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DRIVING FORCES BEHIND EUROPEAN COMMERCIAL REAL ESTATE PRICES PRIOR TO A SHARP FALL IN PRICES

Driving forces behind European commercial real estate prices prior to a sharp fall in prices*

Marius Hagen†and Frank Hansen‡

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Abstract

What factors have driven commercial real estate (CRE) prices upwards prior to a sharp fall in prices? We study this question by identifying turning points in CRE for a dataset covering the prime office segment in 58 cities in Europe. CRE prices are decomposed into rents and CRE yields. Our results show that the increase in rents was the main driver behind the rise in CRE prices before peaks in the period 1980 to 2003. In the period 2004 to 2016, the decline in CRE yields was the main driver and was partly caused by a general downward trend in European CRE yields before the global financial crisis. A significant part of the decline is still left unexplained after controlling for factors such as the risk-free rate, the risk premium and city-specific effects. The reduction in CRE yields caused by the residual and the time dummies was likely driven by a change in omitted variables such as time variation in access to credit, capital requirements, the expected long-run rent growth rate and/or CRE specific risk premiums.

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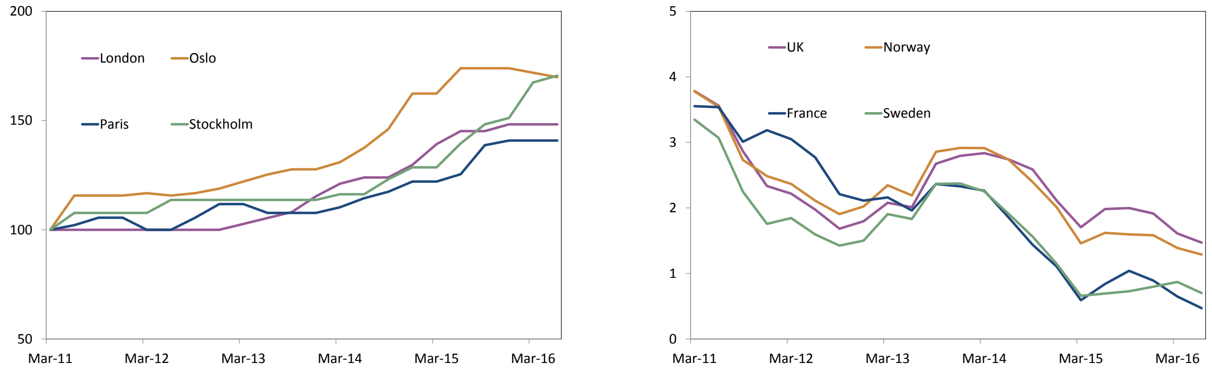
1 Introduction

Commercial real estate (CRE) prices fluctuate with the business cycle and tend to be considerably more volatile than residential real estate prices (see for example Olszewski (2013), Ellis and Naughtin (2010) and Gyourko (2009)). This may be a result of long construction lags, a close connection with the real economy and the lack of transparency in the market(see for example European Systemic Risk Board(ESRB) (2015)). The volatility in CRE prices might also be reinforced by access to credit, i.e. when collateral values rise, the amount of credit made available by lenders also typically increases.

The financial system is vulnerable to negative shocks in the CRE sector as exposure to this sector is high in many countries. Relative to GDP, the total direct exposure of the financial system for countries in the EU was more than 15 percent in 2013, with banks accounting for the largest proportion of exposure to CRE (see European Systemic Risk Board(ESRB) (2015)). CRE is also the sector where banks have historically incurred the largest losses during financial crises. Property-related investments suffered high losses in Norway, Sweden, Finland and the UK at the beginning of the 1990s. During the 2007-2008 global financial crisis(GFC), property-related investments again led to substantial losses for banks in several countries (see for example Kragh-Sørensen and Solheim (2014)).



(a) Implied CRE prices. Index. 2011 Q1 = 100. 2011 Q1 - 2016 Q2

(b) 10-year interest rate on government bonds. Percent. 2011 Q1 - 2016 Q2

Figure 1: *Developments in implied CRE prices and long-term interest rates. Sources: CBRE Group and OECD*

In recent years, CRE prices have once again surged in many European cities, see Figure 1a. A surge in CRE prices can increase the risk of a severe contraction in prices, which in turn can lead to higher bank losses. The increase in CRE prices has been driven by declining CRE yields, likely caused by a substantial reduction in long-term interest rates, which are now at historically low levels, see Figure 1b.[1]

[1]Rents have been more or less stable. This suggests that the drop in interest rates is one of the most important factors behind the increase in CRE prices (see also Krainer (2013)).

In this paper, we address the question of what has historically caused CRE prices to increase before turning points followed by a severe contraction. We analyse this question by identifying turning points for CRE prices in a dataset covering the prime office segment in 58 cities in Europe.[2] For a number of the cities, the statistics date back to the 1980s. As far as we are aware, we are the first to conduct a study on booms and busts in CRE prices on a dataset covering a broad selection of European cities. The empirical results may shed light on the current and future risk of a substantial fall in CRE prices. Our main findings are as follows:

- The rise in CRE prices has been more pronounced prior to a substantial fall in prices than prior to a moderate fall. On average, prices have risen by approximately 85 percent prior to a substantial fall, while prices have risen by approximately 20 percent before a moderate fall.
- In the period from 1980 to 2003, the increase in CRE prices prior to severe contractions was primarily driven by higher rents. Growth in employment has likely been an important driver behind this development.
- In the period from 2004 to 2013, the increase in CRE prices prior to severe contractions was primarily driven by declining CRE yields. We find that the yield compression was partly caused by a general downward trend in yields in European cities before the GFC. A significant part of the decline in yields is left unexplained after controlling for factors such as city-specific effects, the risk-free rate and a general risk premium[3]. This indicates that factors we are not able to control for, such as access to credit, capital requirements, expectations of the long-run growth rate in rents and/or CRE specific risk premiums, were important drivers behind the compression in CRE yields.
- After turning points, CRE prices typically fall as a result of higher CRE yields in the short term. In the somewhat longer term, rental driven booms have been driven downwards by a reduction in rents. One possible explanation for this is that higher rents make it more profitable to increase building activity, which in turn will push rents downward in the longer term.
- Along with falling long-term interest rates, CRE prices have surged in recent years (the dataset ends in Q2 2016). Historically, reduced long-term interest rates have seldom been the main driver behind an increase in CRE prices before severe contractions.

The paper is structured in the following way: Section 2 reviews the relevant literature. Section 3 explains how pricing in the CRE sector is related to general valuation theory. In Section 4, we describe the data used in the analysis, while we present the results in Section 5. Finally, we conclude in Section 6.

[2]The terms "turning points" and "peaks" are used interchangeably in this paper.

[3]The spread between investment grade rated corporates in Europe and government bonds in Germany is used as an proxy for the general risk premium.

2 Literature

Most literature on the dynamics of CRE prices focuses on explaining developments in CRE yields. This is likely a result of the heterogeneity in CRE, which makes it difficult to construct series for CRE prices. The literature mostly focuses on the CRE market in the US, likely due to easier access to longer time series and better data quality. In this paper, we analyse CRE prices in Europe around turning points. As far as we are aware, literature on this topic on European data is limited.

There is a significant body of empirical research focusing on the driving forces behind CRE yields, see for example Sivitanides et al. (2001), Chervachidze and Wheaton (2013), Chaney and Hoesli (2015) and Duca and Ling (2015). In theory, the CRE yield should equal the required rate of return (risk-free rate plus risk premium) less the expected growth rate in rental income. Most studies find a clear positive relationship between the CRE yield and both interest rate and the risk premium. However, the effect of the interest rate on the CRE yield might be distorted by other factors in the short term (see Chaney and Hoesli (2010)). For instance, if inflationary pressure is high and growth is expected to increase, rental income expectations also often pick up. This will put downward pressure on the CRE yield. On the other hand, the central bank will in this scenario likely respond with a higher interest rate which will put an upward pressure on the CRE yield. Regarding how rental expectations are formed, some studies on US data find evidence of adaptively formed expectations, e.g. Sivitanides et al. (2001) and Chervachidze and Wheaton (2013). While Hendershott and Bryan (2005) find based on data for the UK from 1986Q1 to 2003Q1 that investors expect rents to revert to their mean or trend.

There are some recent studies on the causes of the compression of CRE yields before the GFC and subsequent rise. Chervachidze and Wheaton (2013) find that much of the decline in CRE yields in the US before the GFC and the subsequent rise afterwards was caused by the general risk premium and the availability of debt.[4] Duca and Ling (2015) study the drivers behind the boom and bust in CRE prices in the US in the 2000s. Their results indicate that the primary driver behind the surge in prices before the GFC was a lower required risk premium, which among other things was caused by weaker regulatory capital requirements for commercial and investment banks investing in CRE. Benford and Burrows (2013) from the Bank of England uses the dividend discount approach to decompose the movements in CRE prices on UK data from 2000 to 2013. Their analyses indicate that around two thirds of the increase in CRE prices before the GFC was caused by a reduced CRE yield. Further, they find that the reduction in the yield was driven by other factors than the risk-free rate and rental growth expectations. They point to feedback loops between credit growth and CRE prices and irrational exuberance as possible factors that contributed to the fall in the yield.

There are also various studies looking at the linkages between economic growth and the CRE market. Several papers find that GDP growth has a strong impact on returns on

[4] The general risk premium is measured as the spread between Moody's AAA Corporate Bond Index and the 10-year T-Bond yield, while the availability of debt is estimated by the annual growth rate in total debt outstanding divided by GDP.

CRE, see for example Blake et al. (2011) and NBIM (2015). Employment is also often considered to be important for CRE, especially in the office segment. When employment increases, firms will typically need more space and rents will increase as a result. Employment is therefore often used as an exogenous variable in models of the office market, see for example Hendershott et al. (1999). However, Liang and McIntosh (1998) find on US data that employment growth does not contribute to a higher CRE return in the longer term, as supply responses can eliminate the impact of employment growth.

3 Pricing in CRE and general valuation theory

The price of a company is commonly calculated using the discounted cash flow approach:

$$P_0 = \frac{CF_1}{(1+r_1)} + \frac{CF_1(1+g_2)}{(1+r_2)^2} + ... + \frac{CF_1(1+g_2)(1+g_3)...(1+g_\infty)}{(1+r_\infty)^\infty} \tag{1}$$

where CF is the free cash flow[5] and g_t and r_t are the expected growth rate in the cash flow and required rate of return in year t, respectively.

Market participants in CRE commonly use *yield* to estimate the price of CRE. The *CRE yield* can be defined as the ratio of rental income to the CRE price of the property.[6] Turning this expression around gives:

$$P_0 = \frac{R_1}{y_0} \tag{2}$$

where P_0 is the price today, R_1 is the rental income next period and y_0 is the current CRE yield.

To analyse developments in CRE prices, it is useful to understand the link between the discounted cash flow (equation 1) and the yield approach (equation 2). If we assume a constant required rate of return and growth rate of the cash flow and replace the free cash flow with rental income in equation 1, we get:

$$P_0 = \sum_{t=0}^{\infty} \frac{R_1(1+g)^t}{(1+r)^{t+1}} \tag{3}$$

by using the formula for the sum of an infinite series, this simplifies to:

$$P_0 = \frac{R_1}{r-g} \tag{4}$$

Comparing equation (2) and (4), we see that the CRE yield equals the required rate of return less the expected growth rate in rental income. The expected growth rate in rental

[5]The free cash flow is the available cash flow a company can use to pay debt and equity investors after deduction of the cash flow required to maintain growth at the current rate.

[6]Often net rental income is used instead of rental income. Net rental income is rental income minus property-related expenses that the owner cannot pass on to the tenant, such as insurance, maintenance, administration and other operating costs. We do not have data for property-related expenses.

income will in theory depend on expectations regarding future developments in demand and supply of offices in the market, which determines rents. For instance, a positive shift in expectations of future employment growth will likely increase demand for office space, which in turn will put upward pressure on rents.

The required rate of return of investors can be decomposed into a risk-free interest rate and a risk premium. The CRE yield can then be written as:

$$y_0 = r^f + r^p - g \tag{5}$$

where r^f is the risk-free interest rate and r^p is the risk premium. The risk premium will depend on developments in the general capital market and factors relating to the specific property.

There may also exist other variables that affect the CRE yield, which are not captured in (5) due to simplified assumptions. Duca and Ling (2015) for instance, argue that time variation in credit constraints also affects the CRE yield. Furthermore, Benford and Burrows (2013) point out that the discounted cash flow approach assumes that investors are not "irrationally exuberant" about the outlook for future rents. In addition, we should be aware that rental income used in the yield approach may not be a good measure of the free cash flow as it, for example, does not include property-related costs, investments and payable tax.

4 Data

Data on CRE are limited. An important reason is that CRE is normally exchanged in private deals between a seller and a buyer (see Geltner (2015)). In addition, CRE properties trade infrequently and CRE is heterogeneous by nature, which makes it difficult to construct price series. Few countries in the EU have official CRE data on variables such as CRE prices and rents.[7]

In this paper, we use data from the private real estate company CBRE.[8] The dataset covers the prime segment for offices in 58 cities in Europe. The start date is between 1980 and 1989 for 15 of the cities, of which seven are located in the UK and the rest are large cities in Western Europe such as Amsterdam, Barcelona, Madrid, Milan and Paris. For 19 of the cities, the start date is between 1990 to 1999, while for the rest of the sample we have data from 2000 onwards (see Table A.1 in the Appendix for a complete overview).

CBRE defines prime CRE yield and rent as follows:

[7]The Bank for International Settlements (BIS) has collected CRE prices from national central banks, see BIS CRE prices. Unfortunately, the database covers relatively few countries. In addition, the reporting frequency is relatively low for most of the countries.

[8]Based on total revenue in 2015, CBRE was the world's largest commercial real estate services and investment firm.

"Prime CRE yield represents the yield that an investor would receive when acquiring a class A building in a prime location, which is fully let at current market value rents"

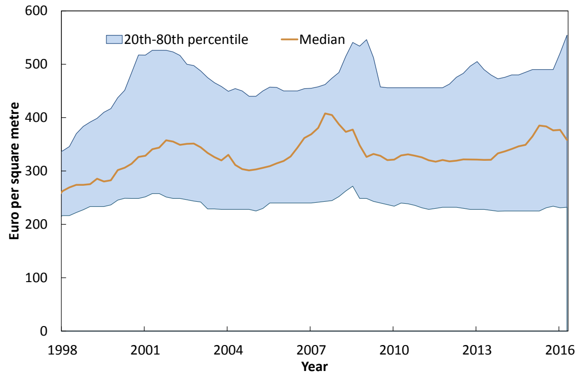
"Prime rent represents the top open-market tier of rent that could be expected for a unit of standard size commensurate with demand in each location."

In general, prime CRE yield and prime rent should reflect the price at which relevant transactions are being completed in the market. The quoted numbers will to a greater extent be based on expert opinions if there are few transactions or unusual one-off deals. If for instance there are no relevant transactions in a quarter, the quoted number will be determined by expert opinions based on assessments of the current market conditions.

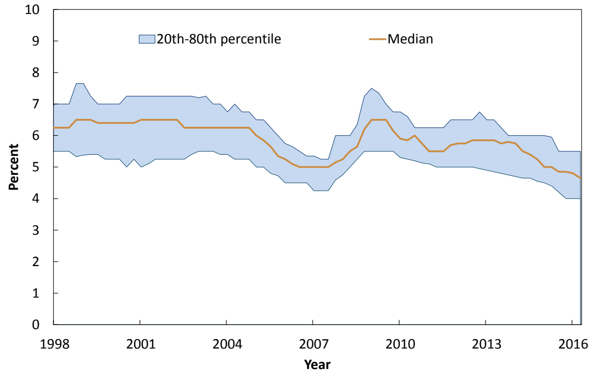
Figure 2 displays time developments in the median and the spread between the 20th and 80th cross sectional percentiles of rents(Panel a) and CRE yields (Panel b). Thus, at any given point in time the figure shows the dispersion in rents and CRE yields for the 26 cities for which we have data from 1998 and onwards.[9] The median rent has shown cyclicality the last 20 years, with peaks at the beginning of the 2000s and in 2007, see Figure 2a. The spread between the 20th and 80th percentile increased from 1998 to 2001, and has fluctuated around EUR 250 per square metre. The median CRE yield has also been cyclical, with a substantial fall before the GFC and in the last few years, see Figure 2b. The spread between the 20th and 80th percentile also declined considerably from 2004 to 2006 - a period in which the securitisation market for commercial real estate loans increased.[10] The increase in the securitisation market may have increased the investor base and contributed to the reduction in the spread in the CRE yield. A similar trend with decreasing spreads occurred in other asset classes in the years before the GFC. For example, the spread between high and low risk bonds shrank considerably in both the euro area and the US, see Kalyan (2007).

[9]Note that the median is not necessarily the same city over time. The point of this figure is to display changes in the cross-sectional variation of rents and yields over time, and not time series developments for a given city.

[10]See SIFMA and the excel file "Europe Structure Finance Issuance and Outstanding".



(a) Prime rents. Median, 20th and 80th percentile. Euro per square meter. 1986 Q1 - 2016 Q2.



(b) Prime CRE yield. Median, 20th and 80th percentile. Percent. 1986 Q1 - 2016 Q2.

Figure 2: *Prime rents and prime CRE yield. Median and 20th and 80th percentile, based on the cities with data from and including 1998. Source: CBRE Group*

To create series for implied CRE prices, we follow equation (2) and divide the prime rent by the prime CRE yield.[11] The series for implied CRE prices may be volatile, as they will fluctuate with the prime rent. In practice, it takes time before existing rental agreements expire and are adjusted to the market rent. Therefore, the impact on prices of a change in rents will be lower than what the implied CRE prices suggest. It is also important to have in mind that we only look at the prime segment, which is not necessarily representative of the whole market.

We use data for 10-year government bond yields in each country from the OECD as a proxy for the risk-free interest rate. This variable will not be completely risk-free as it for instance captures government risk and inflation risk. We also include the spread between investment grade rated non-financial enterprises in Europe and government bonds in Germany from Merrill Lynch, see Figure B.1 in the Appendix. This variable is used as a measure of the general risk premium.[12] Both in Chervachidze and Wheaton (2013) and Duca and Ling (2015), the general risk premium is proxied by the spread on investment grade bonds. Ideally, we should have included country-specific risk premiums, but were not able due to data constraints.

From Investment Property Forum (IPF) we have semi-annual data for expected rental growth the next five years (per annum) for around 40 percent of the cities in the sample.[13] Unfortunately, the data from IPF only goes back to the end of 2006. The series for expected rental growth has a correlation of 70 percent with actual rental growth the last four quarters. We have also regressed the IPF series on the last four quarters' rental growth, see Table A.2 in the Appendix. Rental growth the last four quarters explains almost 50

[11]Prime rents and prime CRE yields are smoothed by taking the two-quarter moving average.

[12]Investment grade bonds with a rating above BBB- issued by non-financial enterprises with maturity of 7 to 10 years. Each bond has an option-adjusted spread (OAS) against the relevant government bond issued by Germany. A bond with 8 years to maturity will have an OAS against 8-year German government bonds.

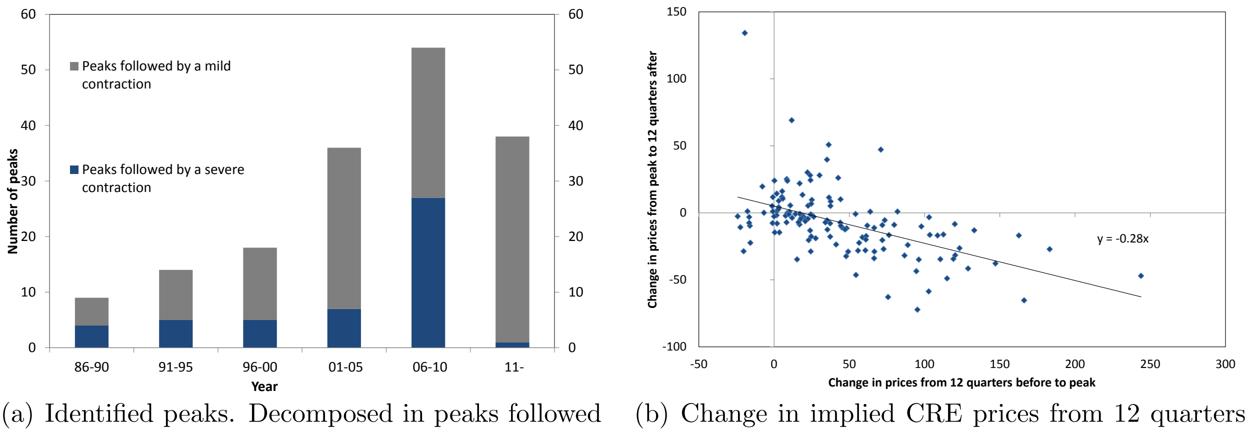
[13]Quarterly data is estimated by linear interpolation.

percent of the variation in the IPF series. The adjusted R^2 only increases marginally when we include lags of the independent variable and city-specific effects. This indicates that the market participants form their expectations of future rental growth adaptively. Some studies on US data also find evidence of adaptively formed expectations for future rental growth, e.g. Sivitanides et al. (2001) and Chervachidze and Wheaton (2013). In the analysis, we will use average rental growth over the last four quarters as a proxy for expected rental growth in the near term.

Developments in employment is used as a proxy for the change in demand for offices. We use quarterly data from the OECD for total employment at the national level. From CBRE we have data for the total office stock, measured in square metres, for 33 of the cities. The total stock covers the supply of office space in the whole city, not only the prime segment. The starting dates for most of the cites are from 2000 onwards, see Table A.3 in the Appendix for an overview.

5 What has driven CRE prices before and after turning points?

We identify turning points by using a version of the algorithm set out in Bry and Boschan (1971) (see Harding and Pagan (2002)). The method identifies turning points in a cycle and divides the sample into an expansionary phase (from a local trough to a local peak) and a contractionary phase (from a local peak to a local trough).[14]



(a) Identified peaks. Decomposed in peaks followed by a severe and a mild contraction.

(b) Change in implied CRE prices from 12 quarters before to peak and from peak to 12 quarters after. Percent

Figure 3: *Peaks from 1980 to 2016 and change in CRE prices before and after peaks. Source: CBRE Group and Norges Bank*

[14]A contractionary phase is defined as a decline for at least two consecutive quarters. We impose the criterion that the complete cycle (expansion plus contraction) must be a minimum of 5 quarters. For an illustration, see Figure B.2 in the Appendix.

We divide the identified turning points into severe and mild contractions. A contraction is classified as severe if the fall in implied CRE prices from peak to trough exceeds 20 percent. Otherwise, it is classified as a mild contraction.

We identify a total of 169 turning points, of which 49 are characterised by a severe contraction in CRE prices.[15] The turning points are heavily skewed towards the latter part of the sample, see Figure 3a.[16] This is partly due to the data collection for many cities commencing in the 2000s. Of the 49 episodes of severe contractions, 26 coincide with the GFC. Figure 3b shows the correlation between the rise in CRE prices before peaks and the subsequent fall. There is a distinct negative relationship, i.e. episodes with a more pronounced rise in CRE prices were followed by a more substantial fall in prices.

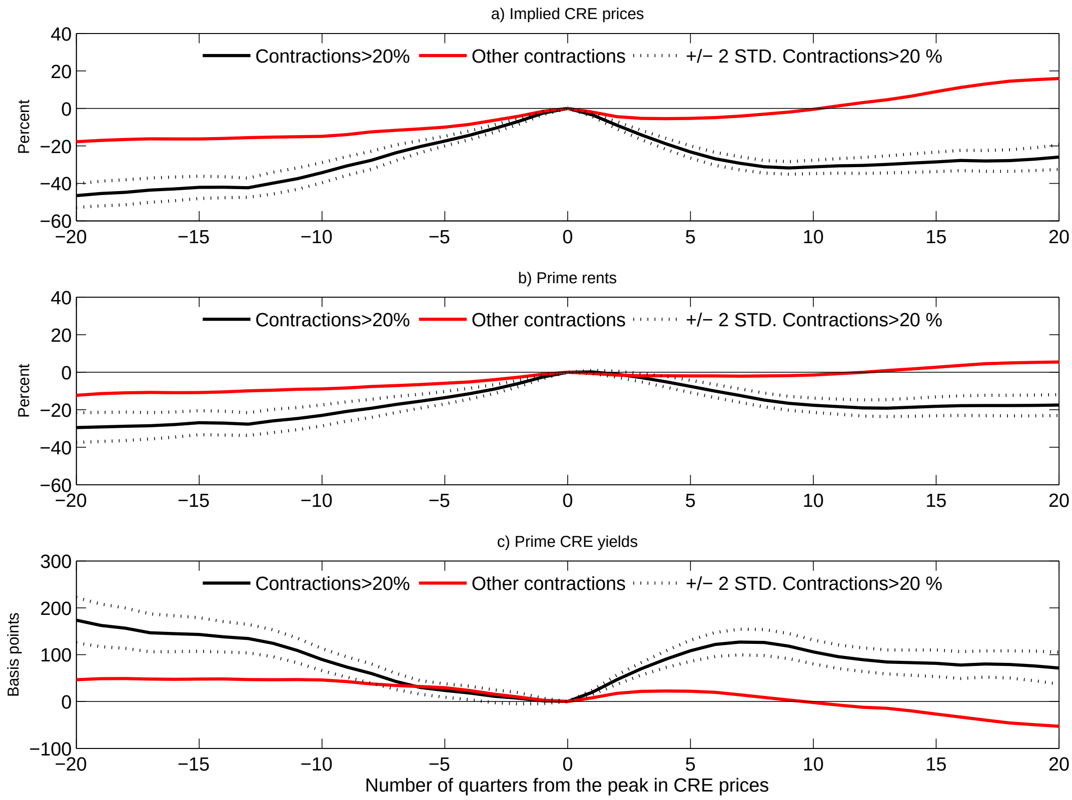


Figure 4: *Average developments in implied CRE prices, rents and CRE yields around turning points.*[1] *The dotted lines show the standard deviation for the average for severe contractions. Implied CRE prices and rents are measured in percent of the level of these variables at the time of the peak in CRE prices, while CRE yields are measured as the difference in basis points. Normalised around turning points to zero. Sources: CBRE Group and Norges Bank*

[1] For some of the episodes the data do not go back to 20 quarters before the identified peak. The average is therefore calculated based on the episodes where data is available at each point in time.

[15] We have removed observations where prices three years before the identified peak were more than 50 percent higher than at the peak. In total, six observations have been removed.

[16] See Table A.4 in the Appendix for a overview of the identified turning points.

In order to analyse what has driven prices upwards before sharp falls, we look at developments in average implied CRE prices, rents and CRE yields 20 quarters before and after all the identified turning points, see Figure 4. Implied CRE prices and rents are measured in percent of the level of these variables at the time of the peak in CRE prices, while CRE yields are measured as the difference in basis points.

Figure 4 displays clearly that the average rise in CRE prices and rents and the fall in CRE yields were significantly higher for peaks followed by a severe than a mild contraction. For severe contractions, CRE prices 20 quarters preceding the turning points were on average around 46 percent lower compared with their peak level, while rents were approximately 30 percent lower, see black lines in Figure 4a and b. This implies that CRE prices on average increased by 85 percent and rents by 40 percent.[17] The difference between the increase in CRE prices and rents implies a decline in the CRE yield. The CRE yield fell on average by around 170 basis points, see Figure 4c. In the contraction phase, it appears that the CRE prices first fell as a result of higher CRE yields and later also as a result of lower rents.

Prior to episodes of mild contractions, CRE prices 20 quarters before the turning points were on average 18 percent lower than at their peak level and rents 12 percent lower, see red lines in Figure 4a and b.[18] CRE yields fell on average by around 45 basis points during the expansion phase, see Figure 4c.

5.1 Rent- and yield-driven peaks

In order to get a better overview of what has driven CRE prices prior to turning points, we define each peak as either rent- or yield-driven. A turning point is defined as rent(yield) driven if more than 50 percent of the growth in the implied CRE prices in the expansion phase has been caused by changes in rents (yields).[19]

Table 1: Number of turning points divided into main driver behind the expansions in CRE prices.

Turning points	1980-2003	2004- [1]	Full sample
Yield-driven	19[5]	71[23]	90[28]
Rental growth-driven	52[16]	27[5]	79[21]
Total	71[21]	98[28]	169[49]

Notes: Contractions above 20 percent in brackets
[1] Includes all turning points identified from 2004 onwards.

[17]For example, if CRE prices were 55 and peaked at 100, the increase in percent will equal 80, while compared with its peak level the CRE price was 45 percent lower.

[18]This implies an increase in CRE prices of 22 percent and in rents of 14 percent.

[19]First, we find the lowest value for the CRE price from 20 quarters before the peak to the peak and calculate the total increase in percent. Second, we calculate how much rents increased in the same period. Third, we divide the increase in rent in percent by the increase in CRE price in percent. A peak is defined as rent-driven if the ratio exceeds 50 percent, otherwise it is classified as yield-driven.

Of all the turning points identified in the sample, the number of yield- and rent-driven expansions has been roughly the same, see Table 1. However, the distribution across time differs substantially. Around three out of four turning points were rent-driven in the period 1980 to 2003 (that is excluding the GFC), compared with approximately one out of four in the period 2004 to 2016 (including the GFC). We get roughly the same distribution if we only focus on turning points followed by a severe contraction.

The main driver of the rise in CRE prices before peaks seems to have shifted in the middle of the 2000s from rent towards yield. We therefore divide our sample into turning points prior to 2004 and turning points from 2004 onwards.

5.2 Turning points from 1980 to 2003 and from 2004 to 2016 followed by a severe contraction

Figure 5 shows the average behaviour of CRE prices, rents and CRE yields around turning points prior to and from 2004 that were followed by a severe contraction. We clearly see that the cause of the rise in CRE prices differs in the two time periods. On average, the rise in rents was significantly higher and the drop in CRE yields significantly lower for peaks in the period 1980-2003 than peaks in the period 2004-2016.

For severe contractions prior to 2004, implied CRE prices were mainly driven upwards by booming rents preceding the peak, see black lines in Figure 5a and b. Implied CRE prices 20 quarters preceding the turning point were on average around 56 percent lower compared with their peak level and rents were around 52 percent lower. This implies that CRE prices increased on average by around 130 percent while rents increased by 110 percent. There was also some decline in CRE yields. In the contraction phase, implied CRE prices fell in the short run mainly due to higher CRE yields. Rents fell gradually and were from around a year and a half onwards the main cause of the contraction in CRE prices. The substantial increase in rents may have led to higher building activity. CRE is characterised by a low elasticity of supply; it often takes between two and six years to complete a building (see European Systemic Risk Board(ESRB) (2015)). There is a risk that the demand for office space will be lower when the buildings are completed, leading to oversupply and falling rents. Unfortunately, we do not have sufficient data on building activity before 2004 to see if activity picked up along with higher rents. However, in subsection 5.3 we will analyse how factors affecting demand varied around the turning points.

When we focus on severe contractions in the period 2004-2016, the increase in implied CRE prices preceding the peaks was mainly driven by a decline in CRE yields, see red lines in Figure 5 a,b and c. Higher rents also contributed to some extent to the increase in CRE prices. On average, CRE prices were around 41 percent lower 20 quarters before the turning point compared with their peak level and rents 17 percent lower. This implies an average increase in CRE prices of almost 70 percent and in rents of 20 percent.[20] CRE yields declined by over 200 basis points. The fall in yields might have been caused by

[20]Implied CRE prices increased by 70 percent (41/(100-41) and rents by around 20 percent (17/(100-17)).

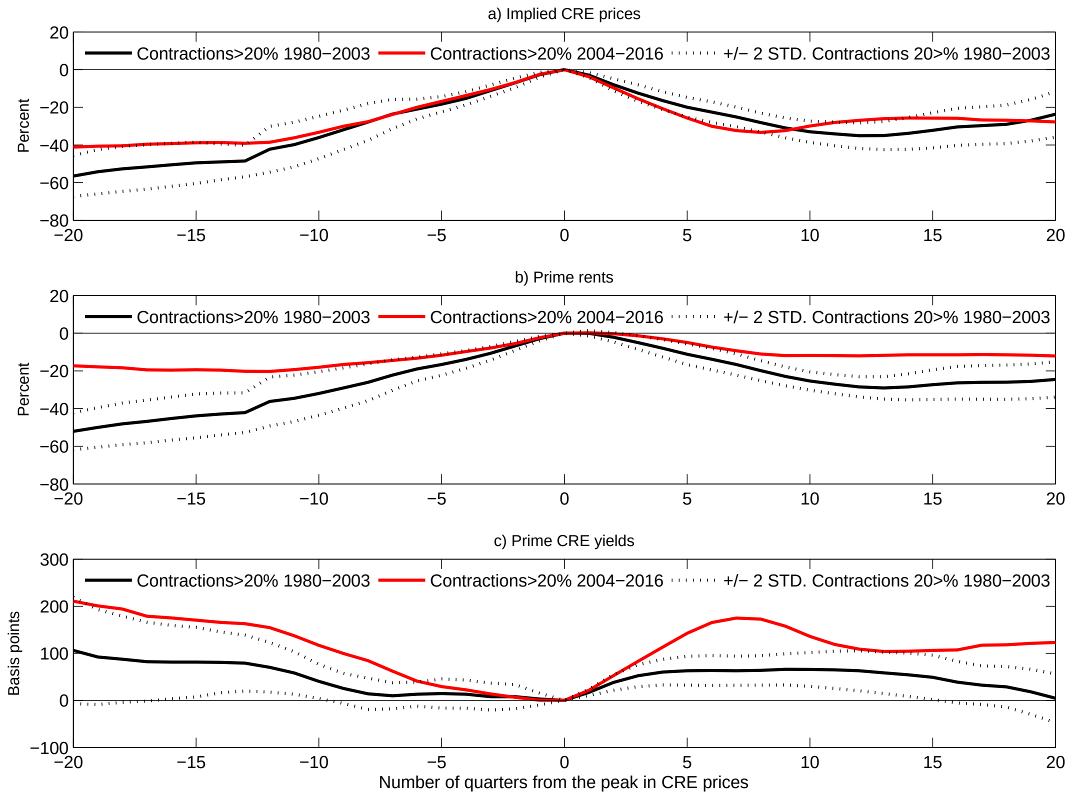


Figure 5: *Severe contractions in the period 1980-2003 and in the period 2004-2016. Average developments in implied CRE prices, rents and CRE yields around turning points.*[1] *The dotted lines show the standard deviation for the average for contractions before 2004. Implied CRE prices and rents are measured in percent of the level of these variables at the time of the peak in CRE prices, while CRE yields are measured as the difference in basis points. Normalised. Turning points = 0. Sources: CBRE Group and Norges Bank*

[1] For some of the episodes the data do not go back to 20 quarters before the identified peak. The average is therefore calculated based on the episodes where data is available at each point in time.

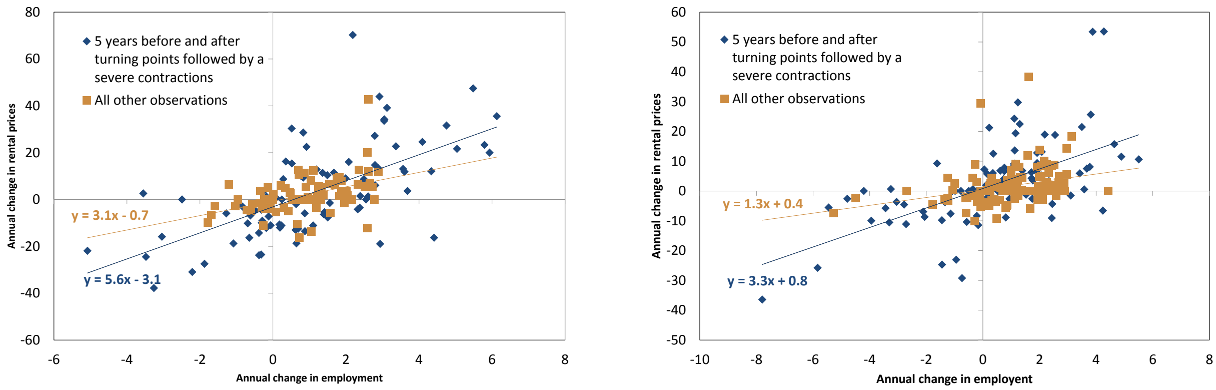
the risk-free rate, risk premium, expected growth in rents or other factors, see equation (5). We will analyse what caused yields to fall before turning points from 2004 onwards in subsection 5.4.

5.3 Potential drivers behind the rise and fall in rents around turning points

Almost all of the expansions in CRE prices before peaks in the period 1980 to 2003 were driven by booming rents. High growth in rents also contributed to some extent to the rise in CRE prices before peaks in the period 2004-2016.

Rents should be determined by the demand and supply of office space.[21] Demand will among other things be influenced by employment.[22] When employment increases, firms will typically need more space and the demand for office space will rise as a result, pushing up rents. In this part of the analysis, we use national employment along with rents for only the capitals, as the capital is often the city with the highest population in the country and therefore developments in national employment as likely more representative for the capital than other cities.[23]

As expected, there has historically been a clear positive correlation between the annual rise in rents in capitals and national employment, see Figure 6a and b.[24] The correlation between rents and employment seems to have been somewhat higher between 1980 and 2003 compared with 2004 to 2016. Further, we look at observations 20 quarters before and after turning points followed by a severe contraction and all other observations.[25] Our results show that the correlation is clearly stronger around turning points followed by a severe contraction, see blue versus grey squares in Figure 6a and b. The correlation is especially strong for turning points between 1980 and 2003, where rents also showed substantial fluctuations.



(a) In the period 1980-2003. (b) In the period 2004-2016.

Figure 6: *Rents in capitals and employment at the national level. Annual change. Source: CBRE Group, OECD and Norges Bank*

Further, we compare four-quarter growth in employment 20 quarters before and after all the identified turning points followed by severe and mild contractions, in both of the pe-

[21]CRE yields will also be affected by the balance in the office space market through the estimated future growth rate in rents, see equation (5). For example, expectations of increased supply the coming years can put downward pressure on current rents and upward pressure on CRE yields through reduced expectations of rental growth.

[22]Demand will also depend on factors such as expectations regarding future developments in employment and long-term structural factors such as changes in office space per worker.

[23]The OECD also have data for employment at the city level. However, the time series are only annual from 2000. We have chosen to use employment data at the national level since they cover a longer time span and have higher frequency.

[24]We have also looked at the correlation between implied CRE prices and employment and CRE yields and employment. There is a clear positive correlation between the annual change in implied CRE prices and employment. We also find a negative correlation between CRE yields and employment.

[25]Also includes observations not within 20 quarters from identified turning points.

riods 1980-2003 and 2004-2016. Our results indicate that employment growth on average was somewhat higher before and lower after identified turning points followed by a severe contraction, see Figure 7a and b. More pronounced fluctuations in employment may have contributed to the substantial increase and fall in rents.[26]

Higher rents should make it more profitable to increase building activity. We have data for the total office space in square metres for a fairly large share of the cities, but the time series are relatively short.[27] Unfortunately, we do not have enough data to analyse developments in building activity for turning points in the period 1980-2003, when we saw large fluctuations in rents. We will therefore focus on turning points from 2004 onwards, where we have data for developments in office space for around 40 percent of the turning points.[28]

We find that building activity was on average somewhat higher around peaks followed by a severe than those followed by a mild contraction, see Figure 7c.[29] A stronger rise in rents and CRE prices before severe contractions may have contributed to increased building activity.

[26]Before 2004, we identify in total 28 turning points, of which 11 were followed by a severe contraction. From 2004 onwards, we identify in total 33 turning points, of which 13 were followed by a severe contraction. Developments in average rents, CRE yields and CRE prices, both for identified severe contractions before and from 2004, are broadly in line with Figure 5, which includes all cities, not only the capitals.

[27]See Table A.3 in the Appendix for start and end date for all the cities.

[28]We only include cities with total office space above 1 million square metres. We have removed the cities where we have detected a likely break in the series.

[29]Developments in prices, rents and CRE yields in Figure 7 are similar to those in Figure 5, where we look at identified contractions from 2004, not only those where we have data for developments in the stock of offices.

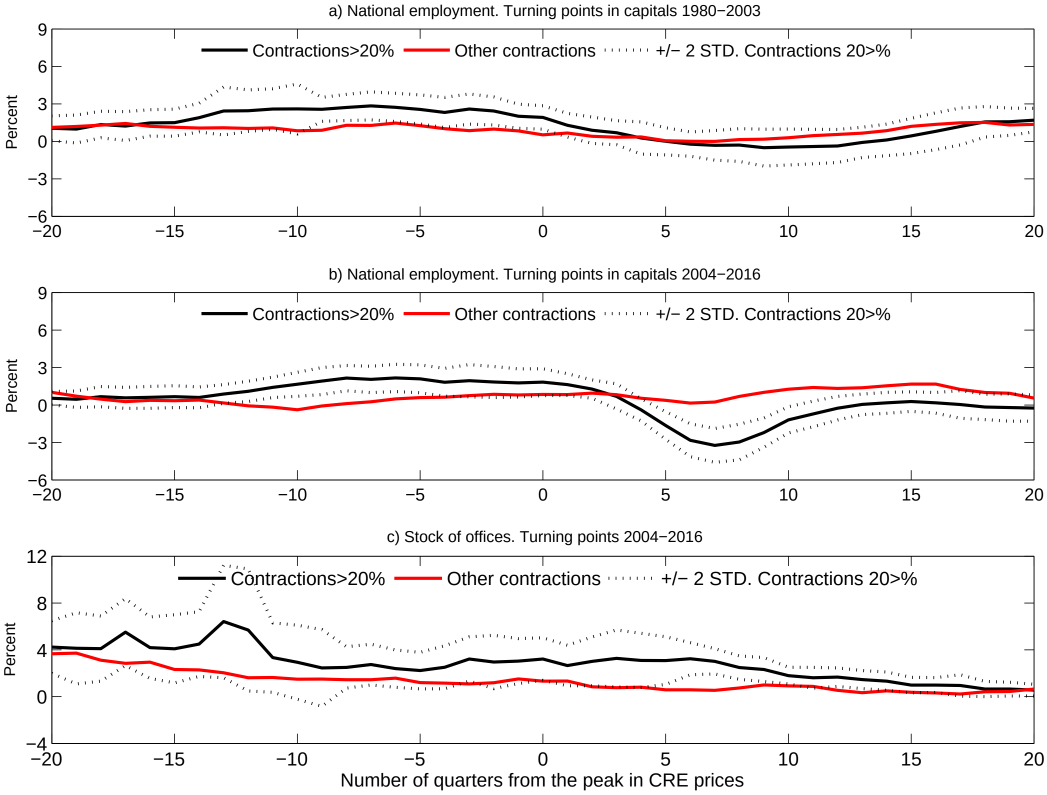


Figure 7: *Average developments in employment and construction around turning points.*[1] *Standard deviation calculated around the average for severe contractions. Four-quarter growth. Sources: CBRE Group, OECD and Norges Bank*

[1] For some of the episodes the data do not go back to 20 quarters before the identified peak. The average is therefore calculated based on the episodes where data is available at each point in time.

5.4 What drove the fall in CRE yields before turning points in the period 2004-2016?

In theory, the CRE yield should depend on variables such as the risk-free interest rate, risk premium and expected rental growth, see equation (5). We expect that the CRE yield increases with a higher risk-free interest rate or risk premium, while it declines if expected rental growth increases. Table 2 displays the data we use to proxy these variables in the analyses in this section.

Table 2: Main variables used in specification.

Variable	Description	Source
$Y_{i,t}$	**CRE yield**. See Table A.1 in the Appendix for an overview of the start date for the different cities.	CBRE
$r^f_{i,t}$	**10-year interest rate on government bonds** in each country. Nominal. For most of the countries the data goes further back than the CRE yield.	OECD
r^p_t	**Spread investment grade bonds** calculated as the spread between investment grade rated non-financial enterprises in Europe and government bonds in Germany with maturity of 7 to 10 years. Each bond has an option-adjusted spread against the relevant government bond issued by Germany. The series start in 2000 Q1. This variable does not vary across the panel, only over time.	Merrill Lynch
$E_{i,t}(\overline{g_{i,t+5}})$	**Annual expected rental growth the next five years**. This data covers around 40 percent of the cities. For the majority of the cities the data starts in 2006 Q4.	IPF
$g_{i,t}$	**Rental growth last four quarters**. This variable is used as a proxy for expected rental growth, as this series is highly correlated with the series from IPF, and also explains most of the variation in the IPF series, see regression results in Table A.2 in the Appendix. The data starts four quarters after the CRE yield.	CBRE

Figure 8 displays how CRE yields, the 10-year interest rate on government bonds, the spread on investment grade bonds and average rental growth the last four quarters developed around turning points in the period 2004-2016. The 10-year interest rates on government bonds and the spread on investment grade bonds were both relatively stable in the periods prior to turning points followed by a severe contraction in CRE prices, see Figure 8b and c. This indicates that other factors drove the decline in CRE yields. For severe contractions, rental growth the last four quarters increased quite substantially preceding the peak and may explain some of the reduction in CRE yields. On average, four-quarter growth in rents was -3 percent 20 quarters before the peak, while at the peak four-quarter growth was 12 percent. Hence, four-quarter growth increased by around 15 percentage points, see Figure 8d.

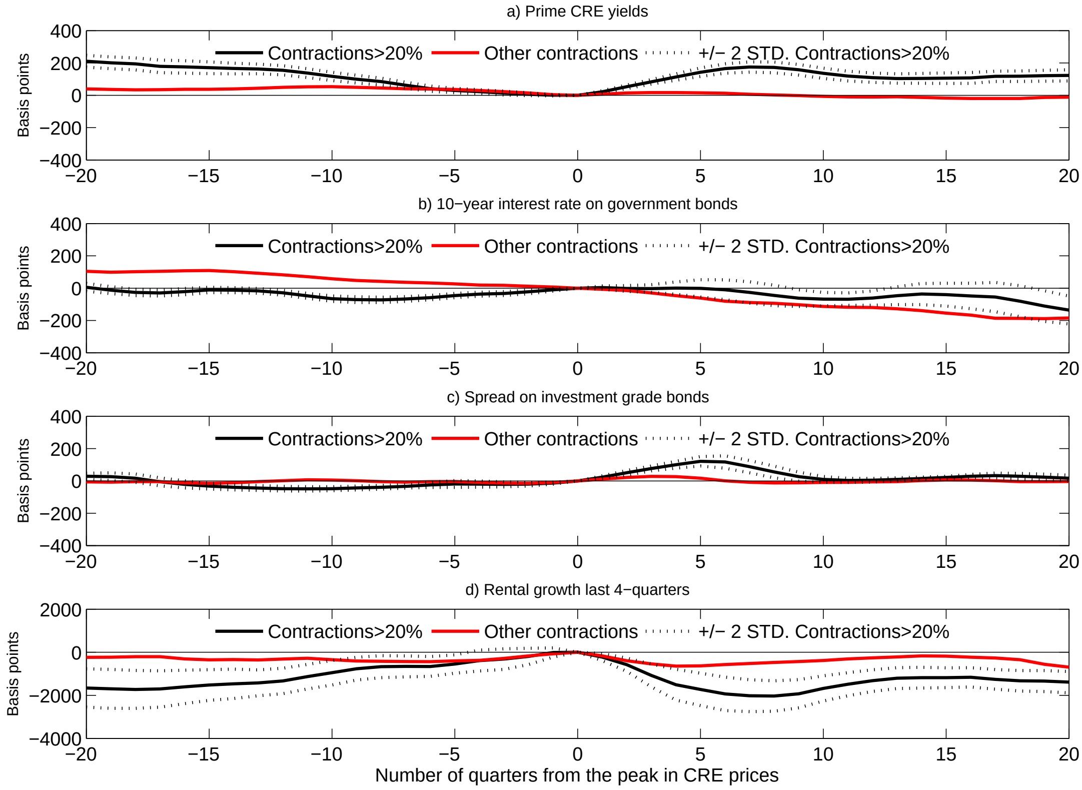


Figure 8: *Average developments in CRE yields, long-term interest rates, spread on investment grade bonds and rental growth last four quarters around turning points in the period 2004-2016.*[1] *The dotted lines show the standard deviation for the average. All variables measured as the difference in basis points between the levels of these variables at the time of the peak in CRE prices. Normalised. Turning points = 0. Sources: CBRE Group, OECD and Norges Bank*

[1] For some of the episodes the data do not go back to 20 quarters before the identified peak. The average is therefore calculated based on the episodes where data is available at each point in time.

Even though theory suggests that CRE yields are driven by the variables in Table 2, this might not necessarily be the case. We therefore run some simple regressions to test empirically whether these variables have the expected impact on the CRE yield. Our regression specification is the following:

$$y_{i,j,t} = \beta_1 r^f_{j,t} + \beta_2 r^p_t + \beta_3 g_{i,j,t} + \gamma_i + \tau_s + \epsilon_{i,j,t} \tag{6}$$

where i indexes the city, j denotes the country, t is year-quarter, s denotes the year. $y_{i,j,t}$ is the CRE yield for city i belonging to country j in year-quarter t. $r^f_{j,t}$ is the 10-year government bond yield for country j and r^p_t is the spread on investment grade bonds and does not exhibit cross-sectional variation, only variation over time. $g_{i,j,t}$ measures average rental growth over the last four quarters for city i in country j at time t, which serves as a proxy for expected rise in rents. Finally, γ_i are city-fixed effects and τ_s are year-fixed effects, and $\epsilon_{i,j,t}$ is the error term for city i in country j at time t. Table 2 gives a detailed description of the variables used in the regressions.

Over long time periods, there are theoretical reasons to expect that the variables in equation (6) are stationary, *I(0)*. However in our sample, there is evidence that both the CRE yield and the 10-year government bond yield contain a unit root and that they are integrated of order one, *I(1)*. It is well known that standard inference theory in general ceases to be valid if the data are non-stationary (see Granger and Newbold (1974)). However, if a linear combination of *I(1)* series is stationary, the series is said to be cointegrated, see Engle and Granger (1987)). This implies that there is a long-run relationship between the variables and it also means that valid inference can be conducted. For this reason, we have tested for cointegration between the CRE yield and the fundamentals. We perform the test both including and excluding the spread on investment grade bonds, as we only have data from 2000 and onwards for this variable. In our case, we assume similar slope coefficients for all units in the panel. For this reason, we apply the approach developed by Kao (1999), which tests the null of no cointegration against the alternative that all units are cointegrated with the same cointegration coefficients. Both when excluding and including the spread on investment grade bonds, we strongly reject the null hypothesis of no cointegration among the series, see Table A.5 and A.6 in the Appendix. Hence, we conclude that the series are cointegrated and therefore that our results are not spurious.

Table 3 displays the results. We also report the p-value from a test for stationarity of the residuals (labeled "Stationarity test (p-value)" in the table). It is evident that this test corroborates the cointegration tests, suggesting that there exists a cointegrating relationship between the CRE yield and the independent variables.

We find that all the explanatory variables have a significant effect on the CRE yield. The sign of the coefficients for the 10-year government bond rates and spread on investment grade bonds are positive as expected, but considerably lower than one.[30] Studies on US data have also found a coefficient for the 10-year government bond below one, see for example Sivitanides et al. (2001) and Clayton et al. (2009). The coefficient for average rental growth over the last four quarters is estimated to be negative, which may indicate that market participants form their expectations adaptively.

For a subset of the cities, we have data from IPF for expected rise in rents from 2006, see Regression (4). The coefficients of the 10-year government bond and the spread on investment grade bonds are virtually unaffected when the series from IPF is replaced with average rental growth over the last four quarters for the same subset, see Regression (5). The adjusted R^2 increases substantially when we include city- and year-specific dummies.

[30] Historically, a significant proportion of the variation in CRE yields has been driven by the long-term interest rates.

Table 3: Regression results.[1]

	(1) Yield (percent)	(2) Yield (percent)	(3) Yield (percent)	(4) Yield (percent)	(5) Yield (percent)
10-year interest rate gov. bonds	0.198***	0.356***	0.211***	0.152**	0.154***
	(22.07)	(30.36)	(4.13)	(3.56)	(4.09)
Rental growth last four quarters	-0.0237***	-0.0286***	-0.0161***		-0.0173***
	(-12.82)	(-15.14)	(-7.65)		(-4.93)
Spread investment grade bonds		0.114**	0.179***	0.176***	0.169***
		(3.28)	(5.47)	(4.38)	(4.21)
Expected rental growth (IPF)				-0.114***	
				(-7.25)	
City	No	No	Yes	Yes	Yes
Year	No	No	Yes	Yes	Yes
Adjusted R^2	0.222	0.305	0.802	0.877	0.874
P-value[2]	0.00	0.00	0.00	0.00	0.00
Observations	4183	3115	3115	913	913

[1] Heteroscedasticity robust standard errors in Regression (1). Cluster-robust standard errors on city in Regression (2), (3) and (4).

[2] Unit-root test of the residual based on an ADF-test. H_0: All panels contain unit roots. H_A: At least one panel is stationary.

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We want to decompose the share of the reduction in CRE yields which can be explained by the fundamentals, i.e. the 10-year interest rates on government bonds, the spread on investment grade bonds and rental growth over the last four quarters. To decompose CRE yields, we use the estimated coefficients from Regression (3) and the change in each variable from the peak:

$$\triangle_h y_{h+p} = \frac{\sum_{n=1}^{P} \hat{\beta}_1 \triangle_h r^f_{j,h+p} + \hat{\beta}_2 \triangle_h r^p_{h+p} + \hat{\beta}_3 \triangle_h g_{i,j,h+p} + \triangle_h \hat{\tau}_{h+p} + \triangle_h \hat{\epsilon}_{i,j,h+p}}{P} \quad (7)$$

where subscript p denotes the time of each peak and h is the number of quarters from the peak and takes values from -20 to 20. P is the number of peaks followed by a severe contraction in the period 2004-2016, which in total was 28. For every peak the change in the explanatory variables from h quarters before/after to the peak is simply multiplied by the estimated coefficient.[31] Finally, we take the average across all peaks by dividing by the number of peaks.

[31] For example, on average the interest rate on 10-year government bonds three years before the peak was around 30 basis points lower than at the turning point. By multiplying 30 basis points by the estimated coefficient of 0.2, we find that the interest rate contributed to an increase in CRE yields of six basis points from three years before to the peak.

Figure 9 displays the decomposition of the change in CRE yields. Average rental growth over the last four quarters contributed to some of the compression in CRE yields before the turning points. The 10-year interest rates on government bonds and the spread on investment grade bonds only explain a marginal part as they were both relatively stable around the turning points. However, a substantial part of the variation was driven by the time dummies. Over 90 percent of the turning points followed by a severe contraction were in 2007 and 2008. This indicates that there was a global downward trend in CRE yields in the years preceding the GFC. Still, a considerable share of the variation in CRE yields is left unexplained (see yellow area in Figure 9). The reduction in CRE yields caused by the residual and the time dummies has likely been driven by a change in omitted variables such as access to credit, capital requirements, expected long-run rent growth rates and CRE specific risk premiums.

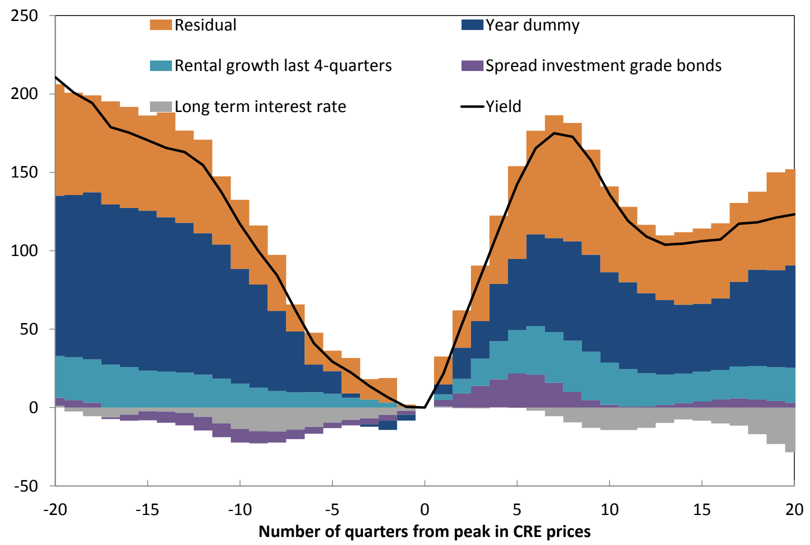


Figure 9: *Decomposition of average CRE yields based on Regression (3) in Table 3. The yield is decomposed into a long-term interest rate, the spread on investment grade bonds, rental growth over the last four quarters, year dummies and a residual. Only turning points in the period 2004-2016 that were followed by a severe contraction. Yields measured as the difference in basis points between the levels of the yields at the time of the peak in CRE prices. Normalised. Turning points = 0. Sources: CBRE Group, OECD and Norges Bank*

6 Conclusion

Our results show that rents were the main driver behind the increases in CRE prices before peaks in the period 1980-2003. As from 2004, we find that a decline in CRE yields has been the primary driver. The decline in CRE yields before peaks can partly be explained by a general downward trend in CRE yields in Europe before the GFC. A significant part of the decline is still left unexplained after also controlling for factors such as the risk-free rate, risk premium and city-specific effects. The reduction in CRE yields caused by the residual and the time dummies, has likely been driven by a change in omitted variables such as access to credit, capital requirements, expected long-run rent growth rates and CRE specific risk premiums.

CRE prices are currently surging as long-term interest rates have continued to fall. Historically, the fall in CRE yields has for most episodes far exceeded the drop in long-term interest rates. This indicates that reduced long-term interest rates have seldom been the main driver behind the increase in prices before severe contractions. However, as long-term interest rates and CRE yields are at record-low levels, a negative shock to interest rates, risk premiums or demand for office space, could potentially lead to a severe contraction in CRE prices.

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Appendix A: Tables

Table A.1: Start and end date for prime rents, CRE yields and CRE prices

City	Start date	End date
Aarhus	2005Q4	2016Q2
Aberdeen	2010Q3	2016Q2
Amsterdam	1985Q2	2016Q2
Barcelona	1988Q4	2016Q2
Belfast	2004Q1	2016Q2
Berlin	1999Q4	2016Q2
Bratislava	2004Q1	2016Q2
Bristol	1980Q2	2016Q2
Budapest	2001Q4	2016Q2
Cardiff	1980Q2	2015Q3
Cologne	2000Q1	2016Q2
Copenhagen	1995Q4	2016Q2
Dublin	1997Q4	2016Q2
Dusseldorf	2000Q4	2016Q2
Edinburgh	1980Q2	2016Q2
Frankfurt	1985Q2	2016Q2
Geneva	1994Q4	2016Q2
Glasgow	1980Q2	2016Q2
Gothenburg	2003Q4	2016Q2
Hamburg	1999Q4	2016Q2
Helsinki	1999Q4	2016Q2
Katowice	2008Q2	2016Q2
Krakow	2008Q2	2016Q2
Leeds	1980Q2	2016Q2
Lille	1998Q4	2016Q2
Lisbon	1985Q2	2016Q2
Liverpool	1980Q2	2016Q2
Lodz	2008Q2	2016Q2
London	1984Q1	2016Q2
Lublin	2014Q2	2016Q2
Luxembourg	2006Q4	2016Q2
Lyon	1998Q4	2016Q2
Madrid	1985Q2	2016Q2
Malaga	2004Q1	2016Q2
Malmo	2012Q3	2016Q2
Manchester	1980Q2	2016Q2
Marseille	1998Q4	2016Q2
Milan	1985Q2	2016Q2

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Table A.1 – continued

City	Start date	End date
Munich	1999Q4	2016Q2
Nice	2010Q2	2016Q2
Oslo	1994Q4	2016Q2
PalmaDeMallorca	2004Q1	2016Q2
Paris	1989Q4	2016Q2
Poznan	2008Q2	2016Q2
Prague	1993Q4	2016Q2
Rome	2001Q1	2016Q2
Rotterdam	1995Q3	2016Q2
Southampton	2010Q2	2016Q2
Stockholm	1999Q4	2016Q2
Szczecin	2010Q1	2016Q2
Tampere	2005Q1	2015Q4
TheHague	1995Q3	2016Q2
Utrecht	1995Q3	2016Q2
Valencia	2004Q1	2016Q2
Vienna	1991Q4	2016Q2
Warsaw	1995Q4	2016Q2
Wroclaw	2008Q2	2016Q2
Zurich	1994Q4	2016Q2

Table A.2: Annual expected rental growth next five years (IPF), regressed on the last four quarters rental growth

	(1) IPF	(2) IPF	(3) IPF	(4) IPF
Rental growth last four quarters	0.142***	0.141***	0.109***	0.105***
	(15.32)	(8.91)	(5.85)	(4.88)
L.Rental growth last four quarters			0.0459*	0.0475***
			(2.19)	(4.67)
L2.Rental growth last four quarters			0.0175	0.0193**
			(0.86)	(2.96)
L3.Rental growth last four quarters			-0.0322	-0.0327***
			(-1.60)	(-4.09)
L4.Rental growth last four quarters			-0.0228	-0.0266
			(-1.62)	(-1.68)
City	No	Yes	No	Yes
Adjusted R^2	0.472	0.521	0.499	0.552
Observations	913	913	913	913

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.3: Start and end date for total office space. Cities with total office space below 1 million square metres are not included in the analyses.

City	Start date	End date
Aarhus	No data for total office space	
Aberdeen	No data for total office space	
Amsterdam	2007Q4	2016Q2
Barcelona	1994Q4	2016Q2
Belfast	Office space below 1 million square metres	
Berlin	2000Q4	2016Q2
Bratislava	Not included in the analysis due to possible break in the series.	
Bristol	Office space below 1 million square metres	
Budapest	Not included in the analysis due to possible break in the series.	
Cardiff	No data for total office space	
Cologne	No data for total office space	
Copenhagen	2002Q4	2016Q1
Dublin	2003Q3	2016Q2
Dusseldorf	1999Q4	2016Q2
Edinburgh	2009Q3	2016Q2
Frankfurt	1998Q4	2016Q2
Geneva	2005Q4	2016Q2
Glasgow	2009Q3	2016Q2
Gothenburg	2005Q4	2016Q2
Hamburg	2002Q4	2016Q2
Helsinki	2000Q4	2016Q2
Katowice	Office space below 1 million square metres	
Krakow	Office space below 1 million square metres	
Leeds	No data for total office space	
Lille	Not included in the analysis due to possible break in the series.	
Lisbon	2003Q4	2016Q2
Liverpool	Office space below 1 million square metres	
Lodz	Office space below 1 million square metres	
London	1984Q4	2016Q2
Lublin	2011Q2	2016Q2
Luxembourg	2014Q4	2016Q1
Lyon	Not included in the analysis due to possible break in the series.	
Madrid	1994Q4	2016Q2
Malaga	No data for total office space	
Malmo	2012Q3	2016Q2
Manchester	2009Q3	2016Q2
Marseille	2001Q1	2016Q2
Milan	2000Q4	2016Q2
Munich	2000Q1	2016Q2
Nice	No data for total office space	

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Table A.3 – continued

City	Start date	End date
Oslo	2006Q3	2016Q2
PalmaDeMallorca	No data for total office space	
Paris	1997Q4	2016Q2
Poznan	Office space below 1 million square metres	
Prague	2000Q2	2016Q2
Rome	2004Q4	2016Q2
Rotterdam	2008Q4	2016Q2
Southampton	No data for total office space	
Stockholm	2005Q4	2016Q2
Szczecin	Office space below 1 million square metres	
Tampere	Office space below 1 million square metres	
TheHague	2009Q4	2016Q2
Utrecht	1995Q3	2016Q2
Valencia	No data for total office space	
Vienna	2001Q4	2016Q2
Warsaw	Not included in the analysis due to possible break in the series.	
Wroclaw	Office space below 1 million square metres	
Zurich	Not included in the analysis due to possible break in the series.	

Table A.4: Identified peaks in CRE prices in CRE for European cities. Divided into peaks followed by a mild and a severe contraction.

City	Mild contraction	Severe contraction
Aarhus	2008Q2, 2013Q4	
Aberdeen	2012Q3, 2015Q1	
Amsterdam	1991Q4, 2001Q4, 2003Q1, 2007Q4, 2011Q3	
Barcelona	2001Q2, 2003Q1	1992Q2, 2007Q3
Belfast		2008Q1
Berlin	2008Q1	2001Q2
Bratislava	2012Q3	2007Q4
Bristol	1989Q4, 1991Q1, 1994Q3, 1997Q4, 2003Q1, 2011Q4	2007Q3
Budapest	2012Q1	2008Q1
Cardiff	1990Q4, 1995Q1, 1998Q3, 2000Q2, 2011Q1	2007Q1
Cologne	2005Q4, 2008Q2, 2014Q3	2001Q4
Copenhagen	2002Q1, 2008Q1, 2012Q2	
Dublin		2001Q1, 2007Q4
Dusseldorf	2001Q4, 2005Q2, 2008Q2, 2014Q2	
Edinburgh	1998Q3, 2000Q4, 2003Q3, 2010Q1	1990Q2, 1994Q3, 2007Q3
Frankfurt	2008Q1	1991Q3, 2001Q2
Geneva	2002Q1, 2013Q2	
Glasgow	1990Q2, 1992Q2, 1995Q1, 2010Q2	2007Q2
Gothenburg	2008Q1	
Hamburg	2008Q2	2000Q4
Helsinki	2000Q4	2008Q1
Katowice	2010Q3, 2013Q2	
Krakow	2015Q1	
Leeds	1990Q1, 1997Q3, 2002Q3, 2010Q2	2007Q1
Lille	1999Q3, 2002Q3, 2005Q2, 2008Q2	
Lisbon	2001Q3	1991Q3, 2007Q3, 2010Q2
Liverpool	2010Q3	2003Q4, 2007Q3
Lodz		
London		1989Q3, 2000Q4, 2007Q3
Lublin	2015Q1	
Luxembourg	2007Q4	
Lyon	2000Q4, 2008Q1, 2013Q3	
Madrid		1990Q4, 2001Q2, 2007Q3
Malaga	2006Q2, 2015Q1	2008Q2
Malmo		
Manchester	1990Q1, 1991Q3, 1997Q3, 2000Q3, 2010Q2, 2012Q2	2007Q1
Marseille	2002Q2, 2015Q1	2008Q3
Milan	2002Q3, 2005Q4, 2008Q3, 2011Q4	1991Q2
Munich	2008Q3	2001Q2

Continued on next page

Table A.4 – continued

City	Mild contractions	Severe contractions
Nice	2011Q4, 2013Q4	
Oslo	1998Q2, 2004Q1, 2012Q1	2000Q2, 2008Q1
PalmaDeMallorca		2008Q2
Paris	2001Q2, 2002Q3, 2011Q4, 2013Q1	1990Q4, 2007Q3
Poznan	2015Q2	
Prague	1998Q3, 2001Q3, 2013Q2	2008Q1
Rome	2003Q1, 2008Q4, 2012Q1	
Rotterdam	2007Q3, 2011Q3, 2014Q1	
Southampton		
Stockholm		2000Q4, 2007Q4
Szczecin	2015Q1	2012Q2
Tampere	2009Q1, 2011Q3	
TheHague	2003Q3, 2011Q2	2007Q4
Utrecht	2003Q3, 2007Q3, 2011Q3, 2013Q3	
Valencia		2007Q4
Vienna	1993Q4, 2008Q3	
Warsaw	2002Q4, 2004Q1, 2013Q2	1998Q4, 2008Q3
Wroclaw		
Zurich	1995Q3, 2001Q4, 2003Q1, 2008Q3, 2013Q4	

Table A.5: Testing for a cointegration relationship between the CRE yield and the 10-year government bond yield and four quarter growth in rents.

Kao test for cointegration

Ho: No cointegration		Number of panels =	**58**
Ha: All panels are cointegrated		Avg. number of periods =	**70.121**
Cointegrating vector:	**Same**		
Panel means:	**Included**	Kernel:	**Bartlett**
Time trend:	**Not included**	Lags:	**2.45 (Newey-West)**
AR parameter:	**Same**	Augmented lags:	**1 (AIC)**

	Statistic	p-value
Modified Dickey-Fuller t	**-7.5835**	**0.0000**
Dickey-Fuller t	**-6.5534**	**0.0000**
Augmented Dickey-Fuller t	**-8.3214**	**0.0000**
Unadjusted modified Dickey-Fuller t	**-3.8681**	**0.0001**
Unadjusted Dickey-Fuller t	**-5.3253**	**0.0000**

Table A.6: Testing for a cointegration relationship between the CRE yield and the 10-year government bond yield, spread on investment grade bonds and four quarter growth in rents.[1]

Kao test for cointegration

Ho: No cointegration		Number of panels =	**58**
Ha: All panels are cointegrated		Avg. number of periods =	**51.707**
Cointegrating vector:	**Same**		
Panel means:	**Included**	Kernel:	**Bartlett**
Time trend:	**Not included**	Lags:	**2.24 (Newey-West)**
AR parameter:	**Same**	Augmented lags:	**1 (AIC)**

	Statistic	p-value
Modified Dickey-Fuller t	**-5.1079**	**0.0000**
Dickey-Fuller t	**-3.5707**	**0.0002**
Augmented Dickey-Fuller t	**-6.0048**	**0.0000**
Unadjusted modified Dickey-Fuller t	**-2.5750**	**0.0050**
Unadjusted Dickey-Fuller t	**-2.4262**	**0.0076**

[1] The series for spread on investment grade bonds starts in Q1 2000.

Appendix B: Figures

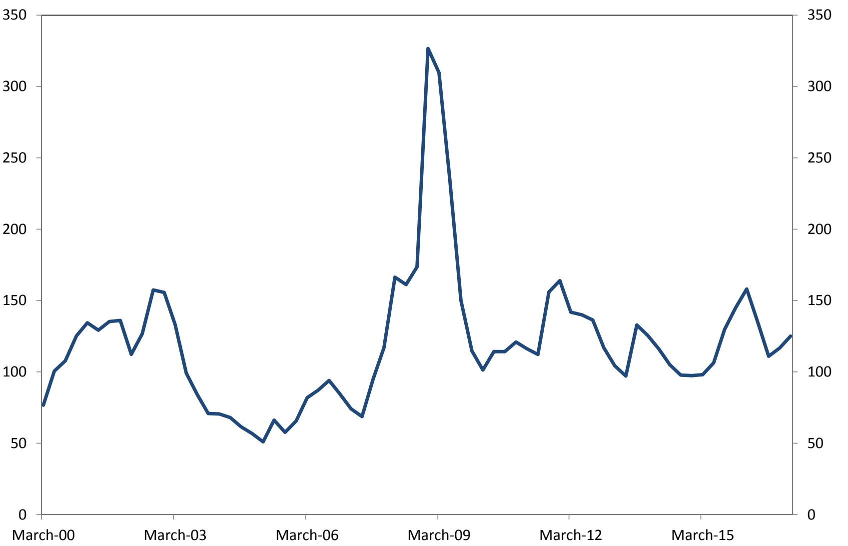

Figure B.1: *Spread between investment grade rated non-financial enterprises in Europe and government bonds in Germany. Basis points. Source: Merrill Lynch*

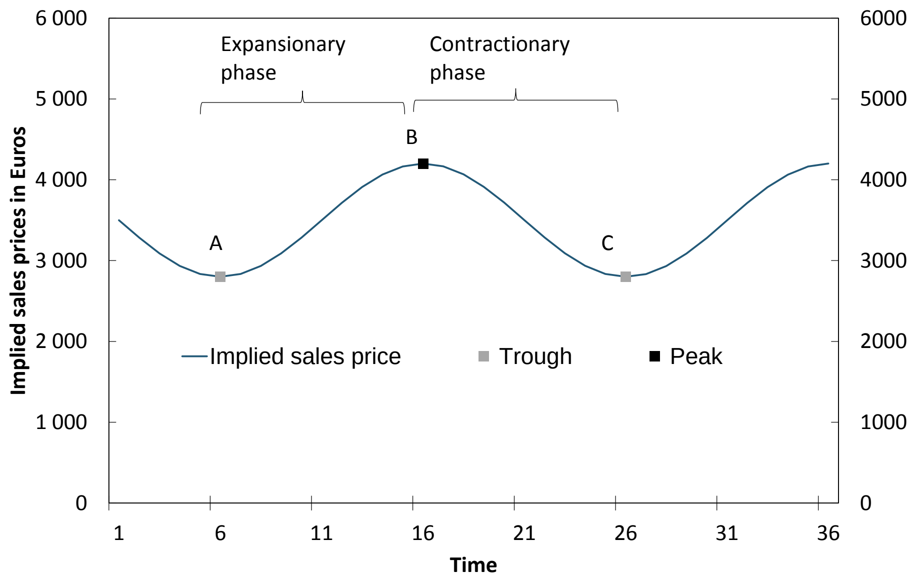

Figure B.2: *Illustration of calculation of expansionary and contractionary phase.*