What drives Contagion in Financial Markets? Liquidity Effects versus Information Spillover

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ABSTRACT

The objective of this paper is to study how contagion works in financial markets by identifying the mechanisms which drive the spillover of shocks from one market to other markets. To address this question we use open-ended property funds (OPFs) as they offer a unique institutional setting which allows to separate between the effects of the two main mechanisms discussed in the contagion literature, i.e. liquidity and information spillover. OPFs are funds that provide daily liquidity (based on the net asset value (NAV) of funds' property) as long as these funds still maintain at least 5% liquidity. If liquidity falls below the 5% threshold, share redemptions will be temporarily suspended for a period of up to two years. During this time, investors can only sell shares on the secondary market (exchange) at significant price discounts compared to the redemption price. This allows us to disentangle the initial price shock into *liquidity risk* and *impending NAV impairment* to study how contagion works in financial markets. In our setting, *liquidity risk* refers to a deterioration of the marketability and trading conditions while *impending NAV impairment* measures the expected write-off potential driven by e.g. a revaluation of the underlying portfolio properties due to worsened economic conditions. We find that that *liquidity risk*, computed by an option-theoretic, upper bound approach formulated in Longstaff (1995), accounts for less than 16 percent of the initial discount but the remaining part comes from *impending NAV impairment*. The fact that the *impending NAV impairment* component of the initial discount significantly affects future write-offs during the suspension period in both an ols- and logit-model confirms the explanatory power of our discount decomposition. Hence we conclude that information spillover is the mayor mechanism by which shocks are transmitted in financial markets.

JEL Classification: G1, G14

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1. Introduction

The collapse of the well-established investment bank Lehman Brothers in September 2008 marked the starting shot for the subsequent US subprime crisis which turned into a global financial crisis. During the past years, markets have suffered catastrophic losses from the ongoing crisis, which was initially triggered by the growing threat of extensive defaults by subprime borrowers in the mortgage markets. Even at the early stages, the markets feared that the subprime crisis might spill over into other sectors of the economy. As the crisis has unfolded, a number of these fears have been realized as large negative shocks have occurred in the housing, equity, municipal bond, real estate and corporate debt markets etc. This development shows quite plainly how contagion can affect global financial markets stemming from a more local crisis (see, for instance, Longstaff (2010)).

The issue of contagion in financial markets is of fundamental importance and there is an extensive literature addressing its causes and effects.[1] The contagion literature identifies two major and possible mechanisms by which shocks in one market may spill over into other markets. The first strand in contagion literature outlines the mechanisms in which negative shocks in one market can be regarded as new economic information which directly affects the underlying value and/or linked cash flows associated with securities in other markets (see, for instance, Kiyotaki and Moore (2002), Kaminsky, Reinhart and Vegh (2003)). In this mechanism, contagion can be viewed as the transmission of information from more liquid markets or markets with more rapid price discovery to other markets (mechanism 1). The second strand by e.g. Allen and Gale, (2000) and Brunnermeier and Pedersen (2005) determines how investors who suffer losses in one market may find their ability to obtain funding impaired, potentially leading to a downward spiral in overall market liquidity and other asset prices via a "flight to quality." In this mechanism, contagion occurs through a

[1] Detailed surveys can be found in Kindleberger (1978), Dornbusch, Park and Claessens (2000), and Kaminsky, Reinhart and Vegh (2003).

liquidity shock across other financial markets. Vayanos (2004), Acharya and Pedersen (2005), and Longstaff (2008) among others extend the argumentation by implying that a negative shock in one market may be associated with an increase in the (liquidity) risk premium in other markets for a reduction in marketability. In this mechanism, contagion occurs as negative returns in the distressed market, which affects subsequent returns in other markets via the time-varying (liquidity) risk premium (mechanism 2).

Our objective in this paper is to analyze how the two types of contagion information spill-over and liquidity risk premium initiated by the crisis in the US subprime segment have affected the price determination in other markets and which source of contagion is the predominant source. A market segment, for which both types of contagion are a major issue, is the open-ended property funds (OPFs) market. OPFs can be regarded as a compromise between direct and listed real estate investments. Fund managers invest directly in an internationally diversified real estate portfolio, while holding a cash-equivalent position ranging from 5 percent to 49 percent of assets under management for daily liquidity. Once the OPF's liquidity falls below 5 percent, the fund must temporarily suspend share redemptions so that investors can no longer redeem their shares at the redemption price (net asset value (NAV) of the portfolio properties plus to the cash/bonds position). Fund managers will then have a maximum of two years to either attract sufficient new asset inflows and/or liquidate portfolio properties to ensure fund liquidity again. During this time, investors can only sell their shares in a secondary market for the exchange price. Actually the share prices in the secondary market quote below the redemption price (discount) during times of temporal suspension of share redemption. If fund managers do not have enough liquidity to reopen within the two-year time limit to restore liquidity again, they have to sell properties within a so called controlled liquidation (even at a loss) to ensure liquidity ("fire-sell") or have to profoundly revalue (depreciate or write-off) portfolio properties due to worsened market conditions where revaluations can take place already during the two years.

As a result, OPF investors are exposed to two types of risk *liquidity risk*, which comes from a worsened marketability of their funds, as well as the *impending NAV impairment* due to revaluations of the property value and uncertain selling prices when share redemptions are temporarily suspended. While *impending NAV impairment* is closely related to mechanism 1 of the contagion literature, *liquidity risk* is related to mechanism 2 of contagion.

Due to the properties of the OPFs funds, the observed discounts are a relevant and interesting object of investigation to figure out the true drivers for a price discount and to decompose it into *liquidity risk* (worsened marketability) and *impending NAV impairment* (information spillover). The beauty of the OPF market is that (i) the underlying asset class, i.e. properties, is closely related to the subprime market which caused the crisis and that (ii) both types of contagion *liquidity risk* (worsened marketability) and *impending NAV impairment* (information spillover) are supposed to have a relevant price impact in this market. In particular, a worsened marketability can be easily observed as it is triggered by a fund's suspension. Due to the structure of the restricted trading opportunities for a given maximum time period, the option-theoretic formula for an upper bound of the liquidity discount proposed by Longstaff (1995) can be applied in a straightforward way (see e.g. Koziol and Sauerbier (2007) for an application to the bond market).

We find that the discount in response to the temporal suspension of share redemption is about 5 percent and that the *liquidity risk* can explain only about 16 percent (or 0.8 percentage points) of the discount and that *impending NAV impairment* or the implied write-off potential is responsible for the remaining major part of the discount. Therefore, a reduction in marketability is not the key driver of the discount. Instead investors may be more concerned about the properness of the reported portfolio property values (NAV) and the threat that OPF management is not able to recover the required liquidity within the two year time limit again to avoid a controlled liquidation. Likewise, we find that the *impending NAV impairment* component of the price discounts can significantly explain which OPF funds have to

depreciate its property values during the time span of the temporal suspension of share redemption. Even if the relations in other markets might be different, the decomposition of the pricing discounts for the considered OPF market is one meaningful starting point and the approach carried out in the paper might be adopted into other markets.

The remainder of this paper is structured as follows. Section 2 introduces the fundamental features of the open-ended property funds market. Section 3 analyzes the capital market reactions triggered by the temporal suspension of share redemption. In section 4, the *liquidity risk* and the *impending NAV impairment* is empirically estimated and its forecast ability is tested. Section 5 summarizes our main results and concludes.

2. The German OPF Market – Fundamental Features

From a legal perspective, an open-ended property fund is a separate special asset, with an investment focus on property initiated and managed by a capital investment company. For investor protection purposes, OPFs fall under the control of regulations for identifying, diversifying, and controlling risks, as well as for realizing gains and for fund liquidity.[2]

Open-ended property funds were first created in 1959 with the establishment of the "Internationales Immobilien Institut" (the international real estate institute, known as iii-investments). The first German OPF was iii-funds No. 1. However, in recent years, the growth of the market has been dramatic. In 1998, there were sixteen OPFs with assets under management of 43.1 billion Euros. As of April 2010, the market had forty-five funds, managing 90 billion Euros. This makes the German OPF market with a market capitalization of about one-third of all European Union member countries the biggest.[3] Table 1 provides an overview of the full sample of all OPFs from 1991 to April 2010.

[2] See Investmentgesetz (InvG) and Klug (2008) for further details.

[3] According to data from the BVI Bundesverband Investment, Asset Management e.V. (German Asset Management and Investment Association), and Deutsche Bundesbank (German Central Bank).

For our analysis, we consider all OPFs that report their data to the "BVI Bundesverband Investment and Asset Management e.V." (the German Asset Management and Investment Association) and are covered by Thomson Financial Datastream. We double checked the prices from BVI for the investments shares with prices obtained from Datastream to test for consistency. 21 pricing differences between BVI and Datastream occurred, for a total accuracy rate of 99.9%. None of the differences exceeded 1% of the stock price. In case of pricing difference we asked the capital investment company for the price. Therefore, the results are not affected from a biased data generating approach.

Table 1: Overview of the German OPF Market
This table shows the number of active OPFs in the German market and the assets under management. Assets under management calculated at year-end. Except for 2010, the reference date is April. The data source is BVI and Thomson Financial Datastream.

Year	Number	In €m
1991	12	9,807
1992	14	13,690
1993	14	21,840
1994	14	25,764
1995	14	29,694
1996	14	37,023
1997	15	40,493
1998	16	43,137
1999	17	50,403
2000	19	47,919
2001	19	55,868
2002	22	71,165
2003	23	85,172
2004	26	87,191
2005	30	85,129
2006	35	75,545
2007	39	83,426
2008	42	84,252
2009	44	87,076
2010	45	90,043

OPFs offer three significant advantages over real estate shares – the following regulatory design is similar to the OPF markets in the European Union member countries:[4]

(1) The OPF share price is *in general* not directly determined by supply and demand – as long as the OPF provides liquidity. Therefore, share prices do not significantly differ from NAV per share reported by the capital investment companies when there is no temporary share redemption (see Figure 2 and A1 in the appendix). This feature is responsible that during times when management accepts share redemptions the OPF returns are quite smooth because there is no additional influence from (equity) capital markets.

(2) The number of outstanding shares varies, which generally ensures high liquidity. As in any investment fund, there is a daily issuance of new shares from buyers and a daily redemption of old shares from sellers.[5]

(3) The rule of risk-spreading governs transactions.[6] This diversification reduces unsystematic risk.

(4) OPFs have to temporarily suspend share redemptions when the fund liquidity is going to fall below the 5%-level.

These specific features of OPFs substantially influence their risk-return profile. In general, portfolio returns are determined by rental income, maintenance costs, and value increases or decreases.[7] Rental income and maintenance costs directly observable; the big challenge is gauging changes in value if comparable properties do not trade regularly. Thus, German investment law (§70 para. 2 sentence 2 InvG) mandates that properties must be evaluated

[4] See, for example, Haß et al. (2010) and Maurer, Reiner, and Rogalla (2004).

[5] Historically, there have been only two periods when share redemptions were temporarily suspended (2005/2006 and 2008/2010). Both are discussed in detail in section 3.

[6] At the time of purchase, one particular property may not constitute more than 15% of the net asset value of the OPF. Furthermore, the total value of all properties with individual values of more than 10% of the fund's net asset value may not constitute more than 50% of the fund's net asset value. See InvG § 73 (1).

[7] More than 55% of the portfolio properties of OPFs have leases with residual terms that extend longer than January 1, 2015. See BVI press release from June 22, 2010.

regularly by an independent appraisal board (at least once a year) to determine the *fair* market price. The appraisal board members must have technical expertise in the area of property market development (§77 para. 2 sentence 1 InvG).

The valuation by-law allows the sales comparison approach, the cost approach, and the income approach for the appraisal of fair market value. The income approach is internationally accepted and is the primary method used to value OPFs. It appraises a property on the basis of objectively evaluated price and income forecasts, as well as dynamic capitalization rates on the valuation date. Therefore, the daily net asset values of OPFs are based on the annual expert appraisals since the last valuation date, but do not necessarily represent "true" daily property values.

This valuation approach aims to minimize subjective views about future expectations[8] and to dampen over- and understatements of property values. However, because past appraisal reports are included in the determination of current net asset values, valuation returns are smoothed, an effect known as "*appraisal-smoothing*".[9,10] And, consequently, the above described valuation process results in an underestimation of OPF risk. Hence, this underestimation is a major part of this paper since OPFs investors have to face a substantial risk when share redemptions are temporarily suspended which is not fully covered by the reported NAVs from the capital investment company.

In principle, OPFs must redeem shares on a daily basis. They thus always maintain a certain level of liquid assets, because property cannot be sold quickly, German investment law requires that OPFs hold a minimum of 5% (and a maximum of 49%) of their assets in cash or easily liquefiable investments (§ 80 InvG). This liquidity reserve, which is typically invested in money market instruments and bonds, theoretically guarantees the redemption of outstanding shares at all times.

[8] See Archner (2006) for an extensive analysis.
[9] See Ross and Zisler (1991) and Geltner (1991) for an extensive discussion.
[10] Other, more secondary, reasons are inflation-linked lease contracts and the consideration of inflation in the appraisal. For further details see Haß et al. (2010).

With daily share redemption, however, comes the risk that investors may redeem too many shares in a too short period, and may render the liquidity position too small to satisfy all the redemptions. If the liquidity reserve falls below the 5% minimum, the redemption of shares in the OPF have to be suspended in order to raise money by e.g. selling property investments and/ or new fund inflows. This temporary suspension may last up to two years (§ 80c para. 2 InvG and § 81 InvG).[11] When OPF management was not successful in restoring liquidity until the end of the time limit they will be forced to sell portfolio properties to ensure liquidity for the investors again (so called controlled liquidation), which can result in high uncertainty about potential selling prices ("fire-sell").

Crises in the real estate markets, which are the main cause of temporary suspensions of share redemptions, often occur after a capital markets crisis. Old rental contracts expire, new contracts yield lower rental income, and past sale prices are no longer realizable. For OPFs, this lagged impact is even more pronounced, because OPF management has an incentive to maintain the (probably) "high valued appraisals" avoiding to report drawdown returns and successively adjust the NAV to market developments. If investors anticipate such a development, it is possible that substantially more shares may be redeemed than issued in a shorter than usual time period. In these cases investors run the risk of a reduction in liquidity when OPF management is forced to temporarily suspend the share redemption.

When OPFs temporarily suspend share redemptions, investors have the option of selling their shares in the secondary market. However, the realized prices in the secondary market do not have to correspond to the redemption prices calculated by the capital investment companies. In fact, they are especially lower in times of redemption suspensions, because of, e.g., uncertainty about the true NAV due to slower value adjustments by management, earnings management, appraisals, and a reduction in liquidity for investors. Therefore, the

[11] By law, a fund may only suspend redemptions for a maximum of twelve months. By contractual agreement, this can be extended to twenty-four months (time limit). Alternatively, management may opt to only partially suspend redemptions, so that shares can only be redeemed monthly instead of daily.

secondary market is truly reflective of the market's assessment of share value, while the NAV may not be. In the next section we assess the consequences for investors when OPF temporarily suspend their share redemptions.

3. Capital Market Reactions to Temporal Suspensions of Share Redemptions

In the fifty-year long history of German OPFs, temporal suspensions of share redemptions happened only during two periods (2005/2006 and 2008/2010):[12]

Prior to the 2005/2006 suspension, the market feared that some funds would need to revalue at least part of their property portfolios. This high appraisal uncertainty led to massive share redemption in a short period, and three funds temporarily suspended redemptions.

On December 13, 2005, Deutsche Bank Real Estate suspended share redemptions in its OPF Grundbesitz-Invest until March 3, 2006, in order to conduct a complete revaluation of property. This event caused a massive outflow of investments (more than 1 billion Euros, or 300 million Euros in the three days before the suspension), as fund management expected a devaluation of several hundred million Euros.

On January 17 and 19, 2006, KanAm temporarily suspended share redemptions in two of their OPFs, Grundinvest US and Grundinvest, after investors redeemed more than 700 million Euros' worth of shares within a few days. The apparent reason was a negative ratings agency report which led to a panic among investors. KanAm, however, did not need a property revaluation, and used the three-month suspension to raise the required liquidity. No devaluation followed, and, in fact, some property sold at great gains. The funds were reopened on March 31, 2006, and April 13, 2006.

In comparison, the 2008/2010 temporal suspensions affected the entire OPF market much more dramatically. In the aftermath of the global financial crisis, investors increased their

[12] For a detailed description of events during the 2005/2006 period, see, e.g., Bannier, Fecht, and Tyrell (2007).

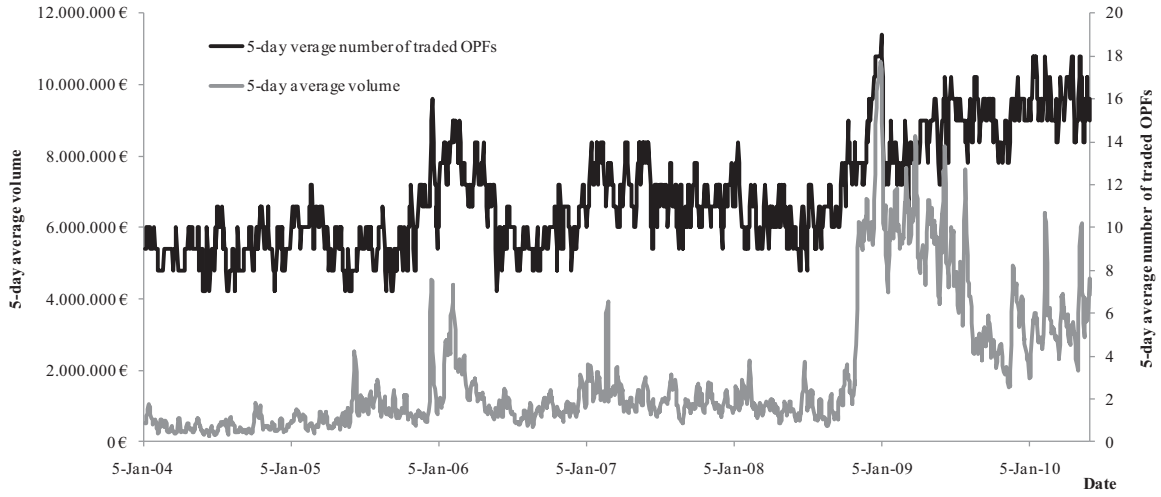
preference for liquidity, and were fearful of tying up capital in the OPF market for an uncertain time. Thus, compared to the 2005/2006 period, this second crisis proved to be a global one.

During the short time period of October 27-30, 2008, twelve OPFs announced temporary suspensions of share redemptions because their liquidity reserves had fallen below 5%. In January 2009, the first OPF reopened, and, through December 2009, eight more followed suit. However, in November 2009, two OPFs that had reopened were forced to temporarily suspend share redemptions once again. In May 2010 again three further OPFs had to suspend share redemptions in the course of the proposal for amendment for OPF regulation by Federal Ministry of Finance (BMF). Therefore our sample exhibits the typical cluster structure as expected for the study of shocks in financial markets.

In order to measure valuation effects in response to suspensions, we use detailed data from the regional exchange Börse Hamburg, where all secondary market transactions of OPFs take place. The data contain every transaction for all traded OPFs for all trading days over the January 2, 2004-June 1, 2010 period, which includes both crises in the OPF market. For the further analyses, we use the number of traded shares and the trading price for all transactions.

Figure 1 illustrates that the average number of traded funds in the secondary market, as well as trading volume, increased significantly during the two crisis periods (see Table 2 for statistical significance) which indicates that investors use the secondary market more frequently when OPFs stop providing liquidity. This observation indicates that capital markets react to the new information and incorporate the change in liquidity into tradable share prices. However, trading volume decreased sharply again as the suspensions continued. We note further that the second crisis had an especially high impact on trading volume, which increased to an average daily peak of about 10 million Euros (compared to an average daily peak of about 4 million during the first crisis).

Figure 1: Number and Volume of Traded OPFs in the Secondary Market
This figure shows the daily five-day average number of traded OPFs and the five-day average trading volume from January 2004-June 2010. See Table A1 for detailed listing of temporal suspended OPFs.



We next measure market reaction to the temporary suspensions of share redemptions by calculating their discount from the secondary market compared to the net asset value (NAV) – redemption prices – calculated by the OPFs themselves around the disclosure date (t_0). Following e.g. Brown and Warner (1985) and Fuller, Netter, and Stegemoller (2002), we apply standard event study methodology to calculate the average discounts (AD_t), as follows:[13]

$$AD_t = \frac{1}{I}\sum_{i=1}^{I}\left(\frac{NAV_t^{(i)} - SP_t^{(i)}}{NAV_t^{(i)}}\right) \quad \forall t = t_0 - \tau_1, \ldots, t_0 + \tau_2, \tag{1}$$

where $NAV_t^{(i)}$ is the NAV of traded and temporarily suspended OPF *i* at time *t*, as reported by the OPF. $SP_t^{(i)}$ equals the secondary market price of that OPF *i* at time *t*, and AD_t stands for the average discount for all suspended traded OPFs (*I*) at time *t*.

[13] Instead of an equal weighting of the average discounts we checked for robustness whether results change when using value weighting. The results remain qualitatively stable. Tables and figures are available from authors upon request.

Both Table 2 and Figure 2 show that the average discount increases significantly for OPFs that announce suspension of share redemptions. These results hold for all event windows.[14] Not surprisingly, the average discount was about 0 percent before the suspension announcement because at this time investors could still redeem their shares to the OPF for the redemption price.[15] Afterwards, it increased to about 5 percent. This average discount clearly reflects investors' perception towards the increased risk of the OPFs.

There are two major sources of uncertainty for investors surrounding temporary share redemptions: (1) how long will be the suspension period until the funds will begin to accept share redemptions again. Recall that the time period can be up to two years depending on funds' liquidity. In the meantime they can only use the secondary market for selling their shares. That is what we term the *liquidity risk*, because for given market values of the properties (NAV) the trading conditions are worse. (2) Since portfolio properties are subject to potential revaluations, the current NAV of the fund might be negatively affected by future write-offs. This effect results in high uncertainty about potential selling prices (both the exchange price and the redemption value once the suspension is over). We denote this uncovering of market prices, as *impending NAV impairment* because it primarily comes from the true underlying value.

Summing up, the average discount thus reflects (i) an increase in the (liquidity) risk premium for reduced OPF marketability (perfect liquidity versus secondary market liquidity) and uncertainty about the length of the suspension period – *liquidity risk* (mechanism 2 of contagion), and (ii) the write-off potentials as a spillover reaction from negative shocks (new economic information) in other real estate markets if funds are forced to sell or to revaluate portfolio properties – *impending NAV impairment* (mechanism 1 of contagion). Investors

[14] We also calculated AD_t based on capital instead of equal weighting. The results remain stable. Tables are available upon request from the authors.

[15] The discount is slightly negative before the announcement of temporal share suspension, because investors do not have to pay the up-front load when buying shares via exchange instead from directly buying from the capital investment company.

react to the ambiguity by incorporating into (secondary) market prices the new information that some OPFs have temporarily halted share redemptions.

The observed average discount reflects the total investors' reaction as response to the temporal share suspension. The goal of the following analysis is to disentangle the average discount into *liquidity risk* and *impending NAV impairment* in order to answer the question what essentially drives the investors' reactions in the secondary market which is done in the next section.

Figure 2: Average Discount of Suspended OPFs Relative to Temporary Share Redemptions
This figure shows the average discount of suspended OPFs for both the 2005/2006 and 2008/2010 crisis periods [as calculated in Equation (1)] relative to the suspension date *t0*. See Table A1 for detailed listing of temporal suspended OPFs.

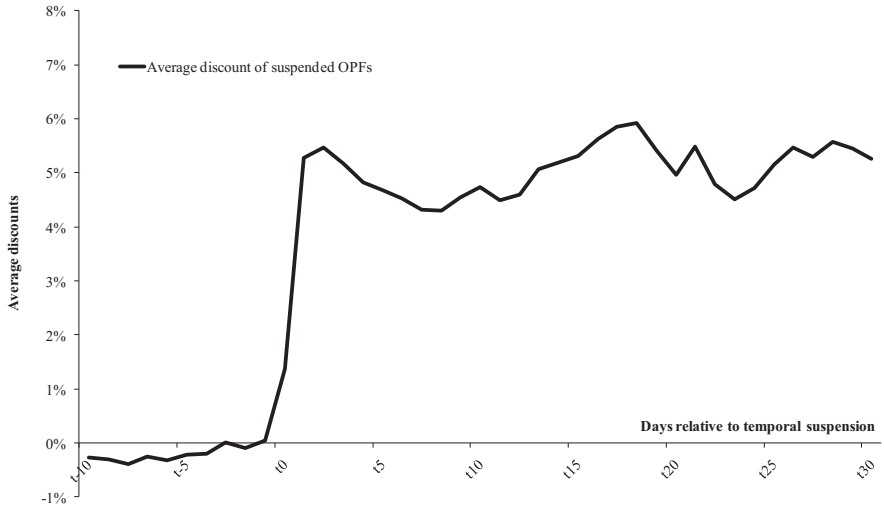


Table 2: Secondary Market Comparison of Market Phases when all OPFs are Redeemable and when some are Temporarily Suspended
This table shows the average discount (AD) for different event windows tested for statistical significance. In the columns Abnormal Trading Volume and Traded OPFs, we test the hypotheses that we will find higher trading volume and a higher number of OPFs traded during the specific event windows, compared to periods when no OPF is temporarily suspended.

Event Window	AD	Abnormal Trading Volume	Traded OPFs	Nobs
[-10, +10]	3,18%***	$2{,}65 \cdot 10^{6}$***	3,77***	16
[-10, +30]	4,56%***	$3{,}38 \cdot 10^{6}$***	3,37***	16
[-1, +1]	2,98%***	$3{,}03 \cdot 10^{6}$***	4,09***	16
[0, +5]	5,29%***	$4{,}10 \cdot 10^{6}$***	4,24***	16
[0, +30]	5,89%***	$4{,}05 \cdot 10^{6}$***	4,25***	16

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

4. Empirical Estimation of the *Liquidity Risk* and *from Impending NAV Impairment*

The approach by Longstaff (1995) provides an intuitive upper bound for a discount caused by restricted trading possibilities. It bases on the idea that in the absence of a trading possibility the assets need to be held until the end of the non-trading period, while in the other case with premature trading the assets might be sold at the optimal selling point. The difference between the values from holding the assets until a future date and optimally selling them before, results in the upper bound for the liquidity discount by Longstaff.

We believe that the Longstaff view exhibits major parallels to the OPF market. During the suspension period share redemptions (to the redemptions price) are restricted but instead only sales of the shares in the secondary market for a substantial discount are possible. Thus, the value obtained from redeeming the OPF at the optimal selling date must obviously be an upper bound for the value of reduced marketability. The Longstaff discount would coincide with the discount in the case the redemption value reflects the fair market value, a secondary market does not exist, and OPF investors have perfect timing ability for the sale of their assets. Since the Longstaff discount addresses the trading conditions of the OPFs, it refers to the *liquidity risk*.

If the magnitude of the observed price discounts is larger than the upper bound for the *liquidity risk*, it can no longer be attributed to a restriction in marketability. In this case the remaining and unexplained part of the discount must come from another source of uncertainty such as *impending NAV impairment*.

4.1 Theoretical Background

In the following formula V stands for the current value of the OPF given that it is continuously marketable in a frictionless market, i.e. the redemption value. The dynamics of V are given by a geometric Brownian motion

$$dV = \mu V dt + \sigma V dZ,$$

where μ and σ are constants and Z is a standard Wiener process. Further, the constant riskless interest rate is r. Now, we consider an investor who holds shares of OPFs in his portfolio, who is restricted to redeem his shares during the suspension period $\tilde{T}$. The value of the OPF for an investor who must hold it until $\tilde{T}$ equals the present value $V_{\tilde{T}}$ received at time $\tilde{T}$. We now compare this illiquid case to the liquid case where the investor can redeem his shares at the redemption price $V_{\tilde{T}}$ at an arbitrary date $t \leq \tau$. To introduce a trading motive, we equip the investor with perfect market timing ability which allows her to optimally sell the OPF shares and reinvest the proceeds in the riskless asset at time τ during the suspension period. Let $M_{\tilde{T}}$ denote the time-$\tilde{T}$ payoff to this investor where the sale could be optimally timed with $M_{\tilde{T}} = max_{0 \leq \tau \leq \tilde{T}}\left(e^{r(\tilde{T}-\tau)} V_{\tilde{T}}\right)$. As long as the investor cannot sell the OPF prior to time $\tilde{T}$ she cannot benefit from having perfect market timing ability.

This marketability restriction imposes an important opportunity cost on this investor since the OPF is only worth $V_{\tilde{T}}$ to the investor at time $\tilde{T}$ if she is restricted from selling, but would be $M_{\tilde{T}}$ if she were allowed to sell earlier. In line with the view that the liquidity discount represents the value difference for the case with and without trading during the suspension period, the present value of the incremental cash flow is $M_{\tilde{T}} - V_{\tilde{T}}$ that the investor would receive if marketability restrictions were relaxed. The present value of $M_{\tilde{T}} - V_{\tilde{T}}$ can easily be determined by using standard Black-Scholes-like valuation approaches. The present value $F\left(V, \tilde{T}\right)$ of the difference $M_{\tilde{T}} - V_{\tilde{T}}$ amounts to

$$F\left(V,\tilde{T}\right) = e^{-r\tilde{T}}\mathbb{E}[M_{\tilde{T}}] - e^{-r\tilde{T}}\mathbb{E}[V_{\tilde{T}}]\,, \tag{2}$$

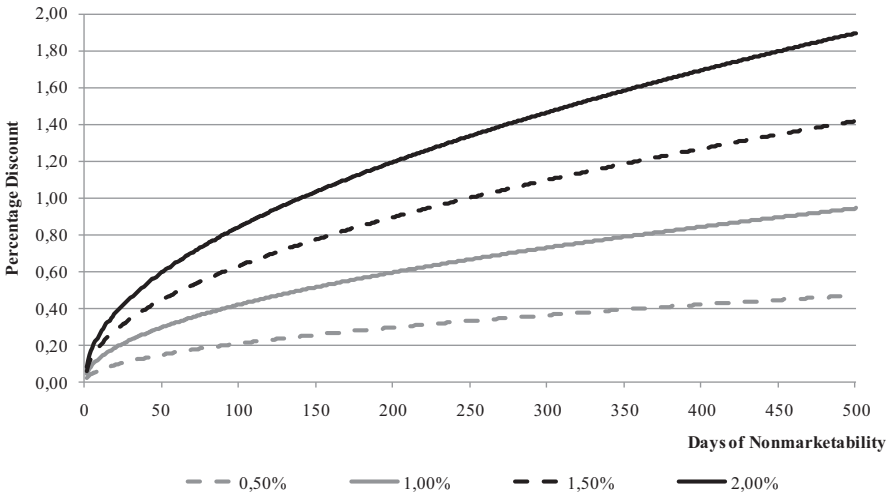
where expectations are taken under the risk-neutral dynamics for V. Harrison (1995) provides a closed-form solution for this type of lookback option,

$$F\left(V,\tilde{T}\right) = V\left(2+\frac{\sigma^2\tilde{T}}{2}\right)N\left(\frac{\sqrt{\sigma^2\tilde{T}}}{2}\right) + V\sqrt{\frac{\sigma^2\tilde{T}}{2\pi}}exp\left(-\frac{\sigma^2\tilde{T}}{8}\right) - V\,, \tag{3}$$

where $N(\cdot)$ is the cumulative standard normal distribution function. The upper bound $F\left(V,\tilde{T}\right)$ for the value of the restricted marketability is proportional to the current value of V. Therefore, the bound on the value of marketability can be easily written as a percentage of the value of V (which can be interpreted as the discount from share prices to the NAV – comparable to Figure 2). One can show that the upper bound is an increasing function of the length of the suspension period $\tilde{T}$ and the volatility σ of the true market value. Clearly, an increasing duration of temporal share redemption and a higher volatility of the underlying value result in a higher opportunity cost of not being able to trade (see Figure 3 for an illustration of this relation) as the limitations for an investor who cannot trade are more severe the longer the suspension period is and the more volatile the asset value is.

Moreover, Figure 3 provides us with a notion for the magnitude of the price discounts to marketability restrictions. As this figure shows the discount related to non-marketability is quite small for a short time period of temporal suspension of share redemptions, but can increase up to almost 2 percent for volatile OPFs and for a suspension period of two years. The assumed volatilities for OPFs in Figure 3 correspond to the historical observed ones which range between one and two percent for individual OPFs (see, for instance, Maurer, Reiner, and Rogalla (2004) or Haß et al. (2010)).

Figure 3: Days of Non-Marketability and the Resulting Upper Bound for Liquidity
This figure shows the percentage discount (upper bound for liquidity) related to the days of non-marketability for different volatilities calculated with equation (3) equal to 0.5% (grey dashed line), 1% (grey solid line), 1,5% (black dashed line), and 2.0% (black solid line).



4.2 Calibration Exercise

We have seen in section 3 that investors react to temporal suspensions of share redemptions which are observable in the average discount (see again Figure 2). Now we have to bring the model framework by Longstaff (1995) and the average discount in line. In particular, we capture *liquidity risk* by the Longstaff liquidity discount and the residual component (given there is any) will be interpreted as *impending NAV impairment*. Since the Longstaff discount is apparently an upper bound for the true effect of a restricted marketability, we are well aware of the fact that our *liquidity risk* component might be overestimated while the *impending NAV impairment* component is underestimated.

Therefore, we calibrate the model for every temporarily suspended OPF by solving equation (3) numerically for the uncertain time of non-marketability $\tilde{T}$, as the discount is observable on the secondary market and its volatility estimated by using its average historical volatility since the issue date.[16] Whenever the resulting uncertain time of non-marketability $\tilde{T}$ is smaller than two years we can interpret the whole discount as a pure premium for the

[16] We have checked for robustness whether our obtained results are driven by the estimation of the volatility. Therefore, we have estimated the volatility for the last five years instead using the entire time period since the OPF was issued and find qualitatively the same results. Tables and figures are available upon request from the authors.

compensation for an increase in *liquidity risk* (*impending NAV impairment* is equal to zero). In case of an uncertain time of non-marketability $\tilde{T}$ larger than two years, the discount cannot be explained by *liquidity risk* only and a further force (*impending NAV impairment*) has to be at work. In this case, we calculate the *liquidity risk* for the temporarily suspended OPFs *i* at *t* for the time limit for the time of non-marketability $\tilde{T}$ equal to two:

$$LR_t^{(i)} = \frac{F(V,\tilde{T}=2)_t^{(i)}}{V_t^{(i)}}. \tag{4}$$

In these cases, the reduction in value of the OPFs caused by the non-marketability is not sufficiently large to explain the observed discount and even if we suppose the upper bound of the Longstaff approach for the *liquidity risk*.

Capturing the *liquidity risk* for every temporarily suspended OPF with the Longstaff approach separately, we can determine the average *liquidity risk* as follows:

$$LR_t = \frac{1}{I}\sum_{i=1}^{I} \frac{F(V,\tilde{T})_t^{(i)}}{V_t^{(i)}} \quad \forall t = t_0 - \tau_1, \dots, t_0 - \tau_2, \tag{5}$$

where LR_t denotes the average non-marketability discount (*liquidity risk*) for all suspended traded OPFs (*I*) at time *t*. After the calculation of the upper bound for *liquidity risk*, we implicitly obtain the *impending NAV impairment* at time *t* formulas the residual component:

$$impending\ NAV\ impairment_t = AD_t - LR_t \tag{6}$$

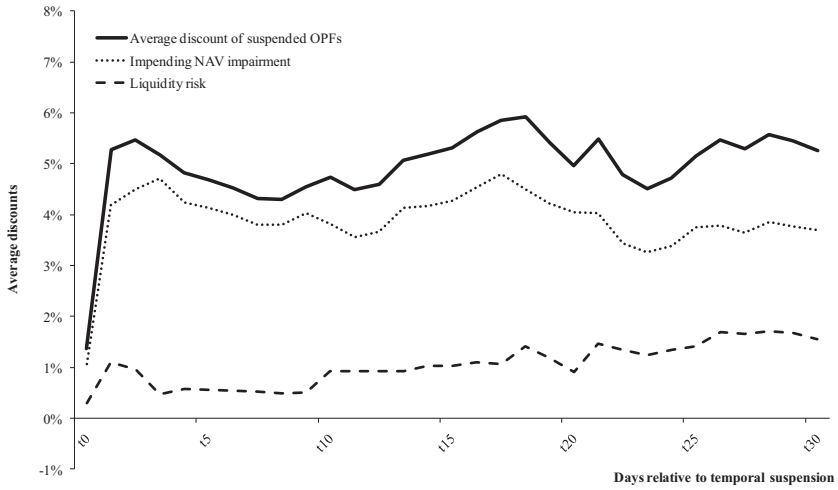
Figure 4 visualizes the *liquidity risk* and *impending NAV impairment* in relation to the average discount. As can be seen from the figure below the increase in *liquidity risk* caused by the reduced liquidity due to the temporal suspensions of share redemptions is by far not able to explain the average discount. The *liquidity risk* accounts for about 16 percent (or 0.8 percentage points) of the average discount whereas the *impending NAV impairment* covers more than 80 percent of the initially average discount (approximately 4.2 percentage points). As a result, the reduction in marketability is responsible for less than one-fifth of the average

discount only but the remaining 80 percent of the discount (i.e. 4.2 percentage points) comes from uncertainty about the funds' property portfolio value.

While the *liquidity risk* in Figure 4 (black dashed line) decreases monotonically over time due to a reduction of the suspension period, the *impending NAV impairment* (black dotted line) fluctuates trendless around its initial level.

Figure 4: Average Discount, *Liquidity Risk*, and *Impending NAV Impairment* of Temporarily Suspended OPFs

This figure shows the average discount of suspended OPFs for both the 2005/2006 and 2008/2010 crisis periods [as calculated in Equation (1)], the *liquidity risk* [as calculated in Equation (5)], and the *impending NAV impairment* [as calculated in Equation (6)], relative to the suspension date *t0*. See Table A1 for detailed listing of temporal suspended OPFs.



4.3 Forecast-Ability of the Initial Discount to Temporal Suspension of Share Redemption

The major finding from the previous subsection is that the *liquidity risk* is inadequate in fully explaining the average discount for suspended OPFs. Instead *impending NAV impairment* is more pronounced to grasp investors' judgment regarding the revaluation of OPFs share price in the secondary market. For this reason, we want to find out whether the initial discount/*impending NAV impairment* in response to the change in marketability when OPFs stop providing liquidity has forecast-ability. In detail, we aim to analyze in a first step whether the initial discount/*impending NAV impairment* can give an indication whether the OPF management depreciates (writes-off) property value during the suspension period or not using a logit-model (see Table 4). In the second step, we consider the accumulated depreciations[17] of the OPF management during the suspension in order to find out whether these depreciations are driven by the initial discount/*impending NAV impairment* using standard ordinary least square regressions (see Table 4).

The logit-model documents that the magnitude of the initial discount/*impending NAV impairment* can explain whether OPF management will conduct depreciations within the suspension period or not (see Table 3).[18] This finding confirms our notion that *impending NAV impairment* is a proxy for investors' perception of the future depreciation potential. The controlling variables size and the period dummy are not statistically significant (except for the period dummy when using initial discount). Remarkably, the size of the OPF is no major driver for the depreciation probability. One could argue that bigger OPF have aggressively wrote up portfolio properties in the past and therefore showed above average returns which

[17] We have calculated the accumulated depreciations by checking press releases, semi-annual report, and annual reports of the OPFs. When no or insufficient information was provided we asked the public relations department of the OPF directly and cross checked the material with their press releases, semi-annual report, annual reports and newspaper articles found in Lexis Nexis and Factiva. See figure A1 for a visualization of to exemplary OPFs.

[18] As a robustness check we calculated the average initial discount and *impending NAV impairment* for the first 5 and 30 days after the announcement of temporal suspension of share redemption and find that the results stay qualitatively stable. Tables and figures available up on request from the authors.

attracted substantial new fund inflows and have for that reason a higher write-off potential. Admittedly, we cannot show such a relation. Furthermore, the indication whether the suspension was during the first or second crisis does not significantly affect the depreciation probability also.

When focusing on explaining accumulated depreciation, we find a slightly different picture (see Table 4). The initial discount/*impending NAV impairment*[19] are still able to explain the depreciation behavior meaning that a higher initial discount/*impending NAV impairment* results in higher depreciations during the suspension period. Interestingly, the variable size of the OPF is now statistically significant and indicates that OPF with more assets under management showed a lower depreciation relative to their fund size compared to smaller funds. Furthermore, the period dummy is statistically significant with a negative sign for both models which means that the depreciation potential during the first crisis in the OPF market in 2005/2006 was lower in contrast to the current crisis.

Summarizing both analyses, we find that (1) market prices have a high explanatory power to forecast which OPF management has to depreciate its property values during the time span of the temporal suspension, (2) investors have a good assessment towards the depreciation potential during the suspension period where they are restricted from redeeming their shares, and (3) therefore, the observed discount that accounts for *impending NAV impairment* reasonably reflects the future prospects of the fund's underlying property values.

[19] As a robustness check we calculated the average initial discount and *impending NAV impairment* for the first 5 and 30 days after the announcement of temporal suspension of share redemption and find that the results stay qualitatively stable. Tables and figures available up on request from the authors.

Table 3: Logit Model Predicting Depreciation of Property Portfolio Value within the Period of Temporal Share Redemption Suspension

The Logit regressions were run so that the dependent variable equals 1 if the OPF depreciated the value of its portfolio properties within the period of temporal share redemption suspensions (and 0 no depreciation take place). The exogenous variables are 1) the *impending NAV impairment* after the announcement of the suspension of temporal share redemption (first ten day average) as calculated in equation 5, 2) the Initial Discount as calculated in equation 1 after the announcement of the suspension of temporal share redemption (first ten day average), 3) Ln(Size) is calculated as the logarithm of OPFs' assets under management, and 4) a Period Dummy variable indicating that the event is during the first crisis for OPFs (2005/2006). We included all OPFs that have already reopened again or are suspended for time period larger than 6 month. See Table A1 for detailed listing of considered temporal suspended OPFs. We estimate two models: else being equal Model 1 uses *impending NAV impairment* as independent variable whereas Model 2 uses the discount instead.

	Model 1		Model 2	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
Constant	22.1073	1.3580	14.1130	0.3365
Impending NAV impairment	1.3082*	2.0039		
Initial Discount			0.9523*	1.8257
Ln(Size)	-1.6872	-1.4900	-1.1061	-1.1639
Period Dummy	-3.7166*	-1.8344	-3.3685	-1.6665
Mc Fadden R^2	42.77%		36.30%	
LR-Ratio	9.0553		7.6854	
Number of Observations	16		16	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Ordinary Least Square Regression Explaining the Depreciation of OPFs Portfolio Property Value

For estimation, we use the depreciation in absolute terms during the suspension period as a dependent variable in both regressions. The exogenous variables are 1) the *impending NAV impairment* after the announcement of the suspension of temporal share redemption (first ten day average) as calculated in equation 5, 2) the Initial Discount as calculated in equation 1 after the announcement of the suspension of temporal share redemption (first ten day average), 3) Ln(Size) is calculated as the logarithm of OPFs' assets under management, and 4) a Period Dummy variable indicating that the event is during the first crisis for OPFs (2005/2006). We included all OPFs that have already reopened again or are suspended for time period larger than 6 month. See Table A1 for detailed listing of considered temporal suspended OPFs. We estimate two models: else being equal Model 1 uses *impending NAV impairment* as independent variable whereas Model 2 uses the discount instead.

	Model 1		Model 2	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
Constant	3.5989*	2.1486	2.4073	1.3090
Impending NAV impairment	0.2292**	2.6437		
Initial Discount			0.1770**	2.1814
Ln(Size)	-0.2444*	-2.0930	-0.1602	-1.3011
Period Dummy	-0.6087**	-2.2093	-0.1602*	-1.9257
R^2	49.37%		42.64%	
Number of Observations	16		16	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

6. Conclusion

As a consequence of a severe crisis in one market segment, other markets can also be impacted by two possible mechanisms of contagion. First, the trading possibilities (for given underlying values) worsen and second the prospects of the underlying values worsen. The OPF market is especially suited for the analysis of these two forms of contagion. Once the fund cannot provide liquidity and is under suspension, the price of the OPF in the secondary market is supposed to be strongly below the potential redemption value due to restricted trading possibilities (*liquidity risk*) and the increased danger of future write-offs (*impending NAV impairment*).

In this paper, we analyze financial contagion mechanisms by disentangling OPF discounts into the liquidity risk component and the NAV component. Remarkably, only a small part equal to 0.8 percentage points of the total OPF discount of five percentage points comes from *liquidity risk*. More than 80 percent of the discount can be attributed to *impending NAV impairment*. Further tests which document that depreciations during the suspension period are positively related to the *impending NAV impairment* component at the beginning of the suspension period confirm this view. Hence we find strong evidence that information spillover is the major driver in the transmission of shocks in financial markets.

The OPF market is especially well-suited for computing the liquidity risk discount according to the Longstaff approach as the maximum length of the non-trading period is two years at most. Apparently, the relation between the discount from liquidity risk and uncertainty about the underlying fundamental value may be different for other markets but still the values estimated for OPFs especially the liquidity discount are a first meaningful starting point.

A relevant challenge for further research is to apply the decomposition of observed discounts into a liquidity component and a component for uncertainty about the fundamental underlying value as carried out for OPFs in this paper to other markets.

Appendix

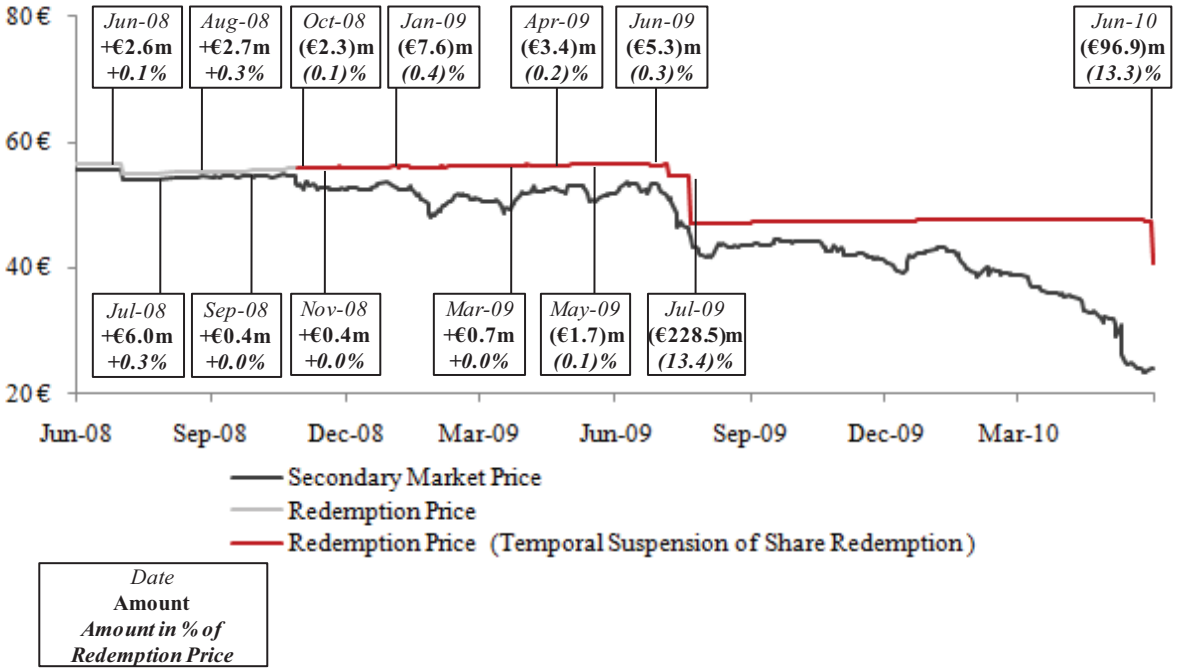
Table A1: Summarization of Suspension Dates of Temporal Share Redemption and the Related OPF Names

This table shows the for every event of temporal suspension of share redemption the suspension date and the reopening date (if possible) and the funds' name. We have excluded the DEGI EUROPA from the sample since no price data was available from Thomson Financial Datastream, BVI, and the capital investment company themselves.

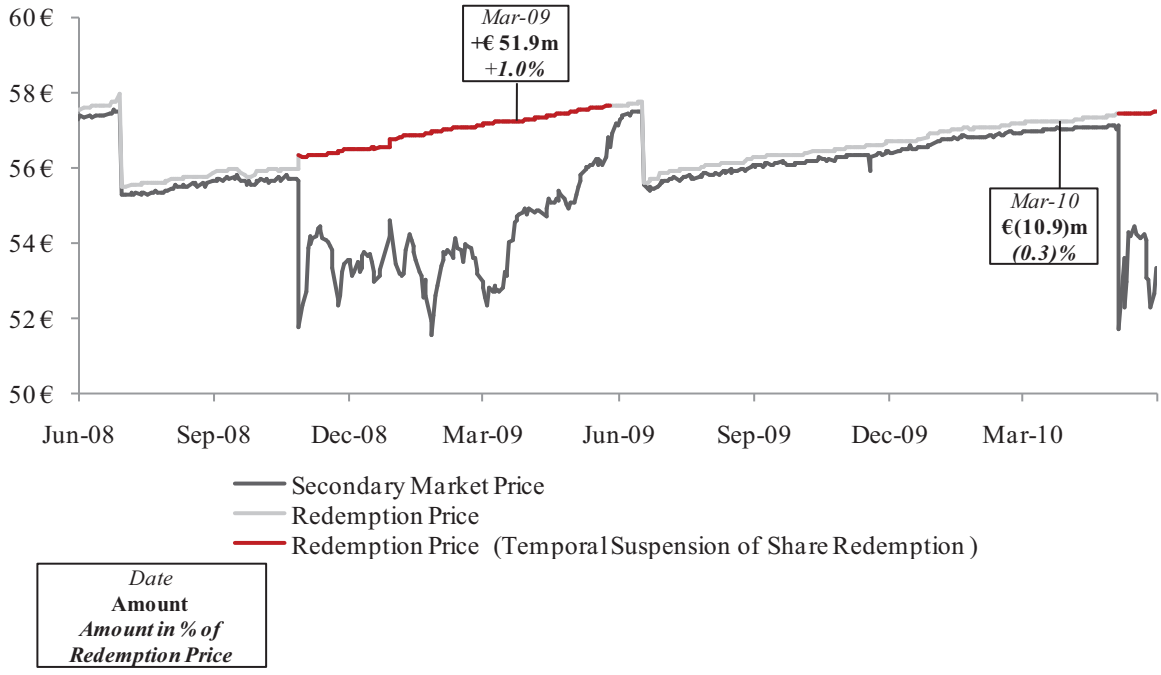
No.	OPF	Suspension Date of Temporal Share Redemption	Date of Reopening
1	Grundbesitz-Invest	December 13, 2005	March 3, 2006
2	KanAm US-grundinvest Fonds	January 17, 2006	March 31, 2006
3	KanAm grundinvest Fonds	January 19, 2006	April 13, 2006
4	AXA Immoselect	October 28, 2008	August 28, 2009
5	CS EUROREAL	October 29, 2008	June 30, 2009
6	DEGI EUROPA	October 30, 2008	-
7	DEGI INTERNATIONAL	October 30, 2008	January 30, 2009
8	Focus Nordic Cities	October 28, 2008	January 28, 2009
9	KanAm US-grundinvest Fonds	October 27, 2008	-
10	KanAm grundinvest Fonds	October 28, 2008	July 8, 2009
11	Morgan Stanley P2 Value	October 30, 2008	-
12	SEB Immoinvest	October 29, 2008	May 29, 2009
13	TMW Immobilien Weltfonds	October 28, 2008	December 11, 2009
14	UBS (D) 3 Kontinente Immobilien [renamed to UBS (D) 3 Sector Real Estate Europe]	October 30, 2008	October 27, 2009
15	UBS (D) Euroinvest Immobilien [investable for institutional investors only]	October 30, 2008	August 6, 2009
16	DEGI INTERNATIONAL	November 16, 2009	-
17	AXA Immoselect	November 17, 2009	-
18	SEB Immoinvest	May 6, 2010	-
19	KanAm grundinvest Fonds	May 6, 2010	-
20	CS EUROREAL	May 18, 2010	-

Figure A1: Appreciation and Depreciations for two exemplary OPFs
This figure shows all appreciations and depreciations of portfolio properties, the secondary market price, and the NAV for the Morgan Stanley P2 Value and the SEB Immoinvest OPF. Price data was available from Thomson Financial Datastream and information about appreciations and depreciations are obtained by checking press releases, semi-annual report, and annual reports of the OPFs and newspaper articles found in Lexis Nexis and Factiva.

a) Morgan Stanley P2 Value



b) SEB Immoinvest



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