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TESTING FOR EAST-WEST CONTAGION IN THE EUROPEAN BANKING SECTOR DURING THE FINANCIAL CRISIS

by Emidio Cocozza* and Paolo Piselli*

Abstract

Large and growing international financial linkages between East and West have altered the nature of the stability risks faced by European banking systems, increasing susceptibility to contagion. This paper aims to identify potential risks of cross-border contagion using a sample of large Western and Eastern European banks. We assume that contagion risk is associated with extreme co-movements in a market-based measure of bank soundness, controlling for common underlying factors. We also find evidence that contagion risk across European banks heightened significantly during the recent crisis. Contagion among Western European banks with the highest market share in Eastern Europe and from this group to Eastern European banks shows the largest increase in our sample. We find also evidence of contagion spreading from Eastern European banks, but this effect seems to reflect a broader phenomenon of contagion from emerging markets to banks in advanced countries exposed to these markets. Finally, our findings offer only mixed evidence of the existence of a direct ownership channel in the transmission of contagion.

JEL Classification: C12, G15, G21.
Keywords: Banking contagion, Distance to default, Testing hypothesis, Logit model.

Contents

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1 Introduction[1]

With the significant increase in foreign banks presence in Eastern Europe (EE),[2] inter-linkages among Western and Eastern European banking systems have grown markedly. The entry of foreign intermediaries has brought important gains in terms of efficiency and diversification and, through increased access to cross-border financing, it has contributed to rapid financial deepening in EE. At the same time, large and growing international financial linkages have altered the nature of the stability risks faced by financial systems, raising susceptibility to contagion. Higher integration by EE countries into the broader European banking system and the strong presence of foreign players have increased host countries' vulnerability to idiosyncratic shocks from abroad. Conversely, the increased importance of EE in large Western European banking groups' portfolios has also heightened the risk of contagion for home countries. The recent global financial crisis has brought to the fore the risks associated with financial interconnectedness and the potential transmission of shocks across intermediaries, and banks with operations in EE have not escaped unscathed from occasional bouts of heightened volatility.[3]

The purpose of this paper is to identify the potential risks of cross-border contagion among the banking sectors of Western and Eastern European countries, using information captured in banks' stock prices. Information from security prices helps to counter data limitations and imperfect knowledge about indirect exposures across financial institutions, connected, for example, to the use of similar investment strategies. As a market-based measure of bank distress we use the *distance to default,* which combines information from equity prices and banks' balance sheets.

We use a dataset of daily distance to default of 33 European listed banks. Our data sample comprises: most of the largest banks operating in Eastern Europe; the Western European banking groups which, through their branches and subsidiaries, own the highest market share in the EE banking systems; the remaining largest, and globally systemic, European banking groups.

We define *contagion risk* as the risk of one bank being in distress conditional on one or more other banks being in distress, controlling for common shocks affecting all banks symmetrically and simultaneously. To investigate contagion, we focus on the behaviour of the left tail of the distribution of the changes in the distance to default (i.e. the lowest 15% quantile) and, using a logistic regression, we estimate how the probability of one bank experiencing an extreme negative change in the distance to default is related to the occurrence of negative tail events in other banks in the sample and to country-specific and global factors.

The approach applied in this paper builds on a recent body of literature which uses a similar methodology to estimate cross-border contagion (Chan-Lau et al., 2007, Čihák

[1] We would like to thank Mardi Dungey, Massimo Sbracia, Demosthenes Tambakis, Melvyn Weeks and two anonymous referees for their helpful comments. Part of the work was carried out while Paolo was visiting the University of Cambridge. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Italy. Email: emidio.cocozza@bancaditalia.it; paolo.piselli@bancaditalia.it.

[2] In the paper "EE" refers to the new EU member states of Central and Eastern Europe (excluding Slovenia), along with Croatia, Russia, Serbia and Ukraine.

[3] An example is offered by the events following the rating agency Moody's release, in mid-February 2009, of a report titled "Western European ownership of East European banks during financial and macroeconomic stress", warning that it might downgrade banks active in Eastern Europe owing to their heavy exposure to the region and the region's rapidly deteriorating macroeconomic environment. The report shocked investor confidence, leading to a sharp drop in banks' equity prices and a steep increase in parent banks' CDS premiums.

and Ong, 2007, Gropp et al., 2010). We extend previous research on the transmission of shocks among banks and banking systems in the following directions:

1) We test for contagion risk among banks in EE and the largest Western European banking groups, some of which operate in Eastern Europe. To our knowledge, this is the first comprehensive attempt to measure contagion among banking systems in the two regions.

2) We provide new evidence of how contagion risks in European banking systems evolved in the recent global financial crisis (i.e. after the summer of 2007).[4]

3) We introduce a test to evaluate whether changes in contagion effects across time and regions are significant.

4) To control for broader contagion from emerging markets, we carry out a counterfactual experiment, comparing our model's results to those obtained substituting a sample of Latin American banks for the Eastern European one.

The remainder of the paper is organized as follows. The next Section describes various potential sources of contagion between Western and Eastern European banking systems. Sections 3 and 4 discuss the methodology and the input data. Section 5 shows estimation results and discusses some issues related to the robustness of our findings. Finally, Section 6 concludes the paper.

2 Potential sources of contagion between Western and Eastern European banking systems

The literature on financial contagion has devised several avenues through which idiosyncratic shocks affecting one bank may spread to other banks or banking sectors. Contagious bank failures may result either from direct linkages connecting banks or from informational externalities (for a survey of the theoretical literature see Moheeput, 2008, and Allen et al., 2009).[5]

Direct linkages may take the form of contractual arrangements, such as the cross-holding of deposits or loans in the interbank market. Interbank exposures may create problems if aggregate liquidity provision is insufficient and banks try to avoid liquidation of their long-term assets by liquidating their claims on other banks (possibly in other regions). A financial crisis in one region could then spread by contagion to other regions and thereby introduce liquidity problems in the latter. Interdependence is thus beneficial in tranquil periods, as the interbank market provides the channel for cross-regional insurance against liquidity shocks, but in turbulent periods interlinkages in the interbank market provide the main conduit that spreads a crisis from bank to bank (Allen and Gale, 2000). Direct linkages may also take less explicit forms, such as those arising from payment and settlement infrastructures, asset prices or common investors.

Informational spillovers as a result of market expectations represent a second potential channel for contagion. For example, if banks' fundamentals are believed to be correlated, bad news about one bank may lead investors in another bank to change their perception of its soundness. This may be the case of banks sharing similar business and geographic strategies or operating in the same region. In Acharya and Yorulmazer (2008) the return to bank loans has two components, a systematic component and an idiosyncratic component, and depositors can only observe the overall realisation of bank loan returns, but not the

[4] Lucey and Ševic (2010) carry out a similar analysis but only up to October 2008.

[5] Empirical research in this field largely focuses on testing for the existence of contagion and to a lesser extent on estimating the different channels through which shocks propagate. Dungey et al. (2005a) provide a review of alternative methods to test for contagion.

actual breakdown. Hence, one bank's poor performance spills over into other banks' borrowing costs.

Since the beginning of the decade banking systems in EE have been closely integrating with the rest of Europe. Currently, most EE economies are highly dependent on Western European banks, either directly, via cross-border credit extended by headquarters to bank and non-bank residents in the region, or through the activity of local branches and subsidiaries. According to BIS data, at end-2008 outstanding consolidated foreign claims (cross-border claims and local claims of foreign affiliates) on non-banks were equivalent, on average, to about 42 per cent of total cross-border and domestic credit to non-banks in EE, even though the magnitude of the exposure varied significantly across countries. Austria, Germany, and Italy accounted for the largest share of foreign claims on the region as a whole, with the notable exception of the Baltics, where claims were mainly held by Swedish banks. A few EE economies had relatively more diversified sources of funds (Table 1).

The high exposure of EE banking systems reflects the strong presence of foreign intermediaries in domestic markets, as the share of foreign-owned banks accounts for the bulk of the banking system assets in many countries. Moreover, given the high degree of foreign ownership, and the relatively undeveloped state of domestic capital markets, banks in EE have been increasingly relying on external funding sources to finance their operations (mostly syndicated loans or parent support). On average, cross-border claims on banks in EE were equivalent to 17 per cent of total banking liabilities at the end of 2008, but for some countries foreign funding played a bigger role, in particular in the Baltics, in Romania and, to a lesser extent, in Bulgaria, Croatia, Hungary and Slovakia.

For EE subsidiaries the importance of funding in the wholesale international interbank markets is generally small if compared to parent-bank financing and syndicated lending, since the latter source of funding is more expensive for the subsidiary, given the risk premiums and counterparty risks. Therefore, the wholesale interbank market does not seem to be a major channel of cross-border contagion in the case of EE banks, even though it may be not negligible in some banking systems, for instance in Russia (Árvai et al., 2009).

Banking systems that are heavily dependent on foreign funding may face a shortfall of funds, or more costly access to them, in the case of a sudden reassessment of exposure to the host country due to concerns about vulnerabilities in that country or in the region. Moreover, while reputational risks and long-term business strategy may make it unlikely for parent banks to withhold support of their affiliates, the degree of their support depends on funding conditions in home markets, and may be limited if these conditions have become strained.

Problems in a host country may also result in liquidity or solvency pressures for the home countrys' banking system, provided that the exposure to the former is substantial. The magnitude of foreign exposure of Western European banking systems to EE is on average contained. The share of claims on EE was about 4 per cent of total banking assets in home countries at end-2008. This share was higher for Austria, Sweden and Belgium, while the other countries were less exposed. However, aggregate country-level data may blur relevant linkages across individual banks. In fact, a relatively small set of Western European banking groups have been taking advantage of the high growth potential offered by EE markets, developing a multiple-country presence in the region and acquiring significant market shares in a number of countries (Table 2). For some of these groups, operations in EE account for a substantial share of their profits as well as of their assets, implying that they could be negatively affected by adverse developments in this region (Figure 1). As these groups have, in some cases, systemic importance in Western European markets and, at the same time, are exposed to several EE countries, a shock affecting one EE country may spread in many directions through these institutions. Indeed, the concentration of the business among a few large and niche players may have an ambivalent effect on financial stability, as the failure of one particular market participant may affect others severely. It not only may impose losses on other institutions, but it can also create doubts about the health of other institutions. In order to analyse these potential sources of contagion, our research relies on a bank-to-bank approach, differently from other empirical papers (e.g. Van Rijckeghem and Weder, 2001).

3 Methodology

3.1 Measure of default risk

In the literature a number of different indicators have been proposed for estimating default probabilities on the basis of the prices of financial instruments. The measure of a bank's default risk used here is the *distance to default* (DD), which represents the number of standard deviations separating the bank's asset value from the book value of its liabilities (Crosbie and Bohn, 2003).[6] A greater DD is associated with a lower probability of distress. Gropp et al.(2006) argue that the DD is a complete and unbiased indicator of bank fragility (from a supervisory perspective), as it combines information about the market value of assets, earnings expectations, and leverage and volatility of assets, thus encompassing the most important determinants of bank default risk.[7]

The derivation of the DD is described in detail in Gropp et al.(2010) and in Chan Lau et al.(2007). The DD measure is based on the structural valuation model of Black and Scholes (1973) and Merton (1974). As equity holders are residual claimants in the firm since they only get paid after creditors, equity can be expressed as a call option with a strike price equal to the face value of debt D and maturity T. At expiration, the value of equity, E_T, is given by:

$$E_T = \max(A_T - D_T, 0)$$

where A_T is the asset value of the firm at expiration.

Given the standard assumptions underlying the derivation of the Black-Scholes option pricing formula, the DD in period t for the horizon of T years is given by the following formula:

$$DD_t = \frac{\ln(\frac{A_t}{D_t}) + \left(r - \frac{\sigma_A^2}{2}\right) T}{\sigma_A \sqrt{T}}$$

where r is the risk-free rate and σ_A is the asset volatility. Default occurs when the value of the firm's assets is less than the strike price, that is, when the ratio of the value

[6] A widely used measure of a bank's distress risk, the probability of default derived from Credit Default Swaps (CDS) spreads, was not considered as CDS are not available for most of the Eastern European banks included in our sample. To our knowledge, however, there is no clear evidence in the literature to suggest the most appropriate method to derive PoDs (for a general discussion see Goodhart and Segoviano, 2009), and during the recent financial crisis different types of PoDs have not produced uniform results for large banks (Singh and Youssef, 2010).

[7] They show that the distance to default is a good predictor of banks' rating downgrades in developed countries, even though its predictive performance is poorer when closer to default. Chan-Lau et al. (2004) find analogous evidence in emerging market countries.

of assets to debt is less than one. The DD is essentially the number of standard deviations in the firm's value from the default point.

Calculating DD requires knowing both the asset value and the asset volatility. The required values, however, correspond to the economic values rather than the accounting figures. In practice asset value and volatility are not observable and must be estimated with a system of simultaneous equations,[8] using the observable market value of equity capital and the equity price return volatility.[9]

As we are interested in the transmission of shocks from one bank to another, we use the percentage changes in the DD. In the spirit of "extreme value theory", to investigate contagion we focus on the behaviour of the left tail of the distribution of the changes in the distance to default, rather than examining statistical interdependence for the entire distribution.[10] As the transmission process of shocks across banks may be non-linear, looking at interdependencies in the tails of the distribution allows the examination of these non-linearities, as well as a relaxation of the assumption of multivariate normality, which tend to be violated in the case of fat-tailed financial market data (De Bandt and Hartmann, 2001; Straetmans, 2000).[11]

To take into account only lasting shocks and to reduce the noise in the data, we calculate the weekly (5 trading-day) changes in the DD (ΔDD), on a daily basis.

We identify extreme values, or large negative shocks (*exceedances*), as the 15^{th} percentile left tail of the common distribution of the ΔDDs across all banks in each subperiod.[12] For each bank, an *exceedance* at time t is thus modelled as a binary variable, y, such that:

$$y=\left\{ \begin{array}{c} 1\ if\ \Delta DD \preceq T15 \\ 0 \text{ otherwise} \end{array} \right\}$$

[8] To obtain the daily time series of DD for each bank, we have to use a non-linear system, which also implies the computation of the cumulative normal distribution. We approximated the normal distribution with a high-order polynomial, following Gapen et al. (2008), and we implemented a routine in MATLAB to solve the non-linear equations.

[9] The value of equity capital corresponds to the market capitalization of the firm, equity volatility corresponds to historical equity volatility. In our case, we drew from Datastream and Bloomberg the daily market value for each bank starting from 1 January 2002 and we computed 1-year historical equity volatility as $\sigma_E = \sqrt{252 * \sigma_d}$,where σ_d is the standard deviation of daily returns in the previous year, to reduce noise. The last parameter, the value of liabilities, D, is assumed to be equal to the face value of total liabilities and the time horizon T is fixed at one year. We calculate D from yearly balance-sheet data; then we interpolate them linearly in order to get a daily estimate. As an alternative, in the literature D is sometimes assumed to be equal to the face value of short-term liabilities plus half the face value of long-term liabilities.

[10] Interdependencies of financial returns have been traditionally modelled based on correlation analysis. However, correlation is a measure of dependence in the centre of the distribution, which gives little weight to tail events when evaluated empirically. Since distress is characterized as a tail event, correlation may not be an appropriate measure of distress dependence when marginal distributions of financial assets are non-normal (Goodhart and Segoviano, 2009).

[11] Gropp and Moerman (2004) show that not only does the distribution of precentage changes of the DD of individual banks display fat tails, but also that the correlation among banks is substantially higher for larger shocks. Bae, Karolyi, and Stulz (2003) do the same for emerging-market stock returns. Both papers suggest that it is necessary to examine the tails of the distribution separately from the overall distribution.

[12] The same threshold is used in Duggar and Mitra (2007). Ideally, a 10^{th} or even 5^{th} percentile left tail would capture the very extreme events; however, either cut-off would have resulted in far too few observations for estimations in the second part of this paper, when we consider a shorter time span to study the effect of crisis on the contagion mechanism. We have checked that our estimates are robust to the choice of a lower threshold; Tables 13 and 14 show that considering only the 10^{th} percentile left tail, differences from the baseline are in general not statistically significant, with the notable exception of contagion among EE banks.

where T15 is the 15^{th} percentile threshold in the left tail of the distribution.

3.2 Empirical model

In order to identify contagion effects and the direction of contagion from one bank to others, we employ a binomial logit, following Chan-Lau, Mitra and Ong (2007).

More specifically, we estimate the probability that bank y will be in distress at time t conditional on other banks $x_i (x \neq y)$ being in distress at time $t-1$, after controlling for other country-specific and global factors z_j. For each bank, we run the following regression:

$$\Pr(y_t = 1 \mid x\beta) = \frac{\exp(\alpha_t + \sum_{s=1}^{5} \beta_s y_{t-s} + \sum_i \pi_i x_{it-1} + \sum_{j=1}^{4} \gamma_j z_{jt})}{1 + \exp(\alpha_t + \sum_{s=1}^{5} \beta_s y_{t-s} + \sum_i \pi_i x_{it-1} + \sum_{j=1}^{4} \gamma_j z_{jt})}$$

The parameters β represents the sensitivity of bank y to extreme shocks (exceedances) experienced by the same bank in the previous periods (up to 5 lags[13]); π represents the sensitivity of bank y to extreme shocks experienced by the rest of the banks in the sample during the previous period ($x_i \neq y$) or in other words, the *co-exceedance* of shocks to bank y with shocks to other banks in the sample;[14] γ represents the sensitivity of bank y to "common shocks" z_i, i.e. financial developments in its own country as well as in global markets. All control variables are also transformed in binary 1/0 variables (following a similar procedure used for the ΔDDs) so that only extreme common shocks are identified (see, for instance, Boyson et al., 2010). Control variables are considered exogenous and therefore included at time t.[15]

3.3 Mapping risk and testing for cross-border contagion

Starting from a bank-to-bank perspective, we try to map risks that individual bank failures turn into a chain of failures across European banking systems. In particular, we are interested in measuring differences in the intensity and direction of contagion, depending on the source of shocks, the banks affected and the period considered. For this reason, we opt for a time series approach rather than a panel one. A panel analysis, carried out in a few papers (Van Rijckeghem and Weder, 2000, Baur and Fry, 2006 and 2009), has the notable advantage of better accounting for common factors underlying shock transmissions, but, on the other hand, it only provides evidence of the average contagion within the sample.

We carry out separate logistic regressions for each single bank in the sample and for each period. Then, we summarize our results to measure contagion among different

[13] We include five lags of the dependent variable in order to control for any autocorrelation in the residuals that may be induced by the use of overlapping weekly changes in the DD.

[14] As only one lag *co-exceedances* are included, we may miss those cases of contagion taking place within one day that would occur if financial markets are efficient and incorporate information very quickly (Gropp et al., 2006). On the other hand, potential simultaneity biases arising from the presence of endogenous variables suggest the use of lagged variables. As shown in Pesaran and Pick (2007), using contemporaneous regressors in this kind of model is likely to bias the measure of contagion upward. To make sure that lagged variables are actually predetermined (exogenous), we test for autocorrelation in the residuals. Q-statistics at lag 1 and up to lag 5 (Ljung-Box, 1979) reject autocorrelation in most cases, with a few exceptions in some equations estimated in the crisis period (the shorter time span).

[15] Details on data and sources can be found in Section 4.

subsets of banks, collecting the significant (positive) coefficients in individual regressions and grouping them by each subset.[16]

As the maximum number of significant coefficients depends on the number of banks in each subset, we measure contagion as the percentage of positive and significant coefficients π_i^+ out of all coefficients (regressors) π_i in the subset, that is, positive significant *contagion* effects are expressed as a percentage of all possible bank *contagion* effects, where possible cases are computed as the sum of all bank-to-bank coefficients in each set of regressions:

$$\frac{\sum_i \pi_i^+}{\#(\pi_i \; coefficients)}$$

Finally, in order to compare differences in contagion effects both across subsets and over time, we carry out a specific test for these percentages. The significance of a variable in a regression can be considered a dichotomous Bernoulli random variable (yes/no). The number (sum) of significant effects or their proportion, assuming that each variable is independent and identically distributed, is then a binomial distribution.[17] Assuming independence between two random variables, a commonly used statistic for testing the difference of proportions is given by $Z = \frac{p_1 - p_2}{V(p_1 - p_2)}$, where $V(p_1 - p_2)$ is the estimated variance of the difference $V(p_1 - p_2) = p_1(1 - p_1)/n_1 + p_2(1 - p_2)/n_2$.

Although this distribution is no longer binomial, we can reasonably use the normal approximation, which is acceptable for n large enough and p far from zero.[18] Equipped with this simple tool, we can test the significance of contagion among groups of banks and evaluate the differences over time, before and during the crisis.[19]

We also carried out McNemar's test, a testing procedure used when the two proportions p_1 and p_2 are correlated (Sheskin, 2007). As expected, all our results are confirmed with a higher probability.[20]

4 Data and descriptive statistics

Our sample is composed of 33 listed European banks. The number of banks included in the sample is the result of a selection based on the need to keep the time span sufficiently long and, at the same time, to include most of the largest banks operating in EE.[21] The

[16] This is basically a meta-analysis approach, which aims at measuring the effect of a variable on another within a specific model/relationship by collecting results from different studies (in our case estimates) and testing for the significance of their overall effect, generally comparing the mean of an experimental group to that of a control group. See for instance Rosenthal (1991).

[17] Let x_1 be the number of significant *co-exceedances* and n_1 the number of regressors in the first group of banks. Then $p_1 = \frac{x_1}{n_1}$, the proportion of significant *co-exceedances,* has a binomial distribution with mean p_1 and variance $p_1(1 - p_1)$. Similarly, the proportion of the significant *co-exceedances* in a second group of regressions has a binomial distribution with mean p_2 and variance $p_2(1 - p_2)$.

[18] A simple rule of thumb is np and n(1-p) > 5, a condition met in our case. See for instance Sheskin (2007).

[19] We are assuming that significant coefficients are mutually independent from each other. This cannot be the case, however, because coefficients come from regressions which have common regressors. This hypothesis is not restrictive, though, as the test in the case of dependent samples would be more powerful at detecting a significant difference in the samples (alternative hypothesis). Hence, our approach can be seen as conservative towards the null hypothesis of no difference in the samples.

[20] This test is feasible when the two samples are made up of the same units and so we applied it to differences over time. It cannot be used for cross-group comparisons.

[21] As highlighted by Chan Lau et al. (2007), including smaller-non systemic banks could have the effect of overestimating the impact of certain banking systems on others.

data sample is divided into three subsets. The first one (EEB) is composed of the largest Eastern European banks listed on a stock exchange and with available stock prices data from January 2003 to March 2009 (Table 3). According to these criteria, we have left out all banks in Serbia and Ukraine (as stock prices data are available only since 2006), Estonia (as there are no listed banks) and Latvia (as these banks were at the lower end of the size ranking). The sub-sample of EE banks is composed of 15 banks, including the two largest independent groups in the region (Sberbank and OTP) and 10 subsidiaries of banking groups with headquarters in advanced economies, 5 of which are included in our sample of Western European groups. The other two sub-samples (Table 4) are made up of the 9 Western European banking groups with the highest market shares in the EE banking system (SWG), provided they are listed in a stock exchange over the entire period under analysis, and the 9 remaining largest European banking groups (OWG).

In order to control for shocks affecting the local economy and global markets, we use four variables, drawing on the existing literature on financial crisis and contagion. We include the local stock market weekly returns to control for country-specific market shocks, the MSCI world price index weekly returns to control for global market shocks, the weekly percentage changes in the implied volatility index (VIX), reported by the Chicago Board Options Exchange, as a proxy of shocks to investors' risk appetite, and the weekly percentage changes in spreads between the three-month U.S. Treasury Bill interest rate and the three-month LIBOR (TED spread), as a proxy for shocks to global funding conditions. In the regressions, control variables are considered exogenous and are included at time t, except for the VIX, which is lagged by one period, to take into account the difference in trading hours between the US and Europe.

After computing banks' DD, we derive the percentage changes in DD and identify extreme negative values in the ΔDDs of individual banks across the sample in two periods, defined as January 1, 2003-July 31, 2007 (*calm period*) and as August 1, 2007-March 31, 2009, the latter starting with the global liquidity squeeze associated with the pressure in the U.S subprime market and dubbed the *crisis period*.[22]

Figure 2 presents the distribution of ΔDDs (we have 39,435 observations in the first period and 14,355 in the second period) and the 15th percentile left tail. As expected, the distribution is not normal, with fat tails which include few extreme values. Moreover, in the *crisis period* there is a shift of the distribution to the left.

Figure 3 shows the number of banks experiencing an extreme negative shock at time t, that is the number of *exceedances* at each date. Looking at the histograms, it is quite evident that tail events in the first sub-period are more evenly spread, while in the *crisis period* they are mostly concentrated in three episodes, and in particular after the collapse of Lehman Brother in September 2008.

By construction, *exceedances* occur in 15% of all observations in each sub-period. For each subset of banks, however, the frequency of *exceedances* may differ. In the first period, *exceedances* are relatively more frequent among EE banks than among SWGs and OWGs (respectively, 18%, 13% and 12% of all observations in each group). This pattern reversed during the crisis, with a prevalence of *exceedances* among SWGs and OWGs compared to EE banks (20%, 18% and 10%, respectively).

These figures are useful to shed some light on how the frequencies of *exceedances* evolve, given the occurrence of at least one shock (i.e. an *exceedance)* in our sample in the previous period. In particular, if there were not contagion, these frequencies should not

[22] The end of March 2009 is generally considered the turning point of the crisis in financial markets. In particular financial markets in emerging market countries bounced back quite quickly from the lowest levels after that time.

be affected by the presence of shocks that occurred in the previous period. The ij^{th} entry of Table 5b shows the (conditional) probability of observing at least one shock to a bank in group j in column at time t, given that at least one shock has occurred in a bank in group i in row at time $t-1$.[23] In both periods, conditional probabilities are much higher than unconditional ones, indicating that shocks tend to spread across banks and regional boundaries. Moreover, shocks seem to be persistent: the probability of a shock continuing much higher than the probability of observing shocks on two consecutive periods if these were independent. For example, in the calm period the empirical probability that a shock in SWGs continues is 23%, which is more than 10 times as large as the probability of two consecutive shocks in the same group (0.13*0.13=1.69%). Finally, conditional probabilities in the crisis period are higher and in some case more than double compared with the calm period, with the notable exception of shocks to EEBs, which remain broadly unchanged in the two periods.[24]

The fact that the probability of a shock tends to increase following a previous shock in another bank indicates that shocks disseminate and may bring about more severe effects over time. However, this preliminary analysis may overestimate contagion, as exceedances could be the result of common shocks affecting several banks at once (such as deteriorating liquidity conditions, shifts in investors' risk aversion, etc.) and for which we do not control. In addition, probabilities are conditioned on a group of banks at a time, thus assuming independence from the third group of banks left out. Finally, for each group of banks, exceedances are summed over time and across banks, neglecting the fact that they are linked over time by their coming from different time series, one for each bank. We take into account all these aspects by modelling probability of contagion in a logit model.

5 Estimation results

As stated above, we run 33 regressions in each period. From each equation we collect the significant (positive) coefficients, out of all 1,056 coefficients, and we tabulate them by sub-sample of banks and sub-period in Table 6 (*baseline model*).[25]

In the *calm period* (left-hand side of Table 6), there is some evidence of contagion among all three groups of banks.[26] This matches with the preliminary evidence we have drawn from the analysis of the transition matrix, where the transmission of extreme negative shocks across banks is not negligible even in the calm period. Moreover, considering the sample as a whole, no subset of banks stands out as a source of contagion, as shown by the percentages in the last column (All banks).

Looking at evidence of contagion for SWGs, it does not appear to be a specific source of contagion from both EEB and SWG groups, respectively, due to linkages between the two groups or similar geographic investment strategies. This result seems to be at odds with the strong presence in EE of the specialized banking groups in our sample. A possible explanation is that, at the beginning of the time span considered in our analysis, the

[23] This kind of analysis goes back to Kaminsky and Reinhart (2000). See Markwat et al. (2009) for details.

[24] Symmetrically, we construct the transition matrix of shocks at time t under the circumstance of absence of shocks at time $t-1$ (Table 5a). As expected, in both sub-periods shock probabilities are much lower than in the presence of shocks in the previous period, and in most cases are lower than unconditional probabilities.

[25] As only positive coefficients are considered, we use one-side t-test at 5% significance level. Standard errors are Huber/White robust. Regressions are available upon request.

[26] Percentages of co-exceedances are all different from zero at conventional levels (results available upon request).

weight of EE in SWGs' strategies was fairly modest. More importantly, the calm period was largely characterized by very strong economic growth in EE countries, and banks operating there made sizable profits without carrying any relevant risk.

By contrast the other sub-sample of large European banks (OWGs) shows a relatively high level of contagion coming from banks within the same subset.

EEBs look relatively prone to contagion only from the same group.

Summing up, before the crisis contagion risk appears to be concentrated mainly among the largest Western European banking groups.[27] In the period of eased financial conditions and solid economic growth up to the summer of 2007, spillovers across banking systems in Western and Eastern Europe were contained. In particular, groups investing in EE were less affected by risks in their operation in the region, possibly as, owing to the stable and high returns realized in these banking markets, the market reaction to negative news was more subdued.[28]

This pattern, however, changed following the eruption of the international financial crisis.

Our results for the *crisis period* are summarized in the right-hand side of Table 6. In addition, in Table 8 we show the results of a test of the significance of the differences in contagion risks between the crisis and the calm periods.

The main results are summed up below.

Overall, there is a more than twofold increase in contagion risk in our sample compared to the calm period (from 9.8 to 20.9% of significant *co-exceedances* on average). Contagion effects rise for all bank groups, *within* each subset and *between* each pair of subsets. The only exception is the risk of contagion *within* OWGs, which is lower in the crisis period compared with the calm period, even though the difference is not statistically significant.[29]

During the crisis, contagion among SWGs, and from SWGs to EEBs, tripled. Also contagion among EEBs and from EEBs to SWGs increased notably. Therefore, after global financial conditions changed in 2007, uncertainties about the risk of operations in EE and their adverse impact on banks' soundness seem to have contributed to deeper stress in SWGs. At the same time, SWGs coming under increasing pressure from the global financial turmoil have heightened market participants' concerns about regional banks' shock-absorption capacities.

Our findings offer only mixed evidence on the existence of a direct ownership channel. In the *crisis period*, the percentage of significant coefficients relative to subsidiaries in parent banks' regressions is 25% and it is not statistically different from the overall average for SWGs. On the other hand, about 40% of all coefficients relative to parent banks in subsidiaries' regressions are significant, a percentage much higher than the average for EEBs and this result seems to suggest that the banking group linkages may have played

[27] Our findings are broadly consistent with those of Čihák and Ong (2007), who analyse contagion in a sample of 33 (mostly Western) European major banks between May 2000 and April 2007. The authors find significant spillovers in about 11 per cent of all possible links among the banks in their sample.

[28] Table 7 summarizes the results on the statistical significance of control variables (percentage of significant coefficients). Local market shocks show the highest proportion of significant coefficients for both EEB and SWG groups. The significance of global funding conditions strongly increased in the crisis period, especially for OWGs. However, as global banks' performance and strategies influence global financial conditions, the increase of significant common factors may reflect an endogeneity problem (Pesaran and Pick, 2007).

[29] This result may reflect the fact that the crisis started primarily as a leap in systemic risk in the banking systems of advanced economies, and among the largest banking groups idiosyncratic shocks were blurred by the markets' perception of an overall deterioration of banking system conditions, over and above direct and bilateral links, as shown also by the increased significance of global funding conditions as an explanatory variable (Table 7, column 2). The same reasoning may be applied to the low increase in cross-contagion among SWGs and OWGs.

a role in the transmission of contagion to Eastern European banking systems during the recent financial crisis. However, the weight of this channel should not be overstated, as significant coefficients relative to parent-subsidiary linkages represent no more than 9% of all significant coefficients in the subset of contagion effects from SWGs to EEBs. More importantly, as shown in Table 9, the result that contagion from SWGs to EEBs increased during the recent crisis is only weakly affected by the presence of parent-subsidiary linkages and stands up even excluding from the regressions all coefficients related to group linkages. Indeed, even though the percentage of significant positive coefficients in the crisis period drop to 20.2%, the difference between the two periods is still significant at the 5% level.

Finally, the increase of *co-exceedances* within EEBs shows evidence of regional contagion. This effect and contagion coming from SWGs may support a common lender explanation.[30]

Our results come with some caveats. As we use lagged bank idiosyncratic shocks in order to avoid a likely positive simultaneity bias, we may miss those cases of contagion taking place within one day. Some banks in our sample may play a significant role in interbank markets or in global or local stock markets, suggesting that some common shock variables, such as conditional volatility, may in fact capture effects that are related to contagion. Our approach is rather conservative, as regards the testing procedure as well as the definition of *co-exceedances*, based on filtered data, which may reduce the power of regressions to identify contagion.[31]

5.1 Testing for emerging market contagion

In order to gain further insight into the transmission of shocks among Eastern and Western European banking systems, in this section we perform a counterfactual experiment, replacing the sample of EEBs by an equal number of emerging market banks, taken as a control group, all from South America. Our goal is to test the hypothesis that, with respect to contagion from and to EEBs, our results reflect specific effects, associated to existing linkages with Western European banks, and do not reflect a broader contagion to and from emerging markets. In order to run our experiment, we select 15 large Latin American banks (LABs), 4 of which belong to two European banking groups included in our sample (Table 10).

Results are displayed in Table 11, while in Table 12 we carry out a test for the significance of the differences in contagion risks between the baseline model and the model with LABs. Two results are worth noticing. In the crisis period contagion from SWGs to EEBs is significantly higher than contagion to LABs. This, together with the circumstance that estimates of contagion among SWGs are not statistically different from the baseline, can be seen as evidence of the robustness of our results regarding specialized Western groups. By contrast, contagion from EEBs to SWGs is higher than contagion from LABs to SWGs, but not significantly different.

Overall, these two latter results suggest that while during the crisis regional specialisation of some European banks resulted in a higher level of contagion to EE banking systems, there is much weaker evidence that contagion from EEBs to Western European groups was any different than contagion from other emerging markets.[32]

[30] The role of specialization also emerges by comparing contagion to EEBs from the two subsets of Western European banks. Contagion to EEBs from OWGs is significantly lower than contagion from SWGs (the difference between the two effects is of 9 percentage points, significant at a 10% level).

[31] See Dungey et al. (2005b).

[32] A high level of contagion between two areas apparently with limited economic and financial linkages can occur through cross-market rebalancing: global investors respond to a shock to a market by readjusting

6 Conclusions

In this paper we use a stock market-based indicator, the distance to default, to highlight contagion risks in Western and Eastern European banking sectors. In the spirit of "extreme value theory", we identify wide variations in this measure as depicting major shocks in banks' financial conditions. Contagion occurs when the incidence of such tail events is associated with similar shocks hitting other banks in the previous period, after controlling for common factors. We distinguish between the period before and after the crisis, because, due to information problems, contagion risk may have increased significantly in the latter period. Improving on the literature, we introduce a testing procedure to measure changes in contagion effects across different groups of banks and over time.

We find that before the recent financial crisis, contagion was generally limited to the largest Western European banking groups, while contagion from Western to Eastern Europe, and the reverse, was relatively less likely. The crisis has not only heightened the risks of cross-border contagion but also modified their patterns. Contagion among Western European banks with the highest market share in EE and from these groups to Eastern European banks shows the largest increase in our sample. We also find evidence of contagion spreading from Eastern European banks to their Western European counterparts, but this result is much weaker, possibly reflecting the presence of a broader phenomenon of contagion from emerging markets sources.

Our findings suggests that after global financial conditions changed in 2007, uncertainty about the risk stemming from operating in EE has increased market participants' concerns about banks' shock-absorption capacities and has contributed to deeper stress in Western European banks with a strong market presence in EE as well as Eastern European banks. This is not surprising, because since the onset of the crisis, financial analysts have singled out EE as one of the riskiest regions among emerging market economies, less able to stand a sudden deterioration of global financial conditions.

The methodology used in this paper does not allow us to explore the exact nature of the underlying transmission channels of contagion. On the other hand, as our measure of contagion reflects risks perceived by equity holders, its main advantage is to encompass all possible channels of transmission, without relying on accurately measuring any particular one. Nevertheless, some conclusions can be drawn about which channels were more likely than others during the crisis. For example, banking group linkages might have played a role in the transmissions of shocks to EE, even though this was not the only channel (and not even the major one) at work in contagion from SWGs to EEBs. Regarding contagion among SWGs, and from SWGs to EEBs, a reaction of equity holders mimicking a run by depositors has probably been an important channel of propagation of contagion, as shocks seem to have propagated due to asymmetric information, with negative news about one bank triggering widespread sell-offs in stocks of other banks sharing similar business strategies.

their portfolio in another market. Due to asymmetric information problems, this effect is more intense during crises (see Krodes and Pritsker, 2002).

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Tables and figures

Table 1 Foreign claims on Eastern European countries

	Foreign claims on non-banks	Cross-border claims on banks	Claims of Western European banks on EE countries (3)						
	(1)	(2)	Austria	Belgium	France	Germany	Italy	Netherlands	Sweden
Bulgaria	64.5	25.8	10.2	3.8	7.1	5.3	14.9	1.3	0.0
Croatia	81.4	28.8	33.7	0.7	8.5	24.5	42.9	0.3	0.0
Czech Republic	96.8	11.1	24.7	22.8	13.6	5.2	5.9	3.1	0.0
Estonia	86.8	51.8	0.8	0.4	0.5	3.4	1.3	0.0	93.2
Hungary	72.9	27.9	20.7	10.0	5.9	18.9	16.5	2.7	0.2
Latvia	76.3	40.0	0.9	0.0	0.6	9.6	2.1	0.0	51.6
Lithuania	70.9	41.1	0.7	0.2	1.2	8.7	1.9	0.3	73.8
Poland	67.9	15.5	4.2	6.6	5.1	14.5	11.2	9.4	2.1
Romania	94.6	37.7	35.8	1.0	13.4	3.6	11.0	8.8	0.1
Russia	20.4	9.5	2.4	1.1	2.8	4.4	2.5	2.2	1.1
Serbia	69.0	18.1	21.4	0.2	7.5	11.1	16.6	0.1	0.0
Slovakia	99.0	17.3	40.8	13.4	6.1	4.2	23.4	3.8	0.7
Ukraine	29.0	21.3	9.1	0.7	7.7	3.6	3.2	2.6	4.6
Eastern Europe	41.9	17.1	11.1	5.2	5.6	8.0	8.2	3.7	4.5
Memorandum item									
Exposure of reporting countries (4)	-	-	17.1	6.7	1.2	1.7	3.7	2.7	8.3

Sources: BIS, ECB, IMF and national authorities.

(1) Cross-border claims and local claims of foreign affiliates as a percentage of total cross-border and domestic credit to non-banks.

(2) Cross-border claims on banks as a percentage of total banking liabilities in the host country.

(3) As a percentage of total banking assets in the host country.

(4) As a percentage of total banking assets in the home country.

Table 2 Market share of key Western European banking groups (1)

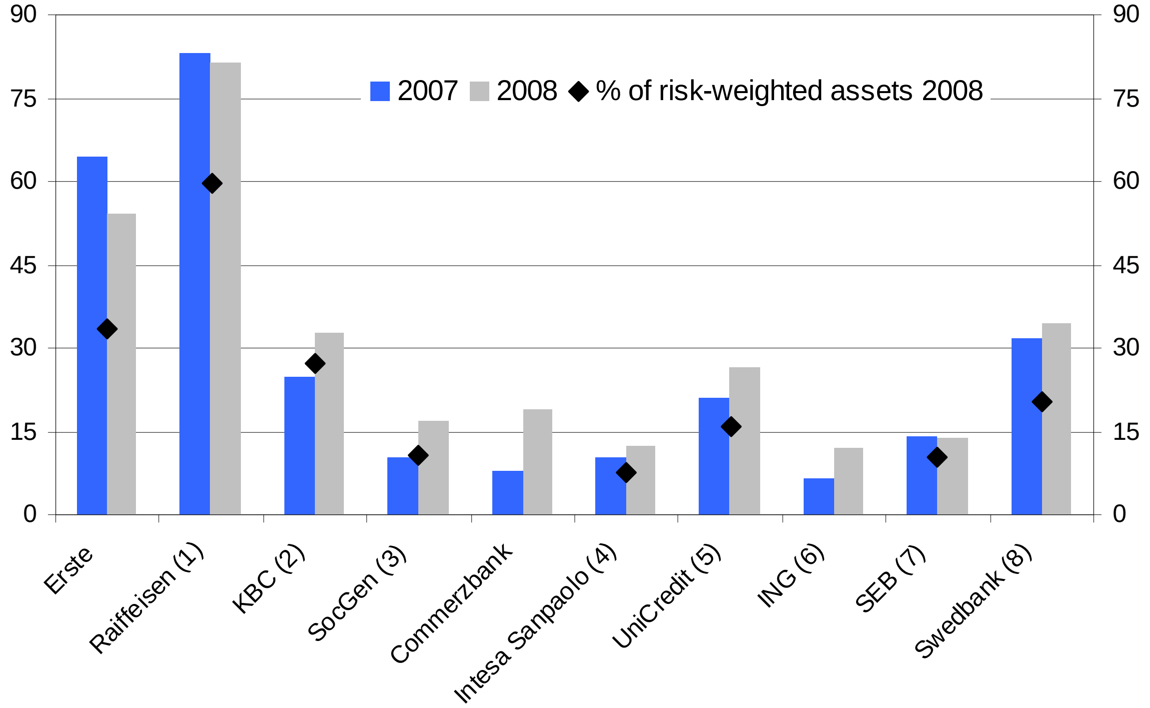
	UniCredit (Italy)	Erste (Austria)	Raiffeisen (Austria)	KBC Group (Belgium)	SocGen (France)	Intesa Sanpaolo (Italy)	Commerzbank (Germany)	ING (Netherland)	Swedbank (Sweden)	SEB (Sweden)
Bulgaria	15.8	0.0	9.9	2.7	3.6	0.0	0.0	0.7	0.0	0.0
Croatia	24.3	12.1	11.2	0.0	7.3	18.2	0.0	0.0	0.0	0.0
Czech Republic	6.9	20.4	6.5	24.7	16.8	0.0	2.2	3.2	0.0	0.0
Estonia	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.9	21.1
Hungary	6.2	8.5	8.7	10.3	0.0	9.9	0.9	0.0	0.0	0.0
Latvia	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.7	13.0
Lithuania	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2	28.8
Poland	12.8	0.0	2.8	3.7	0.4	0.0	8.4	6.7	0.0	0.0
Romania	5.2	20.5	5.7	0.0	15.1	1.0	0.0	0.0	0.0	0.0
Russia	2.0	0.0	2.0	0.6	2.8	0.3	0.3	0.6	0.2	0.0
Serbia	5.0	2.8	9.1	0.9	4.0	14.1	0.0	0.0	0.0	0.0
Slovakia	7.1	19.0	16.1	12.4	0.5	16.7	0.3	2.9	0.0	0.0
Ukraine	6.5	1.2	7.1	0.0	0.0	0.8	2.2	1.0	2.3	0.0
Eastern Europe	6.1	4.8	4.5	4.5	3.9	2.3	1.8	1.8	1.7	1.0

Sources: company data and national authorities

(1) As a percentage of total banking assets in the host country.

Note: data as at end-2008, representing ownership structure as of December 2009. Only participations of 50% or more of share capital are considered.

Figure 1 Western Bank Groups' Exposure to Emerging Europe
(% of operating income in 2008 and 2009 and of risk-weighted assets in 2008)



Source: company data.

Notes:

(1) Central Europe, South-Eastern Europe, Russia and other CIS. Net interest income instead of operating income.

(2) Banking RWA in CEER business line as a percentage of total risk-weighted banking assets.

(3) RWA of subsidiaries in Czech Republic, Bulgaria, Croatia, Romania, Russia and Serbia. On-balance sheet commitments in Eastern Europe for 2007.

(4) International subsidiaries bank division. Loans to customers instead of RWA.

(5) Poland and CEE Divisions.

(6) Underlying income for retail banking operations in Central Europe to total underlying income in retail banking.

(7) Baltic countries. On and off balance sheet credit exposure instead of RWA.

(8) Baltic and international banking operations.Total assets instead of RWA. External income instead of operating income.

Table 3 Sample of Eastern European banks

Bank	Country	Western European Parent Group	Total Assets in 2008 (million euros)
Eastern European banks (EEB)			
SBERBANK	Russia		164,753
Bank Pekao	Poland	UniCredit	32,010
OTP Bank	Hungary		35,866
Komercni Banka	Czech Republic	Société Générale	25,964
BRE Bank	Poland	Commerzbank	20,041
ING Bank Slaski	Poland	ING Group	16,888
Zagrebacka Banka	Croatia	UniCredit	14,501
Bank Handlowy Warszawie	Poland	Citigroup	10,323
Privredna Banka Zagreb	Croatia	Intesa Sanpaolo	9,927
Bank Millennium	Poland	Millenium BCP	11,428
Vseobecna Uverova Banka	Slovakia	Intesa Sanpaolo	11,370
AB DnB NORD Bankas	Lithuania	DnB NOR	4,092
Bankas Snoras	Lithuania		2,478
Central Cooperative Bank	Bulgaria		862
BRD	Romania	Société Générale	12,910

Source: Bankscope

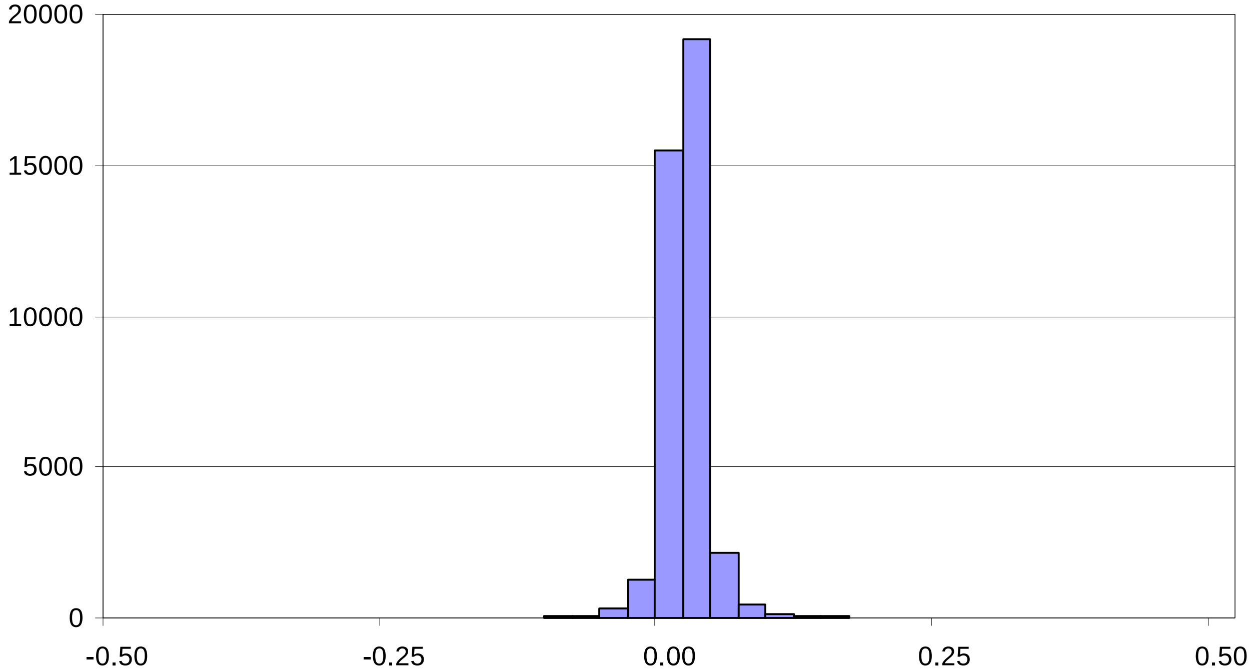
Table 4 Sample of Western European groups

Bank	Country	Total Assets in 2008 (million euros)
	Specialised Western European groups (SWG)	
ING Group	Netherlands	1,034,689
KBC Group	Belgium	318,550
Société Générale	France	1,130,003
UniCredit	Italy	1,045,612
Intesa Sanpaolo	Italy	636,133
Commerzbank	Germany	625,196
Erste Group Bank	Austria	201,441
Swedbank	Sweden	166,670
Skandinaviska Enskilda Banken	Sweden	230,976
	Other Western European groups (OWG)	
BNP Paribas	France	2,075,551
Credit Agricole	France	857,471
Deutsche Bank	Germany	2,202,423
Barclays	United Kingdom	2,150,537
Royal Bank of Scotland	United Kingdom	1,967,122
Banco Santander	Spain	1,049,632
BBV Argentaria	Spain	542,650
Lloyds Banking Group	United Kingdom	456,742
HSBC	United Kingdom	968,127

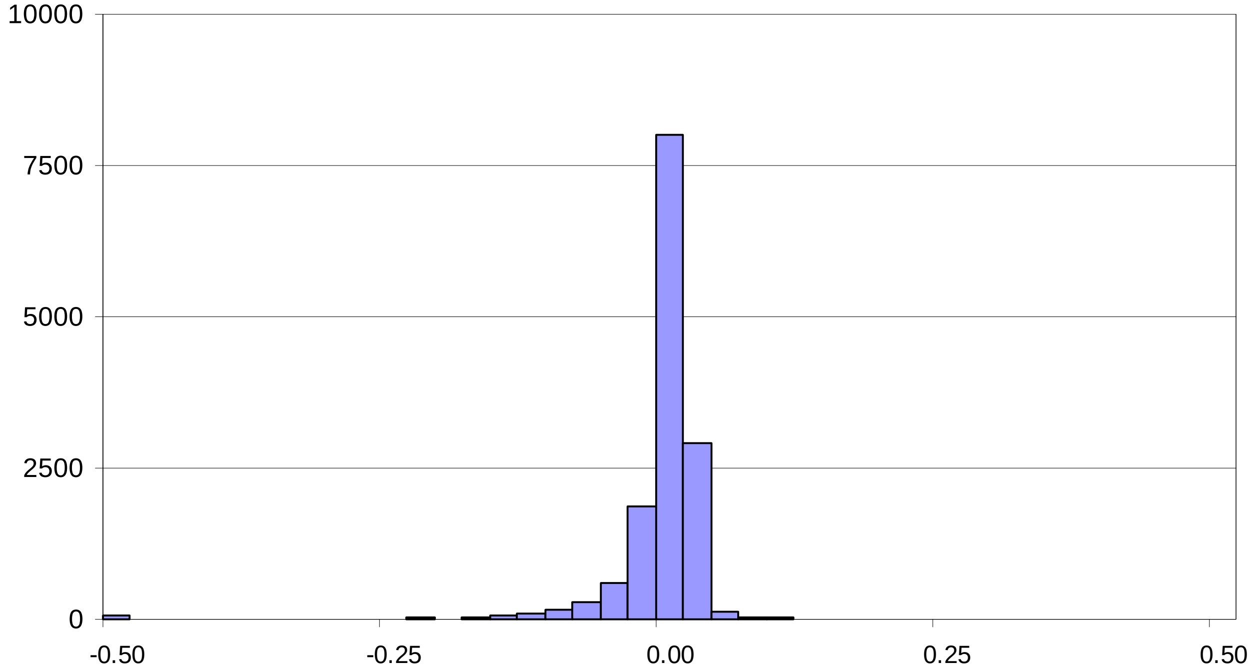
Source: Bankscope

Figure 2 Distribution of changes in distance to default

1 January 2003 to 31 July 2007



1 August 2007 to 31 March 2009



Source: authors' calculations.

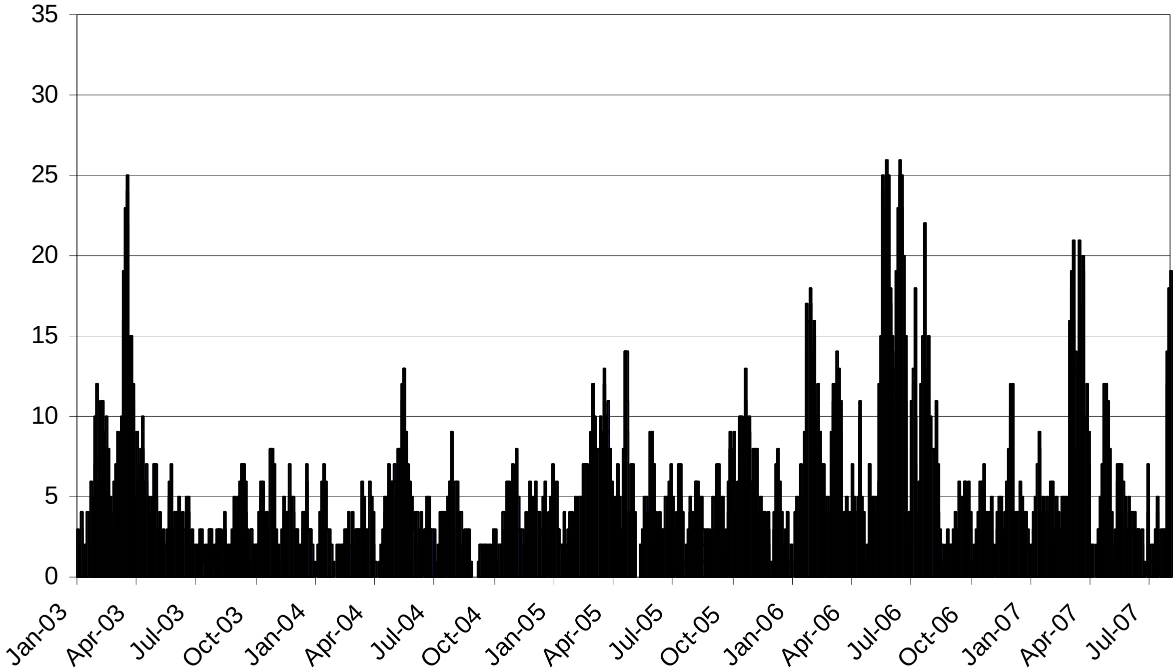
Notes:

Distribution of stacked data on 33 banks' changes in the distance to default.

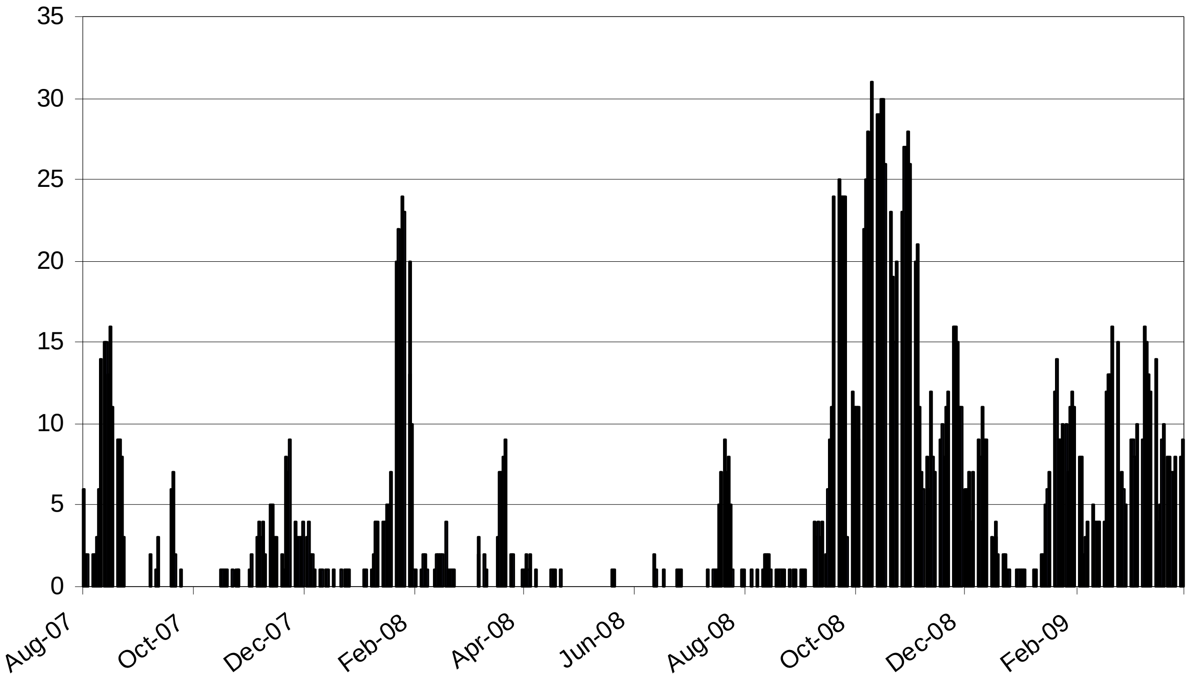
Observations are 39,435 in the first period and 14,355 in the second period. 15^{th} percentile left tail is -0.009 in the period January 2003 to July 2007 and -0.036 in the period August 2007 to March 2009

Figure 3 Exceedances
(number of banks out of 33 in the negative tail)

1 January 2003 to 31 July 2007



1 August 2007 to 31 March 2009



Source: authors' calculations.

Table 5a Shock transition probabilities in the absence of shock in $t-1$
(as a percentage of all possible outcomes)

	(January 2003 - July 2007)				*(August 2007 - March 2009)*			
	SWG	OWG	EEB	All banks	SWG	OWG	EEB	All banks
SWG	2.8	4.6	17.5	10.0	1.3	4.1	3.5	3.0
OWG	5.6	1.6	16.7	9.6	15.5	13.7	7.9	11.5
EEB	8.1	6.4	3.9	5.7	5.4	8.9	1.2	4.5

Note: cell ij in the table shows the probability of observing at least one shock to a bank in group j at time t, given that no shock occurred in the bank group i at time t-1.

Table 5b Shock transition probabilities given a shock in $t-1$
(as a percentage of all possible outcomes)

	(January 2003-July 2007)				*(August 2007-March 2009)*			
	SWG	OWG	EEB	All banks	SWG	OWG	EEB	All banks
SWG	23.1	19.6	18.8	20.2	39.5	39.8	18.9	30.2
OWG	23.3	26.7	20.1	22.7	29.9	30.6	14.6	23.2
EEB	13.4	12.6	19.6	16.0	29.9	30.0	18.6	24.8

Note: cell ij in the table shows the probability of observing at least one shock to a bank in group j at time t, given that at least one shock occurred in the bank group i at time t-1.

Table 6 Significant co-exceedances, baseline model
(as a percentage of all possible links)

	(January 2003-July 2007)				*(August 2007-March 2009)*			
	Contagion to:				*Contagion to:*			
	SWG	OWG	EEB	All banks	SWG	OWG	EEB	All banks
Initial shock to:								
SWG	6.9	14.8	8.9	10.1	26.4	23.5	26.7	25.7
OWG	8.6	20.8	6.7	10.8	17.3	11.4	17.9	16.1
EEB	5.9	10.4	10.0	9.0	20.5	19.1	22.5	21.0
All banks	6.9	14.2	8.8	9.8	21.1	18.4	22.4	20.9

Note: only positive significant coefficients (up to 5% in a one-side t-test) are included. Standard errors are Huber/White robust.

Table 7 Control variables
(percentage of significant coefficients)

	(January 2003 - July 2007)				*(August 2007 - March 2009)*			
	SWG	OWG	EEB	All banks	SWG	OWG	EEB	All banks
Variable								
Global market shocks	11.1	22.2	13.3	15.2	11.1	12.5	27.3	17.9
Local market shocks	66.7	11.1	46.7	42.4	33.3	33.3	46.2	38.7
Investor risk appetite	0.0	44.4	6.7	15.2	0.0	44.4	0.0	12.5
Global funding conditions	0.0	0.0	13.3	6.1	11.1	75.0	7.1	25.8

Note: significant coefficients up to 10% are included.

Table 8 Change in significant co-exceedances
(August 2007 - March 2009 to January 2003 - July 2007)
(percentage points)

	Contagion to:			
	SWG	OWG	EEB	All banks
Initial shock to:				
SWG	19.4***	8.6	17.8***	15.6***
	(6.0)	(6.1)	(4.6)	(3.1)
OWG	8.6*	-9.4	12.7***	6.1*
	(5.1)	(6.1)	(3.9)	(2.8)
EEB	14.5***	8.7**	12.5***	12.0***
	(4.1)	(4.3)	(3.6)	(2.3)
All banks	14.1***	4.2	13.6***	11.2***
	(2.8)	(3.1)	(2.3)	(1.6)

Note: standard errors in parentheses; *, **,*** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 9 Significant co-exceedances: no banking group linkages
(as a percentage of all possible links)

	(January 2003-July 2007)				*(August 2007-March 2009)*			
	Contagion to:				*Contagion to:*			
	SWG	OWG	EEB	All banks	SWG	OWG	EEB	All banks
Initial shock to:								
SWG	6.9	14.8	10.2	10.7	26.4	23.5	20.2	22.7
OWG	8.6	20.8	6.7	10.8	17.3	11.4	17.2	15.8
EEB	5.5	10.4	10.0	8.9	21.6	19.2	19.6	20.0
All banks	6.8	14.2	9.1	9.9	21.6	18.5	19.0	19.6

Notes:
Coefficients relative to parent-subsidiary linkages are excluded from regressions.
Only positive significant coefficients (up to 5% in a one-side t-test) are included.
Standard errors are Huber/White robust.

Table 10 Sample of Latin American banks

Bank	Country	Western European Parent Group	Total Assets in 2008 (million euros)
		Latin American banks (LAB)	
Itau Unibanco Holdings	Brazil		183,675
Banco do Brasil	Brazil		160,329
Banco Santander Chile	Chile	Banco Santander	24,142
Banco de Chile	Chile		20,706
Banco de Credito e Inversiones	Chile		15,404
Banco de Credito del Peru	Peru		12,701
Banco Inbursa	Mexico		11,127
Mercantil Banco Universal	Venezuela		10,112
Banco Provincial	Venezuela	BBVA	9,498
BBVA Banco Continental	Peru	BBVA	7,654
BBVA Banco Frances	Argentina	BBVA	5,405
Banco Santander Rio	Argentina	Banco Santander	5,141
Banco de Galicia y Buenos Aires	Argentina		5,115
Banco Macro	Argentina		4,694
Banco Mercantil do Brasil	Brazil		2,081

Source: Bankscope.

Table 11 Significant co-exceedances: Latin American banks
(as a percentage of all possible links)

	(January 2003-July 2007)			*(August 2007-March 2009)*		
	Contagion to:			*Contagion to:*		
	SWG	OWG	LAB	SWG	OWG	LAB
Initial shock to:						
SWG	15.3	16.0	4.4	22.2	14.8	14.7
OWG	12.3	19.4	7.4	9.9	12.5	20.5
LAB	5.9	3.0	10.0	14.5	13.0	32.4

Note: only positive significant coefficients (up to 5% in a one-side t-test) are included. Standard errors are Huber/White robust.

Table 12 Change in significant co-exceedances
(Baseline to Latin American banks)
(percentage points)

	(January 2003-July 2007)			*(August 2007-March 2009)*		
	Contagion to:			*Contagion to:*		
	SWG	OWG	EEB to LAB	SWG	OWG	EEB to LAB
Initial shock to:						
SWG	-8.3	-1.2	4.4	4.2	8.6	12.1**
	(5.2)	(5.7)	(3.0)	(7.1)	(6.1)	(5.1)
OWG	-3.7	1.4	-0.7	7.4	-1.1	-2.6
	(4.8)	(6.7)	(3.1)	(5.4)	(5.4)	(5.1)
EEB to LAB	0.0	7.4**	0.0	5.9	6.1	-9.9*
	(2.9)	(3.0)	(2.9)	(4.8)	(4.7)	(5.4)

Note: standard errors in parentheses; *, **,*** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 13 Significant co-exceedances: large negative shock as the 10^{th} percentile
(as a percentage of all possible links)

	(January 2003-July 2007)				*(August 2007-March 2009)*			
	Contagion to:				*Contagion to:*			
	SWG	OWG	EEB	All banks	SWG	OWG	EEB	All banks
Initial shock to:								
SWG	15.3	19.8	9.7	13.9	22.2	14.8	29.4	23.3
OWG	18.5	20.8	7.4	10.8	20.0	21.7	25.2	22.9
EEB	9.7	11.1	10.0	10.2	21.4	23.1	35.7	27.9
All banks	13.6	16.0	9.2	12.2	21.2	20.2	30.8	25.2

Note: only positive significant coefficients (up to 5% in a one-side t-test) are included. Standard errors are Huber/White robust.

Table 14 Change in significant co-exceedances
(Baseline to large negative shock as the 10^{th} percentile)
(percentage points)

	(January 2003-July 2007)			*(August 2007- March 2009)*		
	Contagion to:			*Contagion to:*		
	SWG	OWG	EEB	SWG	OWG	EEB
Initial shock to:						
SWG	-8.3	-4.9	-0.8	4.2	8.6	-2.6
	(5.2)	(5.9)	(3.5)	(7.1)	(6.1)	(5.5)
OWG	-9.9*	0.0	-0.7	-2.7	-10.3*	-7.3
	(5.3)	(6.8)	(3.1)	(6.1)	(6.3)	(5.1)
EEB	-3.8	0.7	0.0	-0.9	-4.0	-13.2***
	(3.3)	(3.8)	(2.9)	(5.0)	(5.2)	(4.6)

Note: standard errors in parentheses; *, **,*** denote statistical significance at the 10%, 5% and 1% levels, respectively.

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