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in Europe in the Summer of 2008.

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Investigating the Determinants of Banking Coexceedances in Europe in the Summer of 2008.

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Abstract

We examine the nature, extent and possible causes of bank contagion in a high frequency setting. Looking at six major European banks in the summer and autumn of 2008, we model the lower coexceedances of these banks returns. We find that market microstructure, volatility (measured by range based measures) and limited general market conditions are key determinants of these coexceedances. We find some evidence that herding occurred.

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Introduction

The crisis that originated in the subprime mortgage market in the US was strongly felt in all international financial sectors across the globe. While it started in the credit market in summer 2007, its destructive force was not fully sensed until the beginning of the first quarter of 2008. The short respite that emerged in the subsequent quarter was to be followed by strong downward corrections in the summer of the same year. The interchangeable losing and restoring of investors' confidence around the globe was conditioned by the global financial crisis that has already claimed allegedly not-too-big-to-fail Bear Stearns and Lehman Brothers in the US.¹

In an attempt to avoid similar problems in the European financial system at the beginning of 2008 many banks issued additional share rights to shore up reserves requested for justifying subsequent right-offs or re-intermediation of Residential Mortgaged-Backed Securities (RMBS) and ABS Collateralised Debt Obligation (CDO) originating in the US. Secondly, financial intermediaries became increasingly wary of extending new loans which led to an increase in interest rates and a consequent spill-over of the crisis into the real sector of economies. By end of September 2008, EURIBOR rates had on average increased 17 basis points with respect to the previous month, while the spread between the three-month EURIBOR and overnight lending rates (EONIA), the latter is a good forecast of future European Central Banks' interest rates, doubled from 64 basis points to 125 basis points over the same period. Thirdly, the number of mergers and acquisitions in the banking sector declined in the first half of 2008. In 2007, EU banks recorded not only the highest annual value of M&A deals in a decade, but also the largest spree of acquisitions outside of the USA. By contrast, in 2008 after the exclusion of the acquisition of ABN Amro by a consortium of Halifax Royal Bank of Scotland, Fortis and Santander there was no extensive M&A activity (European Central Bank^b, 2008).

In the environment of distrust and extreme caution the member countries of the European Union in general and the eurozone, in particular, individually decided to shore up ailing banks. The government of Ireland increased the deposit guarantee from €20,000 to €100,000 and subsequently extended an unlimited guarantee to all deposits leading domestic financial institutions. This move was heavily criticised by Eurozone member countries as unfair competition that could have led to an exodus of depositors from countries with less generous protection schemes.² To counteract this a chain of similar guarantees was put in place by othe

¹ In June 2007 two hedge funds of Bear Stearns were heavily exposed to the subprime market and ensuing difficulties lead to an increase in credit default swap premia (Cassola *et al.*, 2008)

² The Commonwealth of Australia introduced the same plan, but the government's decision has been heavily criticised by opposition leaders and managers whose banks were not included in the scheme. In October 2008, Greece, Denmark, Sweden and Austria decided to support all bank deposits, as well (See Appendix I)

remaining Eurozone members. The Federal Deposit Insurance Corporation (FDIC) increased guarantee from US\$100,000 to US\$250,000 per depositor until 31 December, 2009, while EU member countries focused on a €100,000 scheme and a rapid process of case resolutions (up to three days). Both decisions were criticised by the European Banking Federation as rather demanding due to the varying financial (fiscal) strength of member states and administrative constraints that could not shorten the current 3-month to a mere 3-day resolution period. Cultural differences among EU countries and incoherent approach to the global crisis reflect difficulties that EU faces in challenging times as these. In addition, in nine out of fifteen euro area countries the level of general government debt is either close to or in excess of the 60% mark of respective GDPs, which limits the amount of extra debt that could be borrowed by national governments.³ Monetary flexibility is rather limited not only by the strict ECB's policy aimed at stemming inflationary pressures, but also by the non-existence of national monetary policies. The relaxing of fiscal austerity seems to be the only remaining panacea, which will not only reduce the amount of disposable income for taxpayers and further increase government debt levels, but also question the zeal of EU Commission in enforcing its own guidelines that represent the foundation of the euro zone.

In this paper we examine leading banks in the euro area measured by the level of market capitalization in 2008. The largest financial intermediaries have extensive analyst following and in smaller markets they may be the leading companies without comparable substitutes. Therefore, trading patterns may reflect the general trading sentiment. In addition, Bonson, Escobar *et al.* (2008) find that the size of European banking institutions and investment firms is positively related to the application of better risk management practices, and assuming that better practices are related to more effective risk management we can reduce the analysis to intraday trading patterns that reflect more a level of sentiment rather than fundamentals. Accordingly, the size bias does not seem to enhance the problem of poor risk management.

Contagion and Coexceedances

Over the decade from the Asian crisis of 1997 to the beginning of 2007 a very significant body of research on the interlinked concepts of contagion (excess co movement of assets beyond that which would be expected from fundamentals) and asset interrelationships, spillovers and interdependencies has emerged. These have enhanced both our understanding of the dynamics of contagion and the tools that are available to investigate. As an exemplar, Forbes and Rigobon (2002) *et seq* showed the need for research to move beyond simplistic

³ Among other 12 non-euroarea countries only Hungary violates the 60% benchmark. However, with the exception of Sweden, Denmark and the UK all other countries sport much lower levels of GDP per capita than the EU average, which questions their ability to support sizeable financial commitments. (European Central Bank^c, 2008)

models based on unconditional correlation matrices. Contagion has thus become seen as a distinct phenomenon from integration and from increased or decreased integration. There has also been an increase in the literature discussing the various approaches taken for defining contagion (See Corsetti, Pericoli *et al.* (2005) who identify at least five different measures and the first part of Gravelle, Kichian *et al.* (2006)

In this paper we take the notion of contagion as arising from extrema of distributions. The original paper of Bae, Karoli *et al.* (2003) casts contagion as contemporaneous instances of asset prices lying in a particular, negative, portion of the realised distribution. This has the intuitive appeal that it respects the notion that individual assets have greater or lesser inherent volatility. For some assets a fall of 5% may be exceptional while for others a fall of 2% may represent the same degree of “exceptionalness”. Their work used multivariate probit analyses to uncover the common factors that drive asset classes returns to lie in the same percentile of their realised distributions.

Contagion studies proper also focus on the behaviour of asset returns during times of crisis. Many of the methodological issues discussed in papers such as Corsetti, Pericoli *et al.* (2005) and Gravelle, Kichian *et al.* (2006) relate to the identification of crises periods, the windows over which analyses should be concluded and the issues in dealing with shifts in regimes as systems move from calm to crisis and back. The advantage of using a coexceedance model such as we deploy here is that it almost by definition is usable only in periods of crisis when assets are falling across the range studied. Defining “shift contagion” in the commonly agreed manner, as a change or break during a crisis period in the transmission mechanisms of how assets are related, coexceedances are a natural measure of this phenomenon. We define contagion here as the existence of a common (unspecified) shock that propagates across the assets in question, which predisposes them to move into a similar position in their distribution, and which shock emerges from a source external to the assets in question. A shock occurs which causes the banks in this analysis to exhibit returns which are extreme in each case.

This definition is essentially that used in the relatively few papers that have used this modelling approach. Groop, LoDuca *et al.* (2006) use a distance to default measure (derived from the BSOPM) to analyse contagion, on a daily frequency, among EU banks over a 9 year period. They concentrate on the 95th percentile coexceedance and find evidence of periods of contagion. This work is similar to that of Hartmann, Straetmans *et al.* (2004) who use extreme value theory to surface US-European contagious episodes. Outside the equity markets Baur and Schulze (2005) and Christiansen and Rinaldo (2008) apply a coexceedance model to equity markets, also using a daily approach.

We believe that this present paper advances the literature in several ways. First, we focus on high frequency analyses, using 30m data over a 6m period of generally accepted

crisis. Second, we focus on a set of assets that are very homogenous, Eurozone large banks. Third, we uncover dynamics not just from the general market but also from other asset markets including the gold market which has been shown in previous work (Baur and Schulze (2005)) to be a safe haven asset in times of market stress. Finally, we employ a non-parametric model of volatility, the Garman-Klass estimator, which belongs to a class of estimators with desirable properties under high frequency data stylised facts.

Methodology

In order to determine the relationship between the number of coexceedances and selected dependent variables we will apply the Multinomial Logit Model (Greene (2000)).⁴ As suggested by Groop, LoDuca *et al.* (2006) it is advisable to use either order logit or multinomial (unordered) logit model. The latter model is more appropriate, because it does not assume that the move from 0 or no-coexceedances to 1 or two to three banks with coexceedances is the same as moving from 1 to 2, ie. four or more banks involved in coexceedances.

The proposed model is as follows:

$$P[Y = j] = \frac{e^{[\beta_j M]}}{\sum_{m=0}^2 e^{[\beta_m M]}} \quad (1)$$

where $j = 0, 1$ and 2 , i.e. the indicator whether the case of a) no coexceedance, b) two or three banks or c) more than three banks have coexceedances, respectively exist; M are common shocks, variability measures and commonly accepted market microstructure variables to which companies in the eurozone are exposed, while β_j is a vector of coefficients for variable j . The base category is $Y = 0$, which helps alleviate the level of indeterminacy in this model.⁵ The multinomial logit is calculated in RATS with a significance level of 5 percent.

Data

⁴ In probit models it is assumed that error terms have joint multivariate normal distribution with 0 mean and arbitrary variance-covariance matrix, which in the case of market microstructure data sets becomes rather difficult to assume. Horowitz (1980) concludes that logit models provide consistent parameter estimates as long as the utility functions are linear.

⁵ All coefficients are calculated with respect to 0 as a new base. The normalization process involves the assumption that $\beta_0 = 0$, in which case the equation becomes: $P[Y = j] = \frac{e^{[\beta_j M]}}{1 + \sum_{m=1}^2 e^{[\beta_m M]}}$ (Greene, 2000).

We collect from Reuters High-Low-Open-Close price data for 6 large European banks in the Eurozone: Banco Santander, BNP Paribas, Societe General, Banco Bilbao, Deutsche Bank and Credit Agricole. For this paper all measures are, except where noted, constructed using close returns. These data are sampled at 30m frequencies, from 6 June 2008 to 15 October 2008. In total we have 1540 observations. These banks, at end October 2008, represent 42% of the FTSE Eurotop Banking Index by market capitalization. The choice of banks was dictated by they being in the top ten by market capitalization of the FTSE Eurotop Banking Index, and being denominated in euro. We were unable to obtain accurate information for three banks that met this criterion – Unicredito and SanPaolo and National Bank of Greece. We also collect total volume of shares traded (measured in euro millions) within each thirty minute period. As a control on general stock market as opposed to bank shocks we collect the same information on the DJ EuroSTOXX50 index⁶. This also allows us to capture asset class issues.

To capture possible flight to safety we include data on gold, measured as the London AM Fix. Baur and Lucey (forthcoming) find that in periods of market stress gold becomes n attractive “safe haven” for investors. We also include overnight LIBOR, the London Interbank Offered Rate, as a measure of credit conditions. Both Gold and LIBOR are measured as percentage changes. LIBOR and Gold represent a data problem in that both are fixed at 1100hGMT. We overcome this with an alignment of data ; for each day, when the bank data refer to times pre 1100h we use t-1 LIBOR and Gold data, and from times after 1100h GMT we use that days measures.

To capture volatility effects on coexceedances we use two measures of volatility. We first use a standard conditional volatility measure. Conditional variances were estimated using a ARMA(1,1)-GARCH(1,1) specification with a skewed-t distribution for the errors. We estimate this for the STOXX index and also for each bank. These individual banking measures are then averaged to obtain a composite banking average conditional volatility. We also measure the volatility using the Garman-Klass (Garman and Klass (1980) – hereafter GKe) range based volatility estimator. The novelty of the GKe approach lies in the use of use of the open, close, high and low price *within* a particular time interval in its calculation. The GKe therefore provides an alternative, volatility measure to the standard deviation and GARCH approach, which utilises the price change *between* consecutive time intervals. The within period focus allows us to peer more deeply into the high frequency dynamics than do other methods. The GKe and other range based volatility measures have been investigated by Shu and Zhang (2006) and Alizadeh, Brandt *et al.* (2002), who conclude that they represent a

⁶ Note that this index does include in its composition the banks we study here. However, absent an index of non-financial companies in the Eurozone that is also available at 30m intervals we are forced to use this as the most general proxy available. The banks we analyse constitute approx 10% of the market value of the STOXX index.

low-bias and efficient measure of the theoretical volatility and are superior in these respects to the GARCH estimators.

From Garman and Klass (1980), the GKe is:

$$GKe = \sigma^2 = 0.511(H - L)^2 - 0.019(C - O)(H + L - 2C)(1 - C) - 0.383(C - O)^2 \quad (2)$$

where H = log of interval high

L = log of interval low

O = log of interval open

C = log of interval close

Coexceedances are coded 1 where two or three banks exhibit coexceedances, 2 where four or more of the six banks exhibit coexceedances. Two banks exhibit coexceedances when both have returns in that period which are in the lower 5th percentile of their realised distribution.

Finally, we also create indicator variables for a number of microstructure issues. We create dummy variables to indicate if the time is in the early part of the trading day, defined as before 0900h; to indicate if the time overlaps with the opening of the US market; and to control for possible calendar day effects, to indicate that the day is neither a Monday nor a Friday.

Results

In Figure 1 are the numbers of banks exhibiting coexceedances over the period. Despite the prominence given to banking stocks in market reports in the September-October period, it is clear that instances where 5 or 6 banks showed declines in the lower 5% of their distributions were also evident in the early summer. However, it is also evident that this severe coexceedance pattern was more frequent in the later part of the summer. Of the 33 instances where 5 or 6 banks exhibit coexceedance we find that slightly more than one third (12) appear before the start of September 2008

Shown in table 1 are the results of the multinomial logit analyses. A number of points are evident. The coefficient estimate for the constant is mainly insignificant. There is consistent evidence that coexceedances are more likely to occur when the market is in its opening phase. This effect is stronger for the higher coexceedance model. This finding confirms the importance of the opening sessions (see for example Chelley-Steeley (2005))

Contrary to the findings of Groop, LoDuca et al. (2006) and Christiansen and Rinaldo (2008) we find no evidence of significant autoregressive behaviour in the occurrence of sampled banks' coexceedances. Furthermore, there is no evidence on the impact of overlap with the US market, apart from a weak support for this claim when many coexceedances occur and conditional volatilities are included as independent variables. This limited evidence on the impact of the US market on coexceedances in the European context is in conflict with that found in Christiansen and Rinaldo (2008) for developed markets but is consistent with their findings for accession countries. We also find very little evidence in the data of either a flight to quality or to a safe haven, with gold changes having a marginally positive and negative (for larger coexceedances), but not significant effect on the coexceedances. We do not find evidence of the impact of credit conditions.

Of much more importance in determining the coexceedances is the change in volume traded in STOXX Index, indicating a degree of contagion or spillover from the general market to the financial market: we see a positive relationship here, where increases in the general market are associated with a higher likelihood of a coexceedance in the banking sector. This would accord well with the idea that coexceedances are associated not just with declining prices but with an actual flight from equities; not just are stocks marked down but there is an increased sale of said stocks. For the volume of bank shares traded there is a negative sign in both models, but the coefficient estimates are not statistically significant.

Volatility emerges as the other major determinant of coexceedances. Conditional volatility measures are insignificant. This may reflect an inadequacy of the GARCH model, an inappropriate aggregation of the GARCH volatilities to an overall, or an actual result. If it is an actual result however it demonstrates that the range based approaches, which peer "inside" the period when price is being determined, provide a more refined insight into the impact of volatility on coexceedances. Our results are similar to the findings on volatility as per Bae, Karoli et al. (2003), Groop, LoDuca et al. (2006) and Christiansen and Rinaldo (2008). However, the findings in these papers are for conditional volatility, which we find here to be mainly insignificant. The findings here are more significant for range based estimates. We attribute this difference to the fact that our analyses are conducted on high frequency data, as opposed to the daily and lower frequencies of the other papers which have used this approach.

Our results show reasonable explanatory power. The pseudo- R^2 values are 8.79-11.8% which is higher from that found by Christiansen and Rinaldo (2008) and in line with the findings of Groop, LoDuca et al. (2006). The statistics found here are somewhat closer to the 10% findings in Bae, Karoli et al. (2003).

Conclusions

The banking and financial crisis of 2008 has left a rich field for the analysis of contagion and interrelationships. Based on the multinomial logit model we further discover that the number of coexceedances is more prevalent during the early trading session due to influx of overnight information. There is a weak support for the impact of the US market. The change in traded volume in STOXX index demonstrates a positive impact in extreme coexceedances' model. Finally, the conditional volatility seems to have no influence on coexceedance patterns, while the Garman-Klass measure proves to be more statistically powerful.

Table 1. Multinomial logit analysis

Variable	Two or Three coexceedances				Four or More coexceedances			
	Coeff	p-value	Coeff	p-value	Coeff	p-value	Coeff	p-value
CONSTANT	-3.69047	0.210644	-8.90183	0.010153	-4.76483	0.44141	-9.48827	0.089834
COEXCODE1	0.362259	0.220582	0.40928	0.134974	-0.45931	0.410048	-0.42702	0.360888
MIDWEEK	-0.5	0.134016	-0.29506	0.301538	-0.21373	0.6193	0.00312	0.993046
EARLY	1.1895***	0.000608	1.33732***	0.000597	2.419586***	8.5E-07	2.67465***	2E-08
NYSEISOPEN	-0.31396	0.329721	0.23667	0.471781	0.217848	0.743393	0.98199*	0.05123
XSTOXRt-1	0.03476	0.961301	0.45588	0.549985	-1.82811	0.121867	0.56327	0.428221
GOLDFIX	0.000652	0.817111	0.00178	0.489957	-0.0005	0.888502	-0.00043	0.895777
LIBORFIX	-0.15528	0.692918	0.74115	0.198657	-0.00697	0.994878	1.04762	0.267576
CSTOXXRt-1	24.30151	0.276744	8.68202	0.797574	-43.9649	0.216324	-47.4678*	0.090054
VOLSTOXXCHG	0.638713	0.104458	0.73672*	0.052951	1.129103***	0.000677	1.16915***	0.000269
MEANVOLCHG	0.009683	0.964459	-0.04643	0.84077	-0.04371	0.876894	-0.0328	0.885653
GKSTOXXK	-4037.88***	0.000898			-4143.11***	0.003109		
GKSTOXXKt-1	-1681.79**	0.02052			-4766.76***	0.008936		
MEANGKVOLK	79.95933	0.144089			127.3819***	0		
MEANGKVOLKt-1	27.05954*	0.075595			-8.15027	0.795797		
CONDVSTOXX			63.3502	0.991445			-1360.89	0.759921
CONDVSTOXXt-1			-727.599	0.849316			-120.198	0.974155
AVGCONDVOL			-1060.76	0.947986			2738.318	0.890173
AVGCONDVOLt-1			5970.831	0.706348			2634.303	0.892815
Pseudo-R ²	11.8%		8.79%		11.8%		8.79%	

*** p-value < 1%

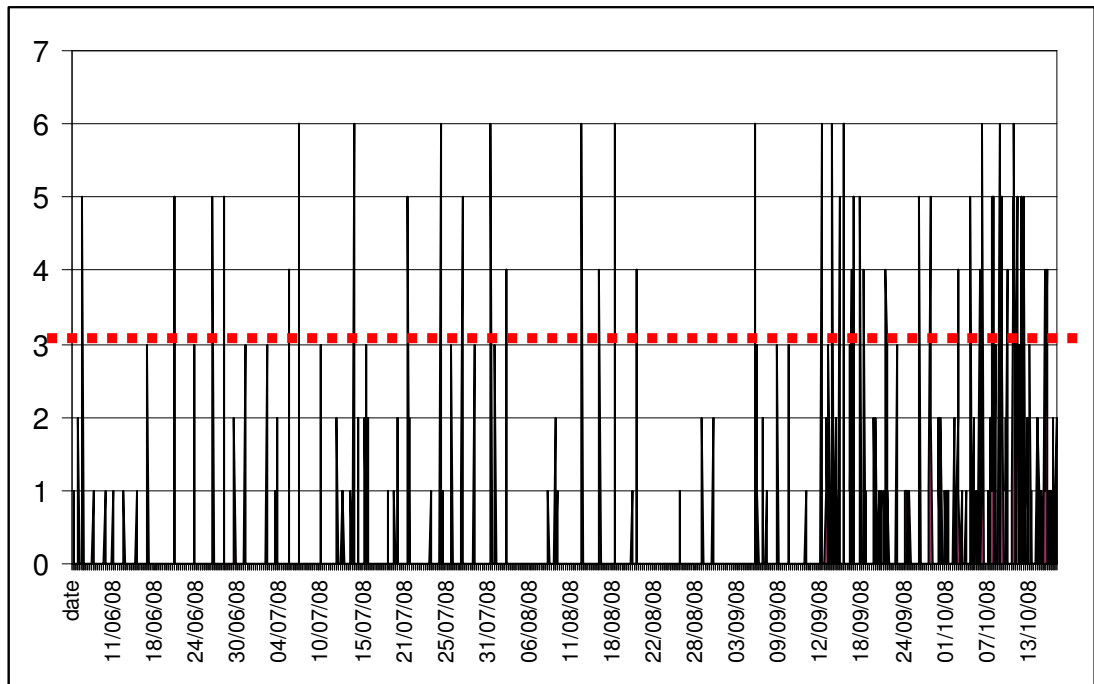
** p-value < 5%

* p-value < 10%

dependent variable is the number of coexceedances, i.e. 0 for no coexceedance, 1 for two or three banks coexceeding and 2 for four or more banks involved in coexceedances. COEXCODE1 is lagged value of coexceedances; MIDWEEK equals 1 if the days in the week are Tuesday, Wednesday and Thursday; EARLY is a dummy variable denoting that intervals are calculated prior to 9.00am; NYSEISOPEN equals 1 for the trading period when NYSE is open, otherwise it is 0; GOLDFIX is the change in the value of gold based on London AM Fix; LIBORFIX is the change in the value of daily LIBOR rate; XSTOXR1 is the number of coexceedances in the STOXX index; CSTOXXR1 is the lagged close return in the STOXX index; VOLSTOXXCHG is the change in volume traded in STOXX index; MEANVOLCHG is the average change in the volume of bank shares traded; GKSTOXXK is the value of Garman-Klass range volatility estimator for STOXX; CONDVSTOXX is ARMA(1,1)-GARCH(1,1) conditional volatility measure for STOXX index; MEANGKVOLK is the average value of Garman-Klass range volatility estimator for banks; AVGCONDVOL is average ARMA(1,1)-GARCH(1,1) conditional volatility measure for bank returns;

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Figure 1 : Number of Banks exhibiting lower 5% coexceedances



Appendix I

Timeline of Financial Crisis in Europe

- 13 September 2007 – UK bank Northern Rock applies for emergency funding support by the Bank of England
- 14 September 2007 – Bank run on Northern Rock
- 17 September 2008 – LIBOR reaches a seven-year high
- 18 September 2008 – Central banks provide \$180 billion in support of global liquidity
- 19 September 2008 – Thanks to the short-selling ban and US rescue plan announcement FTSE regains 315 point to end the trading day at 5,195.
- 21 September 2008 – The Financial Services Authority involved in talks regarding the potential bail-out of Bradford and Bingley, the banking and financial planning group.
- 25 September 2008 – Ireland is the first country in the eurozone to face recession.
- 28 September 2008 – the governments of the Netherlands, Belgium and Luxembourg buy €11.2 billion of bad assets and assume 49 percent of ownership in Fortis, one of the largest bank and insurance conglomerates in Europe. Spain's Banco de Santander buys 200 branches of Bradford and Bingley and £22 billion savings.
- 29 September 2008 – the federal government in Germany along with selected banks provides a rescue package amounting to €35 billion to support Hypo Real Estate. The British government acquired Bradford and Bingley for €63 billion. The government of Iceland takes up 75 percent stake in the largest local bank, Glitnir, for €0.6 billion.
- 30 September – the Irish government is the first to guarantee all bank deposits over the upcoming two years. Dexia, the municipal lender, seeks for bail-out.
- 1 October 2008 – Fortis abandons its seasoned equity offering plan to raise €3 billion due to the lack of market interest
- 2 October 2008 – Greece secures all deposits in Greek banks
- 3 October 2008 – the UK government increases the compensation for deposits from £35,000 to £50,000. The government of Netherlands purchases the local branch of Fortis for €16.8 billion
- 5 October 2008 – The rescue package for Hypo Real Estate increased from €35 to €50 billion. BNP Paribas acquires Fortis' branches in Belgium and Luxembourg for €14.5 billion.
- 6 October 2008 – the authorities in Denmark, Sweden and Austria secure all bank deposits. In Iceland there is trade suspension at the stock exchange.
- 8 October 2008 – The Icelandic internet bank, Icesave, is in default. UK government declares that they might sue Iceland for losses incurred by British depositors.

- 13 October 2008 – The UK government promises to pay £37 billion to recapitalize the Royal Bank of Scotland, HBOS and Lloyds TSB.
- 14 October 2008 – The Icelandic stock exchange continues trading after a week period. The index declines by 76% after the opening session.
- 16 October 2008 – The Swiss government provides support for UBS, while Credit Suisse manages to raise money from private investors and sovereign investment funds.
- 27 October 2008 - IMF provided £16.5 billion rescue package for mainly Eastern European countries and Turkey. Hungary seeks a €10 billion rescue package, while Ukraine due to political stalemate cannot make a decision about the rescue package.
- 28 October 2008 – Bank of England estimates that due to the recent market correction financial institutions around the globe have lost approximately \$2.8 trillion
- 31 October 2008 – Barclays announces the investment of £7.3 billion by Middle Eastern investors who are expected to become owners of one-third of the bank.



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