	14.26	19.96	r=0	r=1	10.88	15.67
r=1	r≥2	3.37	9.24	r=1	r=2	3.37	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.1.2. Long-term interest rate

Table 14 displays the cointegration test for UK long-term interest rate. The null hypothesis of no cointegrating vectors cannot be rejected, as the test statistics 13.73 and 11.35 are smaller than the 5% critical values under either Trace test or Maximum Eigenvalue test. This means the system of UK long-term interest rate and UK REIT index is I (1) but with no cointegrating relationship.

Table 14 Johansen test for cointegration for UK long-term interest rate

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	13.73	19.96	r=0	r=1	11.35	15.67
r=1	r≥2	2.37	9.24	r=1	r=2	2.37	9.24
Note: * Denotes reject the null at 5% significance level							

Table 15 displays the cointegration test for France long-term interest rate. The null hypothesis of no cointegrating vectors cannot be rejected, as the test statistics 11.43 and 9.89 are smaller than the 5% critical values under either Trace test or Maximum Eigenvalue test. This means the system of France long-term interest rate and France REIT index is I (1) but with no cointegrating relationship.

Table 15 Johansen test for cointegration for France long-term interest rate

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	11.43	19.96	r=0	r=1	9.89	15.67
r=1	r≥2	1.54	9.24	r=1	r=2	1.54	9.24
Note: * Denotes reject the null at 5% significance level							

Table 16 displays the cointegration test for Belgium long-term interest rate. The null hypothesis of no cointegrating vectors cannot be rejected, as the test statistics 12.12 and 10.18 are smaller than the 5% critical values under either Trace test or Maximum Eigenvalue test. This means the system of Belgium long-term interest rate and Belgium REIT index is I (1) but with no cointegrating relationship.

Table 16 Johansen test for cointegration for Belgium long-term interest rate

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	12.12	19.96	r=0	r=1	10.18	15.67
r=1	r≥2	1.94	9.24	r=1	r=2	1.94	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.1.3. Consumer Price Index

Table 17 displays the cointegration test for UK CPI. The null hypotheses of no cointegrating vectors and one cointegrating relationship are rejected, as the test statistics are greater than the 5% critical values both when r equals 0 and when r equals 1 under Trace test and Maximum Eigenvalue test. This means the system of UK CPI and UK REIT is I (0), a stationary system.

Table 17 Johansen test for cointegration for UK CPI

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	34.34*	19.96	r=0	r=1	24.22*	15.67
r=1	r≥2	10.12*	9.24	r=1	r=2	10.12*	9.24
Note: * Denotes reject the null at 5% significance level							

Table 18 displays the cointegration test for France CPI. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 32.24 and 30.28 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 1.96 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 18 Johansen test for cointegration for France CPI

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	32.24*	19.96	r=0	r=1	30.28*	15.67
r=1	r≥2	1.96	9.24	r=1	r=2	1.96	9.24
Note: * Denotes reject the null at 5% significance level							

Table 19 displays the cointegration test for Belgium CPI. When testing for r=0, the null hypothesis of no cointegrating vectors cannot be rejected as the test statistics 17.84 and 14.00 are smaller than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have no evidence of a cointegrating relationship.

Table 19 Johansen test for cointegration for Belgium CPI

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	17.84	19.96	r=0	r=1	14.00	15.67
r=1	r≥2	3.84	9.24	r=1	r=2	3.84	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.1.4. Industrial production

Table 20 displays the cointegration test for UK industrial production. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 23.23 and 21.07 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 2.16 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 20 Johansen test for cointegration for UK industrial production

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	23.23*	19.96	r=0	r=1	21.07*	15.67
r=1	r≥2	2.16	9.24	r=1	r=2	2.16	9.24
Note: * Denotes reject the null at 5% significance level							

Table 21 displays the cointegration test for France industrial production. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 26.11 and 20.06 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 6.05 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 21 Johansen test for cointegration for France industrial production

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	26.11*	19.96	r=0	r=1	20.06*	15.67
r=1	r≥2	6.05	9.24	r=1	r=2	6.05	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.1.5. Money supply

Table 22 displays the cointegration test for UK money supply. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistic 24.62 is greater than the 5% critical value 19.96. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 cannot be rejected as the test statistic 8.98 is smaller than the 5% critical value 9.24. Trace test indicates that there is one cointegrating relationship between UK money supply and UK REIT index. However, for Maximum Eigenvalue test, the null of no cointegrating relationship cannot be rejected as the test statistic 15.65 is smaller than the 5% critical value 15.67.

Table 22 Johansen test for cointegration for UK money supply

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	24.62*	19.96	r=0	r=1	15.65	15.67
r=1	r≥2	8.98	9.24	r=1	r=2	8.98	9.24
Note: * Denotes reject the null at 5% significance level							

Table 23 displays the cointegration test for France money supply. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 27.99 and 23.97 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 4.02 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 23 Johansen test for cointegration for France money supply

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	27.99*	19.96	r=0	r=1	23.97*	15.67
r=1	r≥2	4.02	9.24	r=1	r=2	4.02	9.24
Note: * Denotes reject the null at 5% significance level							

Table 24 displays the cointegration test for Belgium money supply. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 30.48 and 22.80 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 7.68 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 24 Johansen test for cointegration for Belgium money supply

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	30.48*	19.96	r=0	r=1	22.80*	15.67
r=1	r≥2	7.68	9.24	r=1	r=2	7.68	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.1.6. Gross Domestic Product

Table 25 displays the cointegration test for UK real GDP. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 35.32 and 27.00 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 8.32 is smaller than the 5% critical value 9.24 under both tests. This means there is one cointegrating relationship.

Table 25 Johansen test for cointegration for UK real GDP

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	35.32*	19.96	r=0	r=1	27.00*	15.67
r=1	r≥2	8.32	9.24	r=1	r=2	8.32	9.24
Note: * Denotes reject the null at 5% significance level							

Table 26 displays the cointegration test for France real GDP. The null hypothesis of no cointegrating vectors cannot be rejected, as the test statistics 11.10 and 9.51 are smaller than the 5% critical values under either Trace test or Maximum Eigenvalue test. This means the system of France real GDP and France REIT index is I (1) but with no cointegrating relationship.

Table 26 Johansen test for cointegration for France real GDP

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	11.10	19.96	r=0	r=1	9.51	15.67
r=1	r≥2	1.59	9.24	r=1	r=2	1.59	9.24
Note: * Denotes reject the null at 5% significance level							

Table 27 displays the cointegration test for Belgium real GDP. The null hypothesis of no cointegrating vectors cannot be rejected, as the test statistics 9.03 and 6.45 are smaller than the 5% critical values under either Trace test or Maximum Eigenvalue test. This means the system of Belgium real GDP and Belgium REIT index is I (1) but with no cointegrating relationship.

Table 27 Johansen test for cointegration for Belgium real GDP

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	9.03	19.96	r=0	r=1	6.45	15.67
r=1	r≥2	2.59	9.24	r=1	r=2	2.59	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.1.7. Government expenditure

Table 28 displays the cointegration test for UK government expenditure. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 32.21 and 27.45 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 4.77 is smaller than the 5% critical value under both tests. This means there is one cointegrating relationship.

Table 28 Johansen test for cointegration for UK government expenditure

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	32.21*	19.96	r=0	r=1	27.45*	15.67
r=1	r≥2	4.77	9.24	r=1	r=2	4.77	9.24
Note: * Denotes reject the null at 5% significance level							

Table 29 displays the cointegration test for France government expenditure. The null hypotheses of no cointegrating vectors and one cointegrating relationship are rejected, as the test statistics are greater than the 5% critical values both when r equals 0 and when r equals 1 under Trace test and Maximum Eigenvalue test. This means the system of France government expenditure and France REIT is I (0), a stationary system.

Table 29 Johansen test for cointegration for France government expenditure

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	43.45*	19.96	r=0	r=1	30.78*	15.67
r=1	r≥2	12.68*	9.24	r=1	r=2	12.68*	9.24
Note: * Denotes reject the null at 5% significance level							

Table 30 displays the cointegration test for Belgium government expenditure. When testing for r=0, the null hypothesis of no cointegrating vectors is rejected as the test statistics 34.03 and 28.77 are greater than the 5% critical values 19.96 and 15.67 under Trace test and Maximum Eigenvalue test. This means that we have evidence for 1 or more cointegrating vectors. Next, when testing for r≥1, the null of r=1 is not rejected as the test statistic 5.26 is smaller than the 5% critical value under both tests. This means there is one cointegrating relationship.

Table 30 Johansen test for cointegration for Belgium government expenditure

Trace test				Maximum Eigenvalue test			
Null	Alternative	λ_{trace}	5% critical value	Null	Alternative	λ_{max}	5% critical value
r=0	r≥1	34.03*	19.96	r=0	r=1	28.77*	15.67
r=1	r≥2	5.26	9.24	r=1	r=2	5.26	9.24
Note: * Denotes reject the null at 5% significance level							

5.3.2 VECM and cointegration relationship

This section discusses the cointegration relationship implied by the underlying VECM model. The VECM is specified below. For the cointegrating relationship to exist, the significance of α_1, α_2 and β are tested. Specifically, α_1 and α_2 are the speed of adjustment parameters, and at least one of such parameters should be non-zero. The larger α_1 is, the greater the response of $LnMacroEcon_{t-1}$ to the previous period's deviation from long-run equilibrium. Extremely small absolute value of α_1 implies that the REIT index is unresponsive to last period's equilibrium error. Also, β defines the long run equilibrium to which α_1 and α_2 adjust. Overall, the parameter results show that all cointegration relationships identified by Johansen's test are significant.

$$\Delta LnREIT_t = -\boldsymbol{\alpha_1}(LnREIT_{t-1} - \boldsymbol{\beta} LnMacroEcon_{t-1}) + lagged\ augmentations + \varepsilon_{1t}$$

$$\Delta LnMacroEcon_t = \boldsymbol{\alpha_2}(LnREIT_{t-1} - \boldsymbol{\beta} LnMacroEcon_{t-1}) + lagged\ augmentations + \varepsilon_{2t}$$

Table 31 displays the parameter results for UK REIT and macroeconomic variables that passed Johansen's test, i.e. 1 rank. All β and at least one of the α_1 and α_2 parameters are significant at 5% significance level for all tested pairs. This means significant long-term equilibrium exists. Also, the absolute values of α_1 are greater than α_2 for all the variables, i.e. REIT index in the UK are more responsive to last period's long-run equilibrium error in their system than macroeconomic variables.

Table 31 Cointegration relationship between REIT index and macroeconomic variables for UK

Parameters	ST-IR	Industrial production	Money supply	GDP	Government expenditure
α_1	-0.058	-0.047	-0.024	-0.476	-2.562
p-value	0.000***	0.004***	0.085*	0.000***	0.000***
α_2	-0.025	-0.017	0.007	-0.019	-0.019
p-value	0.123	0.013**	0.000***	0.005***	0.005***
β	0.623	30.174	-6.151	-2.562	-6.460
p-value	0.000***	0.000***	0.002***	0.000***	0.000***
Note: *, ** and *** denotes coefficient significance at 10%, 5% and 1% significance level					

Table 32 displays the parameter results for France REIT and macroeconomic variables that passed Johansen's test. Again, all β and at least one of the α_1 and α_2 parameters are significant at 5% significance level for all tested pairs. The values of α_1 and β are all significant at 1% significance for each variable. This means significant long-term equilibrium exists. α_1 of industrial production is much lower than that of CPI and money supply, indicating a larger response of France REIT index to the last period long-run equilibrium errors in CPI and money supply in comparison to industrial production.

Table 32 Cointegration relationship between REIT index and macroeconomic variables for France

Parameters	ST-IR	CPI	Industrial production	Money supply
α_1	-0.149	-0.316	-0.008	-0.343
p-value	0.000***	0.000***	0.008***	0.000***
α_2	0.013	0.001	-0.005	-0.009
p-value	0.497	0.622	0.004***	0.389
β	0.346	-6.606	131.787	-1.751
p-value	0.000***	0.000***	0.000***	0.000***

Note: *, ** and *** denotes coefficient significance at 10%, 5% and 1% significance level

Table 33 displays the parameter results for Belgium REIT and macroeconomic variables that passed Johansen's test. For all variables, at least one of α_1 and α_2 is significant at 1% significance level.

Table 33 Cointegration relationship between REIT index and macroeconomic variables for Belgium

Parameters	Money supply	Government expenditure
α_1	-0.032	-0.038
p-value	0.073*	0.221
α_2	-0.014	0.009
p-value	0.000***	0.000***
β	-0.971	-6.553
p-value	0.015**	0.001***

5.3.3 Stationarity of residuals in VECM and cointegrating relationship

To conclude cointegration through Johansen's test, a conditional factor of the stationarity of the residuals of the cointegration relationship and the estimated VECM must be satisfied. For the results of the stationarity test, please refer to Table 34.

ADF test and ERS test are conducted and only UK industrial production and France industrial production are stationary in residual series. Even though UK money supply, UK short-term interest rate and UK real GDP, France CPI and France money supply, Belgium government expenditure are stationary in residuals according to ADF test, the more powerful ERS test, however, does not reject the null of unit roots for at least one residual. The existence of unit root means that VECM model, and more importantly, the cointegrating terms, are invalid for statistical references. Hence, the variables except for UK industrial production and France industrial production cannot be concluded to have a long-term relationship with REIT index.

Table 34 Residuals for the cointegrating relationship and the VECM

Variables	Residuals	Augmented Dickey Fuller (ADF)			The Elliott, Rothenberg, and Stock (ERS) test		
		τ test statistic	1% critical value	5% critical value	DF-GLS test statistic	1% critical value	5% critical value
UK money supply	Cointegrating residual	-3.50***	-2.60	-1.95	-0.93	-3.55	-2.99
	Equation #1 residual	-4.72***	-2.60	-1.95	-10.90***	-3.56	-3.00
	Equation #2 residual	-5.46***	-2.60	-1.95	-10.99***	-3.56	-3.00
UK short-term interest rate	Cointegrating residual	-4.27***	-3.51	-2.89	-1.05	-3.55	-2.98
	Equation #1 residual	-6.19***	-2.60	-1.95	-9.16***	-3.56	-3.00
	Equation #2 residual	-5.57***	-2.60	-1.95	-10.50***	-3.56	-3.00
UK industrial production	Cointegrating residual	-3.74***	-2.60	-1.95	-6.51***	-3.55	-3.00
	Equation #1 residual	-3.40**	-2.60	-1.95	-9.96***	-3.57	-2.94
	Equation #2 residual	-2.70***	-2.60	-1.95	-9.23***	-3.57	-3.01
UK GDP	Cointegrating residual	-3.41***	-2.64	-1.95	-2.03	-3.77	-3.24
	Equation #1 residual	-3.50***	-2.64	-1.95	-5.57***	-3.77	-3.30
	Equation #2 residual	-3.84***	-2.64	-1.95	-6.07***	-3.77	-3.30
UK government expenditure	Cointegrating residual	-4.46***	-2.64	-1.95	-0.93	-2.63	-2.31
	Equation #1 residual	-1.39	-2.65	-1.95	-5.95***	-2.64	-2.35
	Equation #2 residual	-4.27***	-2.64	-1.95	-5.91***	-2.64	-2.35
France short-term interest rate	Cointegrating residual	-0.65	-3.50	-2.89	-2.43	-3.55	-2.98
	Equation #1 residual	-5.13***	-2.60	-1.95	-9.06***	-3.56	-3.00

	Equation #2 residual	-6.35***	-2.60	-1.95	-8.04***	-3.56	-2.97
France CPI	Cointegrating residual	-4.13***	-3.50	-2.89	-1.58	-3.55	-3.00
	Equation #1 residual	-4.61***	-2.60	-1.95	-6.70***	-3.57	-3.01
	Equation #2 residual	-5.75***	-2.60	-1.95	-9.33***	-3.57	-3.01
France industrial production	Cointegrating residual	-4.11***	-3.51	-2.89	-9.05***	-3.55	-3.00
	Equation #1 residual	-4.97***	-2.60	-1.95	-8.81***	-3.57	-3.02
	Equation #2 residual	-3.03***	-2.60	-1.95	-11.13***	-3.57	-3.02
France money supply	Cointegrating residual	-3.70***	-3.50	-2.89	-1.94	-3.55	-2.99
	Equation #1 residual	-4.90***	-2.60	-1.95	-6.63***	-3.57	-3.01
	Equation #2 residual	-4.96***	-2.60	-1.95	-6.91***	-3.57	-3.01
Belgium money supply	Cointegrating residual	-2.65	-3.50	-2.89	-0.49	-2.60	-2.08
	Equation #1 residual	-4.15***	-2.60	-1.95	-9.85***	-2.60	-2.09
	Equation #2 residual	-4.56***	-2.60	-1.95	-8.97***	-2.60	-2.09
Belgium government expenditure	Cointegrating residual	-3.06***	-2.64	-1.95	-0.75	-2.63	-2.31
	Equation #1 residual	-3.31***	-2.64	-1.95	-6.93***	-2.64	-2.34
	Equation #2 residual	-2.74***	-2.64	-1.95	-5.75***	-2.64	-2.34

Note: ** and *** denote significant stationarity at 5% and 1% significance level

5.3.4 Other robustness and diagnostic tests

This section examines the robustness of the cointegration relationship identified through Johansen’s test by testing the potential misspecification of the VECM (VECM serial correlation test, normality test, model stationarity test). The misspecification tests show that some serial correlation on the overall VECM still exists with model unit root. Since the macroeconomic and index data are generally not well-behaved, it can be the case that they cannot pass the strict misspecification tests.

The test results for UK industrial production and France industrial production are further tested for diagnostic tests, as they showed stationarity in residuals in both ADF test and ERS test. Diagnostic results are displayed in Table 35 and Table 36. There are no remaining serial correlations in the residuals of VECM for both markets, as all p-values are greater than 10%. This means the VECM specifications are valid to draw cointegration inferences.

Table 35 No serial correlations in the VECM model

Lag	p-value (UK)	p-value (France)
1	0.63	0.38
2	0.36	0.13
3	0.18	0.47
4	0.05	0.17
5	0.72	0.26
6	0.31	0.36
7	0.51	0.22
8	0.84	0.63

Table 36 Normality test

Test	p-value (UK)	p-value (France)
Jarque-Bera test	0.04**	0.00***
Skewness test	0.20	0.00***
Kurtosis test	0.03**	0.51

Note: ** and *** denotes rejecting normality null at 5% and 1% significance level

The disturbance of the underlying VECM for neither of markets are normally distributed. Johansen’s test derives maximum likelihood estimations under the assumption of normal likelihood, i.e. normal errors. But with large sample size in both markets, the distribution of the parameters and tests can have broader moments. And therefore, the conclusion will still be valid.

However, the VECM for both markets is not stable as stability test indicates they impose a unit modulus. Not all the eigenvalues lie in the unit circle. This could be an issue, which leads to two limitations. Firstly, the cointegration inference could be incorrect. Secondly, the underlying model to draw the inference could be flawed.

5.4 Short-term relationship

This section discusses the short-term relationship between macroeconomic variables and the REIT index in the corresponding market. According to Johansen’s test, for the tested pairs that conclude zero rank or full rank, differenced VAR model is used to test whether and how shocks of one variable in recent periods cause the other in the current period. Both Wald test and Likelihood Ratio test are used to identify a short-term relationship.

5.4.1 VAR construction

Table 37 lists the Granger causality test candidate variables, the Π of which have 0 rank or full rank. The differenced VAR model is constructed for variables that have a unit root. The first order difference is taken based on the natural logarithm of the tested variables. And Table 37 shows that all differenced series are now stationary according to a more powerful ERS test. Note that industrial production for Belgium is stationary at I (0), hence, no differentiation is required. The first order differenced series showed stationarity at 1% significance level in the ERS test. Therefore, stationary differenced series to construct the corresponding VAR model can avoid unit root issues discussed in the methodology part.

Table 37 Unit root test results for differenced and log-transformed data. Industrial production for Belgium is not differenced since data are stationary at I (0).

Country	Variables	The Elliott, Rothenberg, and Stock (ERS) test		
		DF-GLS test statistic	1% critical value	5% critical value
UK	REIT-M	-9.80***	-2.60	-2.09
	Long-term interest rate	-7.46***	-2.60	-2.08
	CPI	-9.24***	-2.60	-2.09
France	REIT-M	-10.71***	-2.60	-2.09
	REIT-Q	-4.47***	-2.64	-2.34
	Long-term interest rate	-7.22***	-2.60	-2.08
	GDP	-3.17***	-2.64	-2.34
	Government expenditure	-2.78***	-2.64	-2.32
Belgium	REIT-M	-10.57***	-2.60	-2.08
	REIT-Q	-6.29***	-2.64	-2.34
	Short-term interest rate	-3.96***	-2.60	-2.08
	Long-term interest rate	-7.18***	-2.60	-2.08
	GDP	-3.49***	-2.64	-2.32
	CPI	-3.38***	-2.60	-2.08
	Industrial production	-2.24**	-2.60	-2.08

Note: ** and *** denote stationarity at 5% and 1% significance level

5.4.2 Granger causality test

This section discusses the Granger causality test results. Wald test and Likelihood ratio test are conducted, and the final results are based on the combination of the two tests. The consistent conclusions of both tests are summarized in Table 38 and Table 39. The detailed results for each factor will be discussed further in the section.

Overall, it is found that no Granger causality is identified in the UK tested pairs. The short-term disturbance in previous periods of France REIT affects France GDP and France government expenditure. The short-term disturbance in previous periods of Belgium long-term interest rate and industrial production affects Belgium REIT. The short-term disturbance in previous periods of Belgium REIT affects Belgium short-term interest rate.

Table 38 Summary result of Granger Causality for REIT as dependent variable

Country	ST-IR	LT-IR	CPI	Industrial production	Money supply	GDP	Government expenditure
UK							
France							
Belgium		✓		✓			
Note: ✓Denotes Granger causality with REIT market before robustness check.							

Table 39 Summary result of Granger causality for REIT as independent variable

Country	ST-IR	LT-IR	CPI	Industrial production	Money supply	GDP	Government expenditure
UK							
France						✓	✓
Belgium	✓						
Note: ✓Denotes Granger causality with REIT market before robustness check.							

5.4.2.1 Wald test

Wald test shows the presence of Granger causality for some pairs when REIT index is set as a dependent and for some as an independent variable. This means that some REITs are significantly responsive to the previous shocks in some macroeconomic variables in their corresponding market, while some macroeconomic variables are also significantly responsive to the previous shocks in the REIT in their corresponding market.

Table 40 below shows the test results for Wald test (REIT index as the dependent variable). The null hypothesis of the following test is that the excluded variables (i.e. macroeconomic variables) do not Granger cause the dependent variables (i.e. REIT variables). The pairs of UK CPI and REIT, Belgium Long-term interest rate and REIT, as well as Belgium IP and REIT reject the null at 1% significance level. The pair of France long-term interest rate and REIT reject the null at 5% significance level. To conclude, the macroeconomic variables indicated above Granger cause the paired REIT index in their corresponding market.

Table 40 The results from Granger causality Wald tests- REIT index as the dependent variable

Excluded	Dependent		
	UK REITs	FR REITs	BL REITs
Short-term interest rate	-	-	0.94
Long-term interest rate	0.38	0.02**	0.01***
CPI	0.005***	-	0.37
GDP	-	0.15	0.07*
Government expenditure	-	0.50	-
Industrial production	-	-	0.000***

Note: Each entry in the table denotes the p-value. *, **, *** Significant at 10, 5 and 1 percent level

Table 41 below shows the test results for Wald test (Macroeconomic variables as the dependent variable). The null hypothesis of the following test is that the excluded variables (i.e. REIT variables) do not Granger cause the dependent variables (i.e. macroeconomic variables). The pair of Belgium REIT and short-term interest rate rejects the null at 1% significance level. The pair of UK REIT and CPI, the pair of France REIT and GDP, as well as the pair of France REIT and government expenditure, reject the null at 5% significance level. To conclude the REIT indices indicated above Granger cause the paired macroeconomic variables in their corresponding market.

Table 41 The results from Granger causality Wald tests- macroeconomic factors as dependent variables

Excluded	Dependent					
	Short-term interest rate	Long-term interest rate	CPI	GDP	Government expenditure	IP
UK REIT	-	0.16	0.02**	-	-	-
France REIT	-	0.17	-	0.03**	0.041**	-
Belgium REIT	0.00***	0.62	0.30	0.32	-	0.48

Note: Each entry in the table denotes the p-value. *, **, *** Significant at 10, 5 and 1 % level

5.4.2.2 Likelihood ratio (LR) test

The likelihood ratio tests are displayed in Table 42. The likelihood ratio test rejects the null of no Granger causality relationship at 5% significance level for France GDP and France government expenditure with REIT index in their corresponding markets. Specifically, France REIT Granger cause GDP and government expenditure at 5% significance level. Belgium REIT Granger causes short-term interest rate at 1% significance level. Belgium long-term interest rate and industrial production Granger causes Belgium REIT at 1% and 5% significance level respectively.

Table 42 The results from Granger causality likelihood ratio test

Country	Variables (differenced logarithm)		Likelihood Ratio test		
	Dependent	Independent	LR statistics	1% critical value	5% critical value
UK	REIT-M	LT-IR	3.94	13.28	9.49
	LT-IR	REIT-M	5.86	13.28	9.49
	REIT-M	CPI	19.60	26.22	21.03
	CPI	REIT-M	16.63	26.22	21.03
France	REIT-M	LT-IR	7.53	13.28	9.49
	LT-IR	REIT-M	2.43	13.28	9.49
	REIT-Q	GDP	2.04	6.63	3.84
	GDP	REIT-Q	4.60**	6.63	3.84
	REIT-Q	GOV-EX	0.49	6.63	3.84
	GOV-EX	REIT-Q	4.19**	6.63	3.84
Belgium	REIT-M	ST-IR	0.00	9.21	5.99
	ST-IR	REIT-M	12.22***	9.21	5.99
	REIT-M	LT-IR	9.26***	9.21	5.99
	LT-IR	REIT-M	1.11	9.21	5.99
	REIT-Q	GDP	3.24	6.63	3.84
	GDP	REIT-Q	1.02	6.63	3.84
	REIT-M	CPI	2.15	9.21	5.99
	CPI	REIT-M	2.15	9.21	5.99
	REIT-M	IP	24.21**	26.22	21.03
	IP	REIT-M	8.84	26.22	21.03

Note: ** and *** denote stationarity at 5% and 1% significance level

5.4.3 Diagnostic test

To evaluate the robustness of the Granger causality test, diagnostic tests are conducted on the underlying VAR models for the pairs below:

$$France\ REIT \xrightarrow{granger\ cause} France\ GDP \tag{1}$$

$$France\ REIT \xrightarrow{granger\ cause} France\ government\ expenditure \tag{2}$$

$$Belgium\ long-term\ interest\ rate \xrightarrow{granger\ cause} Belgium\ REIT \tag{3}$$

$$Belgium\ industrial\ production \xrightarrow{granger\ cause} Belgium\ REIT \tag{4}$$

$$Belgium\ REIT \xrightarrow{granger\ cause} Belgium\ short-term\ interest\ rate \tag{5}$$

According to Table 43, the pairs (2), (4) and (5) have remaining serial correlations in the defined VAR model. This means that the conclusion might be built upon a model with an incorrect number of lags, and the result could be invalid. However, (1) and (3) show no remaining serial correlations and so the conclusion is based on the right model.

Table 43 Serial correlation check

Lag	p-value (1)	p-value (2)	p-value (3)	p-value (4)	p-value (5)
1	0.58	0.00***	0.89	0.19	0.71
2	0.61	0.03**	0.83	0.00***	0.66
3	0.73	0.25	0.72	0.02**	0.33
4	0.10	0.30	0.24	0.04**	0.23
5	0.32	0.47	0.09	0.21	0.25
6	0.80	0.07	0.97	0.42	0.75
7	0.58	0.93	0.09*	0.09*	0.01***
8	0.61	0.72	0.70	0.37	0.35

Note: *, ** and *** denote stationarity at 10%, 5% and 1% significance level

Table 44 shows that disturbance of the VAR model follows the normal distribution only for the pairs (1) and (2). As discussed before, since (3), (4) and (5) are based on a large sample size, the distribution of the parameters and tests can have broader moments. And therefore, the conclusion for (3), (4) and (5) will still be valid.

Table 44 Normality check

Test	p-value (1)	p-value (2)	p-value (3)	p-value (4)	p-value (5)
Jarque-Bera test	0.13	0.30	0.00***	0.00***	0.00***
Skewness test	0.14	0.27	0.00***	0.07*	0.00***
Kurtosis test	0.20	0.33	0.00***	0.00***	0.00***

Note: ** and *** denote stationarity at 5% and 1% significance level

The results for VAR model stability check indicates that all the eigenvalues lie inside the unit circle. VAR satisfies stability condition for all pairs.

5.5 Discussion

The first and second hypotheses could not be rejected. The results show no short-term or long-term relationship between REIT performance and interest rates, neither 3 month-interest rate nor 10-year government bond, which is in line with our initial expectation and the research of Loo, Anuar & Ramakrishnan (2016) that found no significant relationship with interest rates in such developed markets as Singapore and Hong Kong. The exception is the country-specific significance of long-term and short-term relationship in Japan. In a similar manner, we found the country-specific significance of short-term relationship in Belgium. The research by Loo, Anuar & Ramakrishnan (2016) is the most comparable research in terms of the selected research method; however, it is important to note that other studies show inconsistent results with regard to the integration between REIT index performance and interest rates. For example, the results support the findings of several authors that include Chen and Tzang (1988), Pauley and Mueller (1995), but are in contradiction to a certain extent with authors Cheong et al (2006), Reddy and Wong (2017), Fang et al (2016) that find either a short-term or long-term relationship with the same macroeconomic factor. The conflict leads to a conclusion that there are other factors that could affect the sensitivity towards interest rates, for example, the leverage level, the time-period, the economic cycle or types of investment trusts included in the index. Alternatively, inconsistency in research papers could be considered as a result of differences in the research methods applied.

The opposite of our expectation of a long-run equilibrium with CPI, we found no sufficient evidence to support such statement. Although France has indicated a potential cointegration with inflation factor, the robustness check failed to confirm such relationship. Furthermore, we found no short-term relationship in the UK, France or Belgium. The results are not in line with the evidence on developed markets in the Asian region, all of which showed cointegration with inflation factor as presented by Loo, Anuar & Ramakrishnan (2016). Also, similar evidence has been found by Chen and Tzang (1988), Chatrath and Liang (1998), Glascock, Lu, and So (2002), Simpson, Ramchander, and Webb (2007), Wong (2017) and Fang et al (2016).

The hypothesis of a short-term relationship between REIT market performance and GDP has proven to be true in France, where REIT market seems to have a significant contribution to the economic growth. A similar pattern has been found by Loo, Anuar & Ramakrishnan (2016) in Singapore. Also, Atchison and Yeung (2014) have mentioned the relevance of REIT market as a stimulus for the economic growth in their research on the impact of REITs on Asian economies.

The expectation about money supply variable has shown to be satisfied with no sufficient evidence to support the significance of the factor. Although a potential cointegration appeared in the UK, France, and Belgium, the robustness check failed to confirm the relationship. In the research by Loo, Anuar & Ramakrishnan (2016), Japan showed a long run cointegration with the money supply, while Hong Kong showed a short-run relationship, both of which are country-specific. The fact that results are country-specific indicate that the linkage between REIT performance and macroeconomic variables could not be generalized and a more complex model might be required to explain the pattern.

The industrial production factor proved to be a significant factor in the long-run cointegration with REIT performance. Therefore, the hypothesis of a long-run equilibrium between industrial production and REIT market could not be rejected. The exception can be observed in Belgium, where industrial production Granger causes the REIT performance in the short run. The results are in line with findings of Loo, Anuar & Ramakrishnan (2016).

Government expenditure, which is a recent introduction to the research, showed no significance in the long run but seems to be an important determinant in France in the short-term. The REIT market performance seems to have an influence on the government expenditure. A similar pattern is found in Singapore in the recent paper of Loo, Anuar & Ramakrishnan (2016). Taking into consideration observed patterns across various macroeconomic variables, France and Singapore seem to show a similar behavior which can be explored further.

As mentioned above, the effect from the research method selected should be considered and could be a partial explanation for the different results among the studies performed. The decisions as to the model selection (trend, random walk with drift, random walk without drift), or for instance the choice of information criteria to select the number of lags, as well as the choice of the test for stationarity of data can influence the results and lead to a different conclusion.

6. Conclusion

This paper contributes to the limited literature on European REITs by the illustration of integration between REIT markets and macroeconomic factors in the first developed markets in Europe, which include the UK, France, and Belgium. Given that the adoption of REIT legislation in Europe takes place several decades after the first introduction in the United States, the results from the study serve as the first insight into the behavior of European REIT markets which can be compared to the markets that are more established. The study covers seven macroeconomic factors which are short-term, long-term interest rates, CPI, GDP, money supply, industrial production and government expenditure. In general, the factors such as industrial production and government expenditure have been researched little in the current literature, but have proven to be significant in our research.

Overall, the results indicate that the impact of macroeconomic variables is somewhat different across the countries tested. However, the higher number of short-term relationships show that markets react in a shorter time horizon, in contrast to the previous research that found a higher number of long-run relationships in markets like Asia. In the long run, only industrial production had sufficient evidence to have a long run equilibrium with REIT index in the UK and France.

Important to note, both markets are similar in terms of market capitalization and development. For Belgium, industrial production appears to be a significant factor in short-term. Also, in contrast to the widespread perception that REIT can serve as the inflation hedge, we found no suggestive evidence of long-run equilibrium with CPI.

In the short-term, we found that factors such as industrial production and long-term interest rate impact REIT index in Belgium. Furthermore, the direction of short-term relationships indicates that REIT sector has a significant effect on factors such as GDP and government expenditure in France and short-term interest rate in Belgium.

Three main limitations of this paper are discussed below. Firstly, the main limitation of the study is the short sample period that might not be sufficient to observe a significant pattern in the long run. Furthermore, important to note that the sample period includes GFC and post-GFC period. In crisis and non-crisis period, the behavior of REIT market could be different and should be further researched. Secondly, a higher number of countries analyzed could increase the extent to which we can make generalized inference about developed REIT markets in Europe. The three selected markets have non-trivial differences in terms of the number of REITs and their market capitalization, limiting the power to make generalized inferences for investors or policymakers. Although Belgium has been classified as a developed REIT market, it has not been such throughout the whole period researched. Thirdly, the Johansen's methodology gives evidence only in the long-run that the tested pairs will correct from shock deviations to the long-term equilibrium. Therefore, no direction of long-run causality can be concluded. Similarly, Granger causality does not conclude causality but only gives inferences if one variable is useful in predicting the other.

Three areas for further research are identified. Firstly, the inconsistent results across markets, in general, indicate that there might be more factors to consider, such as diversification by property type, average leverage level, the market size that could affect the interdependence between REIT markets and the macroeconomic environment. The suggestion for future research is to include such factors in the analysis of REIT performance. Also, the future research could look at the behavior of non-developed REIT markets in Europe and make a comparison with developed REIT markets in the same region. Finally, as this paper does not segment the time horizon into GFC and non-GFC due to data limitations, it is interesting to look at differences in how European REIT markets are related to macroeconomic factors in economic upturn and downturn in the future.

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Appendix 1

Figure 1 Illustration of MSCI US REIT performance versus MSCI US IMI, Source: msci.com

Figure 2 Illustration of MSCI Asia Pacific REIT performance versus MSCI Asia Pacific and MSCI All Country World Index, Source: msci.com