When the Rivers Run Dry:
Liquidity and the Use of Wholesale Funds in the Transmission of the U.S. Subprime Crisis[*]

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Abstract

This paper provides new systematic evidence of the role of banks' reliance on wholesale funding in the international transmission of the financial crisis of 2007-2008. It conducts an event study to estimate the impact of the liquidity crunch of September 15, 2008, on the stock price returns of 772 individual banks across 44 countries, and tests whether differences in abnormal returns relate to these banks' ex-ante reliance on wholesale funding. Globally and within countries, banks that relied more heavily in non-deposit sources of funds experienced a significantly larger decline in stock returns even after controlling for other transmission mechanisms.

1 Introduction

During the second half of 2007, the problems caused by the increase in defaults in US subprime mortgages--observed since late 2006, quickly started to spread across asset classes and countries. This spread resulted in an international financial crisis with strong repercussions in the real US and global economy even as of late 2010.

The crisis has reshaped the global financial landscape: Bear Stearns and Lehman Brothers, two of the largest US investment banks, merged or filed for bankruptcy. The US government bailed out the two largest US banks, Citibank and Bank of America, and the insurance giant AIG, and put under conservatorship Fannie Mae and Freddy Mac, the two largest US mortgage companies. As a result, the traditional model of investment banking that dominated Wall Street during the 20th century disappeared altogether. Outside the US, many large financial institutions have either experienced large losses or been taken over by their governments, such as BNP Paribas in France, Northern Rock in the UK, UBS in Switzerland, and IKB in Germany, just to name a few. In other countries, like Iceland and Ireland, the whole banking system has been at the verge of collapse and has received massive government bailouts and guarantees, some of which have lead to serious fiscal problems[1]

The magnitude and reach of the ongoing financial crisis, several orders of magnitude larger than the size of the initial shock, has led many to wonder how a shock to a seemingly small segment of the US financial market managed to propagate so much, so fast. By July 2007 most analysts still expected limited consequences from the collapse of the subprime mortgage market because it represented only about 12 percent of the overall US mortgage market, which in turn was only 30 percent of US fixed income markets (Deutsche Bank, 2007). As frequently mentioned, US stock markets routinely dealt with the expected losses in subprime loans, then valued at about $200 billion. A widespread contagion across asset classes and especially across countries was considered unlikely. For instance, on May 17, 2007, the chairman of the US Federal Reserve, Ben Bernanke, stated: *"We believe the effect of the troubles in the subprime sector on the broader housing market will be limited and we do not expect significant spillovers from the subprime market to the rest of the economy or to the financial system."*

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[1] On September 30th, 2008, Ireland's finance minister announced a blanket guarantee on the deposits and almost all the debt of the country's six biggest banks until September 2010. The Iceland government nationalized its three largest banks on early October 2008. These policies imposed large fiscal burdens that have leaded the Irish government to seek help from the International Monetary Fund.

Although a standard real channel through trade linkages with the US has undoubtedly played a role in the international transmission of the crisis (Levchenko et al. 2009), the timing of some of the events strongly suggests that the first line of action took place through international financial linkages. For instance, the bank run on Northern Rock took place in September 2007, only one month after the beginning of the crisis in the US and when the US economy had not started to contract yet.

This paper studies the financial mechanisms behind the international transmission of the crisis. In particular, the role of the increasing use of wholesale funds as a source of financing for banks and other financial institutions. Among several possible sources of financial linkages such as exposure to correlated risks, a global decline in risk appetite, and shocks to investors or institutions with positions in many markets, there has been during this crisis a lot of attention focused on the potential role played by the worldwide reliance of financial institutions on short-term wholesale funds. There are three basic reasons for this attention. First, the crisis resulted in a sharp and widespread collapse in US wholesale and interbank market funds, including repo markets (Brunnermeier, 2009; Gorton, 2009). Second, interbank markets have become increasingly connected, so the contraction in interbank lending was not limited to the US, but consisted in a worldwide decline in liquidity provision (Acharya and Merrouche, 2009; Brunetti et al. 2009). Finally, financial institutions worldwide have increasingly relied on wholesale funding to supplement demand deposits as a source of funds, becoming, therefore, vulnerable to a sudden dry up of them.[2]

The combination of these three ingredients could explain the global spread of distress across the financial sectors of different countries, particularly across their banking sectors. In fact, although the earlier literature emphasized the benefits of these alternative sources of financing (Feldman and Schmidt, 2001; Calomiris, 1999), some voices of concern about the implications of this liability structure for systemic vulnerability had been raised before the crisis. For instance, Rajan (2006) noted that banks' greater reliance on market liquidity makes their balance sheets more suspect in times of crisis, and Demirguc-Kunt and Huizinga (2009) found that a bank's reliance on non-deposit sources of funds increases its risk. These concerns increased as the ongoing financial crisis started to unfold, and recently various papers and publications have suggested that banks' reliance on wholesale funds may have been behind the failure of some institutions. Shin (2009) indicates that the cause of the Northern Rock demise was not its reliance on securitization, but rather its high leverage, coupled with its reliance on institutional investors for short-term funding. The Economist (2008), citing Citigroup analysts stated that:

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[2] Stylized facts backing these claims will be presented in section 2.

"A growing number of banks are being subjected to a wholesale version of a bank run, with access to wholesale funding evaporating in a matter of days, if not hours". Also in its recent review of the causes of the recent financial crisis, Brunnermeier (2009) indicates that banks' increasing use of short-term maturity instruments left them particularly exposed to a dry-up in funding liquidity, and Huang and Ratnovski (2008) present a theoretical model that highlights the dark side of bank wholesale funding

However, despite the emphasis recently put on the use of wholesale funding as a source of international propagation of the crisis, and the anecdotal evidence from cases like the one of Northern Rock, there is so far no systematic evidence of its role and its potential to facilitate broad international contagion independently of other real and financial transmission mechanisms. Was the increasing use of wholesale funds by banks worldwide systematically important for the international transmission of the crisis, or was the failure of some wholesale dependent banks an anecdotal side show?

This paper aims to answering this question and provides systematic evidence of the importance of banks' reliance on wholesale funding as a source of vulnerability, and of its contribution to the international transmission of the financial crisis. The paper focuses on the largest episode of the crisis: the bankruptcy of Lehman Brothers on September 15, 2008 (henceforth *"Lehman"*). This event resulted not only in a sharp liquidity crunch but also in an abrupt decline in asset prices and risk appetite, constituting an ideal shock to study the qualitative and quantitative impact of various channels of financial contagion. The methodological approach combines in a novel way ingredients from a standard event study with those of difference-in-difference estimation to determine the impact of Lehman on the stock-price returns of 772 individual banks across 44 countries excluding the US, and to test whether differences in abnormal returns are related to the banks' ex-ante reliance on wholesale funding, after controlling for other bank characteristics. The test relies on the idea that if the use of wholesale funds was important for the international contagion of the Lehman event, banks with higher dependence on wholesale funds would be more affected and perform worse than other banks located in the same country. On the other hand, if the main transmission mechanism is unrelated to the banks' exposure to a liquidity shock, there is no particular reason for wholesale dependent banks to perform relatively worst after controlling for other bank characteristics related to alternative sources of contagion. Furthermore, if the transmission was purely panic driven, one would observe a large average decline in banks performance, unrelated to fundamental bank characteristics.

The use of an event study methodology has two important advantages for understanding the channels of transmission of the crisis. First, as long as the event is unanticipated and exogenous,

the estimates have a clear causal interpretation: they measure the abnormal impact of the shock on each of the banks in the sample. Therefore, differences in these abnormal impacts across banks provide strong causal indirect evidence on the mechanisms of propagation of the shock. Second, the use of daily data permits isolating the impact of the shock from that of the policy responses to it. The recent financial crisis was an extremely eventful period where shocks were quickly followed by massive government interventions on many fronts. Looking at long-term performance differences across banks may confuse their differential responses to the shocks driving the crisis and to the policy responses taken to alleviate them. It is also more prone to endogeneity problems since a country's policy responses may be related to the exposure of its banks to various sources of risks.

The results confirm that the banking sector across the world experienced a large and significant abnormal return decline following this event. Banks' abnormal returns worldwide declined about 3 percent in the three days after Lehman. More interestingly, the results show that, within countries, banks that before the crisis relied more heavily on wholesale funding experienced a larger abnormal return decline in response to US events than other banks. In the days following Lehman, within a country, the returns of banks with high wholesale dependence (75th percentile) declined about 2 percent more than those with low wholesale dependence (25th percentile). This difference is not only large but also statistically significant. These qualitative and quantitative results persist after controlling for other bank characteristics that could explain their differential response to the Lehman episode, such as banks' riskiness, size, profitability, direct exposure to Lehman Brothers, ownership, or specialization. While not the main focus of the paper, the results show that some of these characteristics also affected the relative returns of banks in manners that are consistent with increases in counterparty risk and the importance of the too-big-to fail argument immediately after Lehman.

Quantitatively, the results show that the use of wholesale funds can explain an important fraction of the fast global transmission of this event, confirming that the widespread use of these types of funds played a significant role in the propagation of the financial crisis. A similar but weaker pattern emerges during the early stages of the crisis (August 9, 2007) which confirms the presence of liquidity based transmission but suggests that other factors, such as the exposure of international banks to subprime mortgages, may have initially played a more important role.

The main findings of the paper on the differential impact of the event on banks with higher wholesale dependence rely only on the within country, across-banks, daily variation of the data, so they are not driven by country-level differences on the incidence of the crisis, or on any measure of aggregate exposure. In addition, the paper's main results are robust to a battery of

changes in the details of the specification and estimation procedure. As an extension, the paper explores the role of some country level characteristics on explaining the vulnerability of wholesale dependent banks after Lehman, but finds no supportive evidence that many of the characteristics mentioned in the policy discussion, such as the coverage of deposit insurance, reduce the vulnerability of wholesale dependent banks to liquidity crunches.

The paper also sheds some light on the role of banks' use of wholesale funds on the transmission of the crisis to the real economy. Comparing, for each bank in the sample, the last balance sheet reported before and the first balance sheet reported after the bankruptcy of Lehman Brothers, it shows that loans, assets, and loan to asset ratios contracted relatively more in wholesale dependent banks, controlling for other bank's balance sheet characteristics. The magnitude of the relative decline is large, loans grew 0.7 percent slower (on a monthly basis) in a bank at the 75th percentile of wholesale dependence than in a bank at the 25th percentile. Because of data availability, these results do not come from a high frequency event study and compare outcomes over a long period (typically one year), so the shock is not well identified and may confuse the shocks with the policy responses. Nonetheless, they provide reduced form evidence that this source of vulnerability may have consequences for the real economy.

This paper relates to several strands of literature. First, and most directly, it relates to the recent theoretical and empirical literature on the amplification and propagation of the financial crisis. This literature has proposed several mechanisms that may have contributed to spread and amplify the initial shocks, such as the presence of Knightian uncertainty among investors (Caballero and Krishnamurthy, 2008), the combination of leverage and margin cycles affecting market makers (Brunnermeier, 2009), the use of wholesale funds (Shin, 2009), the impact of uncertainty on the behavior of the repo market (Gorton and Metrick, 2009), and the use of pro-cyclical leverage (Adrian and Shin, 2008). In addition, some recent empirical papers have studied the role of common factors on the movement of banks' debt spreads during the crisis and their relation to various transmission mechanisms (Eichengreen et al., 2009), and tested whether the crisis spills over to the real economy through reducing consumer demand or tightening liquidity (Tong and Wei, 2008). This paper contributes to this literature by providing systematic evidence of the role of the sources of bank financing in the international transmission of the crisis. In contrast to Eichengreen et al. (2009), this paper looks at a broad set of banks across a large number of developed and developing countries, and for the most part focuses on differences in returns across individual banks to identify specific transmission mechanisms rather than focusing on common factors and their determinants. This paper shares with Tong and Wei (2008) the use of stock market returns and ex-ante characteristics to

identify transmission mechanisms. However, it looks at the international transmission of the crisis to the banking sector instead of the transmission to non-financial US industries, and focuses on the stock market responses to a clearly defined episode to identify the mechanism, instead of looking at the long-run performance of stock price returns.

Another recent literature closely related to this paper has focused on the role of interbank markets in the allocation of liquidity during the crisis, and on the appropriate policy interventions in these markets (Allen Carletti and Gale, 2008; Freixas, Martin, and Skeie, 2009). This literature has also analyzed the impact of central bank intervention on European interbank markets during the crisis (Brunetti, di Filippo, and Harris, 2009) and the relation between European banks' demand for liquidity during the crisis and their posterior performance (Cassola, Hortacsu, and Kastl. 2009). This paper complements this literature by providing further evidence of the consequences of a drying up of interbank lending markets on banks' performance and lending activities worldwide, thus highlighting the possibility of international contagion and giving further ground for liquidity support by central banks.

The paper also relates to the literature on financial structure and riskiness that discusses the impact of the recent changes in the composition of banks' assets and liabilities on their ability to gather spare liquidity in episodes of crisis (Rajan, 2006; Gatev and Strahan, 2006). This paper provides evidence that the increased reliance of banks on wholesale sources of funds, while reducing their dependence on retail deposits, increases their vulnerability to shocks to the money market, and indeed reduces their ability to intermediate the remaining liquid funds toward lending activities.

This paper also contributes to the literature on international contagion (Glick and Rose, 1999; Kaminsky and Reinhart, 2000; Kaminsky et al., 2003; among others), by providing evidence of a different channel through which financial turmoil may spread across countries. In addition to the common portfolio positions highlighted by the models following the Asian and Russian crises (Calvo, 1998; Calvo and Mendoza, 2000; Kaminsky and Reinhart, 2000; Kaminsky and Schmukler; 1999), the evidence in this paper shows that the development of international money markets may help spread financial malaise by globally spreading the impact of money market shocks. The contagion does not only come from a country-specific shock that propagates to countries financially linked to the affected one, but also from a common shock that affects those countries that are structurally exposed to it. Furthermore, the evidence in this paper is robust to the standard criticism that it is difficult to separate trade links and financial links at the aggregate level to determine the channels of contagion. This is because the identification comes

mainly from within country differences in returns across banks, so it controls for country level differences in exposure through trade linkages.

Finally, this paper is closely related and complementary to a recent parallel paper by Beltratti and Stulz (2009) that characterizes what banks suffered more during the recent crisis and finds that banks with more deposits did relatively better. While sharing some findings, the two papers differ in several dimensions, most importantly in terms of the sample and the methodological approach. Regarding the sample, Beltratti and Stulz (2009) focuses mainly on large commercial banks, while this paper does not impose restrictions on the size or asset composition of banks. Although their approach maintains a more homogeneous sample across countries, the broader sample used in this paper includes more countries and more variation in the bank characteristics under study, which is important for the focus of this paper on the channels of international transmission. In terms of methodology, Beltratti and Stulz (2009) study the performance of gross returns during a 6-quarter period or longer, while this paper conducts an event study to characterize the evolution of abnormal returns in a narrow window around the failure of Lehman Brothers. Although, by design, the event-study approach does not allow one to draw conclusions about the relative performance of banks over a long period, it has important advantages in terms of attributing causality and separating the impact of the shock from the responses to it, as discussed above. Finally, this paper also explores the consequences of the shock on the real side of the economy. Nonetheless, the persistence of some key results despite these differences strengthens the conclusions of both papers.

The rest of the paper is structured as follows. Section 2 describes the recent evolution of the wholesale funds market, the main events of the financial crisis, and the evolution of the cost of liquidity during these episodes. Section 3 describes the empirical methodology and data sources. Sections 4 and 5 present the main results and robustness analysis, respectively. Section 6 explores country characteristics and vulnerability to a liquidity crunch. Section 7 looks at the real consequences of the use of wholesale funds on banks' lending activity. Finally, section 8 concludes with some final remarks.

2 Wholesale Funding Market, the Financial Crisis, and the Cost of Liquidity

Banks have traditionally financed their operations with demand deposits, suggesting that the incentives that the threat of a run imposes on bank managers make them a superior form of financing despite their fragility (Diamond and Rajan, 2001). However, banks also rely on other types of markets for their funding needs: commercial paper, repo market, and federal funds

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(interbank) loans. These markets, which typically offer short-term financing, compose the *wholesale funding markets.*

The reliance of various types of intermediaries, particularly commercial banks, on these sources of funding has increased importantly in recent years in the US and around the world (Feldman and Schmidt, 2001; Huang and Ratnovski, 2008; Demirguc-Kunt and Huizinga, 2009). For instance, the gross amount of deposits from foreign banks has increased from 6,240 to 13,856 billion US dollars between 2001 and 2006 among the 41 countries surveyed by the Bank of International Settlements (BIS, 2008). This increased reliance on wholesale funds can also be seen in bank-level data from Bankscope that show an increase in the use of wholesale sources of funds in the 5 years preceding the beginning of the 2007-2008 financial crisis. Across all banks located in the 44 countries covered by Bankscope that have an FTSE financial sector index (which will constitute this paper's sample, as explained below), the average fraction of liabilities that do not correspond to deposits increased in around 60 percent between the end of 2001 and 2006. The increases are larger among commercial banks, reaching about 80 percent. Beyond these global tendencies, the average fraction of non-deposit liabilities increased in 73 percent of the 44 countries described above, with an average increase of 38 percent between 2001 and 2006.

Despite the potential advantages of a broad base of funding, and the apparent fragility of demand deposits, it has been recently recognized that wholesale funds are more volatile than demand deposits—probably because they are typically uninsured, and put banks at risk of liquidity dry-ups (Rajan, 2006), such as those occurring during the ongoing financial crisis. This has led some authors to suggest that the reliance of some banks on these sources of funds can explain the demise of some financial institutions and part of the crisis depth (Shin, 2008).

Although there is broad consensus that the earliest indicator of the crisis was the increase in defaults on loans related to securitized subprime mortgages observed in early 2007 (Brunnermeier, 2009), its unraveling started only by mid 2007 and, despite the fluidity of the situation and at the risk of oversimplifying, took place in two stages. The first stage started on August 9, 2007, when as a result of the uncertainty about the exposure of financial institutions to "toxic assets", liquidity quickly dried up. During this episode, the market for Asset Backed Commercial Paper (ABCP), the standard way in which mortgage securitizers financed their operations, practically disappeared, and the price of liquidity, measured as the TED spread, more than doubled in two days, from 44 bps on August 8 to 103 bps on August 10, 2007. Stock prices declined in the US and several other countries, expected volatility increased and risk appetite started to decline. These developments are apparent in Figure 1, which shows the evolution of various financial market indicators for the US and the rest of the world.

The second, and most important, stage started on September 15, 2008, immediately after the US government decided not to bail out the investment bank Lehman Brothers, and all the major rating agencies downgraded the long-term debt of giant insurance company AIG.[3] The result was a much more pronounced but similar pattern than that observed in early August 2007. Global stock markets plummeted, expected volatility skyrocketed, and the cost of liquidity in the US and abroad, measured by the TED spread or the LIBOR-OIS spreads, raised to historically unseen levels that thwarted the increase observed a year before, as seen in the various panels of Figure 1. The combination of fast and large shocks to several key financial market indicators makes the failure of Lehman Brothers an ideal event to study the different mechanisms of transmission of the financial crisis across asset classes and countries.

In addition to having a large de-facto impact on financial markets, the bankruptcy of Lehman Brothers was largely unexpected. A simple indicator of this is the large and sudden amount of attention it captured from the international press, as seen in Figure 2, which shows the daily evolution of the number of news stories published in the global English media containing the term "crisis" and either "financial", "finance", or "subprime" around the bankruptcy of Lehman Brothers (Panel A). There was a clear increase in the number of news stories related to the crisis immediately after this event (the day after). A similar, albeit smaller pattern is seen after the beginning of the liquidity crunch on August 9, 2007, mentioned above (Panel B).

Clearly, despite the overall volatility in international liquidity markets, the September 15, 2008 episode stands out because of its magnitude and fast onset. Based on these characteristics, this paper treats this episode as an "event", and applies a standard event-study approach to test its international transmission. In what follows, I will refer to the Lehman Brothers bankruptcy episode as the *Lehman* event (September 15, 2008). Although not the main focus of the paper, I will also look at the days following August 9, 2007 as an additional event of liquidity crunch to verify that a similar pattern is seen in the data.

3 Methodology and Data

The impact of the failure of Lehman Brothers on the stock-price returns of banks with different levels of use of wholesale funds is estimated using a regression version of a standard event study that allows the abnormal returns to differ across banks according to their ex-ante use of these funds and other characteristics. To this end, the first step is to estimate the parameters of the following specification during a period of T_1 "normal" days preceding the event,

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[3] The problems were so severe that this large insurance company had to be rescued by the US government on September 16, 2008.

$$R_{i,c,t} = \alpha_{i,c} + \beta_{i,c} \cdot R_{c,t} + \varepsilon_{i,c,t} \quad t \in \left[t_0, t_1\right], \tag{1}$$

where $t_0 < t_1 < t^*$ denote the beginning and end of the time window where parameters are estimated (the *estimation window*), and $R_{i,c,t}$ is the stock-market return of bank i, from country c, between trading days t - 1 and t. In the preferred specification, $R_{c,t}$ is a vector that contains the overall stock-market and banking industry return in country c at time t (a simple two-factor model), but I also estimate a one-factor model that only controls for the stock-market return to characterize the evolution of the whole banking industry. The parameters $\alpha_{i,c}$ and $\beta_{i,c}$ are bank specific coefficients to be estimated, and $\varepsilon_{i,c,t}$ is a random error.[4]

The *abnormal returns* of bank i from country c, $\hat{\varepsilon}_{i,c,t}$ are computed as the deviation of the actual returns from those predicted by the model in equation (1) in a window of $2T + 1$ days around the event (the *event window*),

$$\hat{\epsilon}_{i,c,t} = R_{i,c,t} - \hat{\alpha}_{i,c} - \hat{\beta}_{i,c} \cdot R_{c,t}, \, t \in \left[t^* - T, t^* + T\right]. \tag{2}$$

If banks' use of wholesale funds plays no role in the propagation of the events, the average abnormal returns of banks with high and low use of wholesale funds should not be significantly different following the events. This hypothesis can be formally tested by estimating the parameters of the following regression:

$$\hat{\epsilon}_{i,c,t} = \sum_{\tau = t^* - T}^{t^* + T} (\delta_{0,\tau,c} + \delta_{1,\tau} W_{i,c} + X'_{i,c} \delta_{2,\tau}) \cdot D_{\tau,t} + v^c_{i,t}, \tag{3}$$

where $D_{\tau,t}$ is an event-time dummy that takes the value 1 when $t = \tau$ and zero otherwise, and $\delta_{0,c,\tau}$ is the average abnormal return at event time τ among all banks from country c included in the regression. Notice that this controls for any country-level effect of the events not captured by the bank index included in $R_{c,t}$. The variable $W_{i,c}$ measures bank i wholesale dependence, which in the preferred specification is a continuous variable that is increasing in a bank's use of wholesale funds (details below). The parameters $\delta_{1,\tau}$ are the key coefficients, since they are

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[4] Using a more elaborate model that controls for the standard three Fama and French (1993) factors (market, small to big (SMB), and value to growth (HML)) would require the computation of these factors for the 44 countries in the sample. Many of the developing countries included in the sample have too few traded firms to construct meaningful portfolios along the required dimensions.

estimates of the average increase (or decrease) in abnormal returns at event-time τ resulting from an increase in a bank's wholesale dependence. The vector $X_{i,c}$ includes several bank characteristics that may be related to its vulnerability to the crisis such as size, leverage, ownership, and type of bank.

Under the hypothesis that banks' wholesale dependence plays no role in the propagation of the events, the $\delta_{1,\tau}$ coefficients should not be significantly different from zero. In contrast, under the alternative that banks' wholesale dependence helps to propagate the crisis, these coefficients should be significantly negative around or immediately after the event date, and the *cumulative abnormal differential return* (*CADR*), defined as

$$CADR_t = (W^{high} - W^{low}) \times \sum_{\tau=t^*-T}^{t} \hat{\delta}_{1,\tau}, \ \ t \in [t^* - T, t^* + T] \tag{4}$$

should also decrease significantly immediately after the event. The variables W^{high} and W^{low} are the 75th and 25th percentile values of $W_{i,c}$ in the sample, so the CADR is scaled by the interquartile range of wholesale dependence and captures the difference in cumulative abnormal returns between a bank with high wholesale dependence (75th percentile) and a bank with low wholesale dependence (25th percentile). An analogous scaling will be used when reporting the differential cumulative abnormal returns associated with any other bank level variable included in $X_{i,c}$.

In addition to the CADR, the paper will also report and provide statistics for the *relative cumulative abnormal differential returns (R-CADR)*, which are simply the CADR relative to the pre-event average differential returns $\overline{\delta}_{1,PRE}$

$$R\text{-}CADR_t = (W^{high} - W^{low}) \times \sum_{\tau=0}^{t} (\hat{\delta}_{1,\tau} - \overline{\delta}_{1,PRE}), \ \ t \in [0, t^* + T], \tag{5}$$

$$\overline{\delta}_{1,PRE} = \frac{1}{T} \sum_{\tau=t^*-T}^{t^*-1} \hat{\delta}_{1,\tau}.$$

These relative CADR clean for possible pre-event trends in the average abnormal returns of banks with different degrees of wholesale dependence and provide sharper evidence that the findings are driven by post-event differences only. For space reasons, most of the figures below will report only the R-CADR, which are more visually clear because they normalize pre-event values to zero. However, most results are qualitatively similar when using the CADR instead.

The paper estimates and characterizes the evolution of these coefficients during a 10 (trading) days windows following the Lehman event.[5] Since the identification of the $\delta_{1,\tau}$ coefficients comes exclusively from within-country, across-banks differences in abnormal returns, testing whether they differ from zero provides a sharp test of the hypothesis that bank's use of wholesale funds is driving the impact of the events that is not affected by cross-country differences in banks' returns around the events.

To establish a benchmark average effect of the events on the banking sector worldwide, I also estimate a version of equation (3) that restricts the $\delta_{0,c,\tau}$ to be constant across countries and that does not include the interaction with $W_{i,c}$ or $X_{i,c}$. These $\delta_{0,\tau}$ coefficients measure the average abnormal returns across banks at event time τ and have a meaningful economic interpretation only when the abnormal returns come from a one-factor model that just controls for market returns. In this case, they measure the average impact of the event on the banking sector at time τ *relative to the market,* and can be used to test whether an event has a significant impact on the banking industry as a whole by constructing the total and relative cumulative abnormal returns (CAR and R-CAR) in a similar way as described in equations (4) and (5).

I estimate the parameters of equation (1) using a window of 180 calendar days before June 30, 2007 (the normal times), and a window of 10 days before and after each event for the parameters of equation (3). Returns are measured as "lumped" returns,[6] but since some banks are not traded on every trading date, especially in developing countries, results using returns computed from consecutive trading days, so called trade-to-trade returns (see Maynes and Rumsey, 1993), are also reported in the robustness section. Observations with daily returns larger than 100 percent in absolute value are dropped from the data because they are assumed to be either erroneous or to capture the impact of other corporate event that cannot be controlled for.[7] All parameters are estimated using OLS and correcting the standard errors for heteroskedasticity to ease concerns of changes in post-event volatility, and clustering them at

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[5] The event study literature typically privileges the analysis of cumulative returns because the cumulative impact of the events is easier to visualize. The rest of the paper follows this convention, but also reports the individual $\delta_{1,\tau}$ on occasion.

[6] This means that during periods of inactivity all returns are assigned to the first day in which there is new activity.

[7] The large number of banks in the sample and the length of the window makes including dummies for individual corporate events unfeasible.

the country-event time level to further control for within country correlation among abnormal returns beyond that captured by the country-specific event-time dummies $\delta_{0,c,\tau}$.[8] However, in the specifications that focus on the $\delta_{0,\tau}$ coefficients (i.e. those not including the $W_{i,c}$ variable), the standard errors are estimated using only their time variation to account for the clustering of events in time (see Campbell et al. 1997).

As an extension, the paper studies whether the differential impact of the liquidity crunch on banks with different reliance on wholesale funding—captured by the $\delta_{1,\tau}$, depends on the ability of a bank's country to secure retail deposits, the transparency of the country's financial system, or it's degree of international integration. To test for this additional differential effect I allow the $\delta_{1,\tau}$ coefficients to depend on these characteristics as follows:

$$\delta_{1,\tau}^{c} = \delta_{1,\tau} + \delta_{2,\tau} \times F_{c}, \tag{9}$$

where F_c contains measures of the relevant country characteristics.

The main measure of a bank's reliance on wholesale funding is the ratio of total retail deposits (total deposits minus bank deposits) to total liabilities, $RDEPLIAB$. A high value of this ratio indicates that a bank finances a small fraction of its liabilities with wholesale funds, so I use the following transformation:

$$W_{i,c} = -\log(1 + RDEPLIAB_{i,c}),$$

where a high value of $W_{i,c}$ represents high use of wholesale funds. This logarithmic transformation also reduces the role of outliers and is valid for banks with no deposits.[9] Alternatively, I also use other measures of a bank's dependence on wholesale funds, such as the

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[8] Clustering the standard errors at the event-time level is unfeasible, because all the variables in the regression (3) are interacted with event time dummies, so they would vary only within clusters, resulting in variance-covariance matrices with zero rank (and therefore zero standard errors). However, in principle, it is not necessary to cluster the standard errors at all for the estimation of the $\delta_{1,\tau}$ coefficients because they estimate differences in abnormal returns across banks. Therefore, the cross-banks variation of the data contains relevant information. Furthermore, as mentioned above, the country-specific event-time dummies $\delta_{0,c,\tau}$ absorb any common component affecting all banks in a country.

[9] Alternatively one could use $\log(1 - RDEPLIAB)$, the log of the fraction of non-deposit liabilities. The only inconvenience of this measure is that since deposits are typically a large fraction of liabilities, it is more negatively skewed than the measure defined above. Nonetheless, results obtained with both measures are virtually identical.

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ratio of total retail deposits to total liabilities, interbank loans, and money market funds to liabilities to check the robustness of the results.

Other bank characteristics included in $X_{i,c}$ and used to control for other possible transmission mechanisms are the following. The log of a bank's total assets measure*s size.* The log of one plus a bank's return on assets (ROA) captures differences in *profitability. Riskiness* is proxied by the log of (one plus) a bank's leverage (equity over assets). A dummy variable that takes the value 1 for banks that declared exposure to Lehman between September 15 and October 15, 2008, captures counterparty risk. Finally, a set of dummy variables permits to control for bank type (investment or commercial), and bank ownership (public versus private, and foreign versus domestic).[10] Other bank characteristics were also included in the estimations without finding significant changes in the results.

Balance sheet information for the different measures described above comes from the latest balance sheet available before June 30, 2007, of all listed banks reporting to Bankscope. The description of a bank's specialization used to construct the bank-type dummies also comes from Bankscope. The information used to build the dummies of Lehman exposure comes from the *Daily list of Companies Reporting Lehman Bros Exposure* collected from Factiva Newsplus.

Data on stock market returns of listed banks included in Bankscope come from Bloomberg. Stock market returns correspond to the percentage change in closing price in local currency between two consecutive trading days. Only banks from countries with an available FTSE banking industry index were considered. This ensures that countries included are actively part of the international financial system, and that the regressions can control for industry wide effects (industry factor).[11] For each country in the sample, the market and banking industry returns are the corresponding FTSE indexes obtained from Datastream. Finally, data on country level characteristics, such as trade linkages, coverage of deposit insurance, level of international reserves, power of supervisory authority, and capital account openness are obtained from various sources detailed in the Appendix Table 1.

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[10] The commercial bank category groups all non-investment banks, including bank holdings and non-bank credit institutions.

[11] FTSE indexes include only countries that allow investment by foreign nationals and repatriation of funds. This ensures that countries included are part of the global liquidity market. In addition, the construction of the indexes relies on having banks of appropriate size, capitalization, and liquidity. For further details, see FTSE (2006).

The final sample of banks with data on the main measure of wholesale fund dependence comprises 772 banks in 44 countries excluding the US. The exclusion of the US removes from the sample a large number of banks directly hit by the bankruptcy of Lehman and the problems with AIG. This removes from the sample the "source" of the shock and helps identifying the indirect contagion mechanisms, such as the role of worldwide wholesale dependence, which is the focus of this paper. Nonetheless, as shown in the Appendix, the exclusion of the US is not crucially driving the conclusions of this paper. The sample covers all geographical areas, although most countries belong to Western Europe or East Asia and Pacific (14 and 11, respectively), followed by Latin America, East and Central Asia, Middle East and North Africa, South Asia, North America, and Sub-Saharan Africa (6, 6, 3, 2, 1, and 1 countries, respectively). For obvious reasons, most countries are either high or middle-income (24 and 18, respectively), but two low-income countries are also represented (India and Pakistan). The geographic and income distribution of the sample varies slightly at the bank level. East Asia and Pacific overtakes Western Europe, with 234 and 231 banks, respectively; South Asia surpasses the remaining regions, with 70 banks, and the overall participation of low-income countries increases from 4 percent to 10 percent of the sample. Because of differences in the coverage of different variables, the final samples vary with the specific measure used, but the results are robust to considering only the sample that is common to all measures.

The detailed list of countries in the sample, some summary statistics, and the average wholesale dependence of each country are reported in Table 1. In addition to the overall increase in the use of wholesale funds documented in the previous section, the table shows that there is important heterogeneity in this use across countries. The overall mean in the ratio of retail deposits to liabilities is 0.61 with a standard deviation of 0.31 and an interquartile range of 0.46 (Panel B). Not surprisingly, the ratio is higher in commercial banks than in investment banks, and is also larger in public banks than in foreign banks. Moreover, there is an important degree of variation within country. In fact, 74 percent of the standard deviation reported above comes from within country, and only 26 percent from between countries. Therefore, the data exhibit enough within-country variation for the identification strategy of this paper that, as previously discussed, largely relies on within country comparisons. Finally, Panel C shows that, within a country, the measure of wholesale dependence $W_{i,c}$ is positively correlated with leverage, negatively correlated with size (log assets), and negatively correlated with the ratio of liquid assets to liabilities.

4 Results

The abnormal returns from a one-factor model provide an estimate of the evolution of the average CAR of the worldwide banking sector during the Lehman event. These results are reported in Figure 3. There is a sharp decline in the abnormal returns of banks immediately after the day of the event (Panel A) and the magnitude of the decline in returns is large, reaching 2.9 percent three days after the event (respect to the day before the event), even after controlling for market returns. This corresponds to a 93 percent loss on an annual basis.[12]

Although banks worldwide experienced significantly negative abnormal returns immediately after Lehman, they were performing slightly better than the market before the event. To control for this pre-event trend, I compare the banks' abnormal returns after the event with their average before the event. Finding that banks performed significantly worse after the event, even after controlling for their pre-event abnormal returns, would provide strong evidence that the events affected banks' performance. This is indeed the case, as shown in Panel B, which plots the R-CAR, the cumulative abnormal return of banks relative to their average pre-event abnormal returns. For instance, the average daily abnormal return of banks during the 10 trading days preceding September 15, 2008 was 10 bps: banks were doing relatively better before the event. However, immediately after the event these differences increased in a statistically significant manner: the average abnormal returns were -93 and -69 bps the two days following the event, respectively, 103 and 79 basis points lower than before the event. The figure in Panels B shows the cumulative pattern of these differences. Three days after the Lehman event the cumulative abnormal differential returns reached 327 basis points. Therefore, the evidence shows that banks did relatively worse respect to the market immediately after the event.

If banks' use of wholesale sources of funds was a transmission mechanism for Lehman, the significant return decline documented above should be larger for banks that were more dependent on these sources of funds. This hypothesis is first formally tested by estimating a simple version of equation (3) that includes only a bank's wholesale dependence $W_{i,c}$. Figure 4 reports the resulting CAR for a bank with wholesale dependence at the 25th and 75th sample percentile levels (37 and 87 percent of ratio of retail deposit to liabilities respectively, corresponding to a difference in $W^{high} - W^{low}$ of 0.31) and the difference in CAR between them (i.e. the CADR).

The results in Figure 4 clearly show that a bank at the 75th percentile of wholesale dependence experiences a significantly larger stock price decline than a bank at the 25th percentile (2.6

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[12] This is the multiplicative loss using the average daily decline of 72.5 basis points. It is smaller than the additive loss, which is 133 percent.

percent larger three days after the event, see Panels A and B). This differential effect is large not only in absolute value, but also when compared to the 2.9 percent average banking sector decline documented above. Moreover, two-thirds of the cumulative return decline takes place immediately after the event. In fact, the difference in abnormal returns between banks with high and low wholesale dependence is significantly larger at the 5 percent level (in absolute value) immediately after Lehman than before it (Panel D, Column (1)). Even compared to their bad pre-event relative performance, high wholesale dependence banks experienced a statistically significant 2.4 percent abnormal return decline three days after the event, of which 39 bps occur at the event day (Panel C, and Panel D, Column (7)). This magnitude is large in absolute terms, and also compared to the 3.3 percent decline relative to pre-event trend documented for the whole banking sector in Panel B of Figure 3.[13]

The immediate concern with the results reported above is that banks with different dependence on wholesale funds may be systematically different in other characteristics that are the true determinants of their differential response to the event, and that relate to different transmission mechanisms. To discard this possibility, I included in $X_{i,c}$ several important bank level characteristics that could be behind the differential response of banks to Lehman.

The results, presented in Figure 5, control for the potential role of a bank's leverage, size, asset composition, direct exposure to Lehman, and type of bank (commercial or investment).[14] For space reasons, the figure only displays the relative CADR that adjust for pre-event trends (R-

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[13] Results restricting the $\delta_{0,c,t}$ coefficients to be constant across countries (with and without controlling for the country level performance of the banking industry in Eq. [1]), or adding a country fixed-effect are qualitatively and quantitatively similar to those reported above. Results using a dummy variable to separate between banks with high and low dependence on wholesale funds (above and below the worldwide median) are also similar. These results are not reported, but available upon request.

[14] The criteria to select the bank characteristics is their availability for most of the banks in the sample. The addition of more sophisticated measures of balance sheet composition biases the sample toward larger banks, weakening some results. Nonetheless, I also explored results controlling for capital adequacy ratios, loan loss reserves to gross loans, and the ratio of liquid assets to deposits, among other variables. These additional measures reduced importantly the sample, did not appear significant, and did not affect the results for wholesale dependence (although the significance was reduced, it was still within conventional levels). Results are available upon request. I also tested for differences between public and foreign banks and the rest. The results, available upon request showed no systematic differences between these types of banks and the rest. However, the sample is importantly reduced by considering these characteristics, so this lack of precision may be behind the findings. Nonetheless, the results for wholesale dependence survive controlling for these bank characteristics.

CADR). The results for standard CADR are similar, but in a couple of bank characteristics, such as the type of bank, the pre-event trend does not render the standard CADR significant. The first message to take from the figure is that the magnitude and significance of the R-CADR associated with wholesale dependence (Panel A) is almost identical to that reported in the simple uncontrolled regression above, despite this being a much more heavily parameterized model and having a slightly smaller number of observations. Thus, the results discussed above cannot be fully explained by the correlation between wholesale dependence and any of these bank characteristics. The results for each of the other bank controls are discussed next.

Larger banks may have better access to non-deposit sources of funds like certificates of deposits (CDs), as shown by Kashyap and Stein (1995), or just have better access to external funds (Gertler and Gilchrist, 1993). It is also quite possible that larger banks are perceived as safer because their size allow them to have better diversified portfolios or because investors rationally anticipate that they will be bailed out in case of trouble for being "too big to fail". The results in Panel B of Figure 5 support these hypotheses. They show that larger banks did relatively better during the Lehman episode, with a significant R-CADR of about 2 percent three days after Lehman.[15]

Banks that were more profitable before the crisis may have had better investment opportunities or business models, but they may have also had been taking more risk to boost the return in equity. The results in Panel C of Figure 5 indicate that, outside the US, banks that were more profitable before the crisis did relatively better. The magnitude of the differential effect, however, is small. Banks at the 75th percentile of ROA obtained a statistically significant 40bps increase in returns relative to banks at the 25th percentile of ROA in the days immediately following Lehman's demise. Nonetheless, markets favored more profitable banks, suggesting that past profitability was associated with better investment opportunities rather than with risk taking. This is consistent with the view that, even amid the turmoil, markets could at least partly properly discriminate among banks (Calomiris, 2009).

There has recently been a lot of attention devoted to the role of leverage in the amplification of the ongoing financial crisis, especially the leverage of financial institutions that act as market makers (Adrian and Shin, 2008; Brunnermeier, 2009). A high leverage implies that the capital cushion available to absorb losses on asset values is small. The larger the initial leverage, the

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[15] Separating the diversification from the too big to fail story requires appropriate measures of diversification, which is beyond the scope of this paper, but it would be interesting to further explore this issue.

larger the increase in leverage resulting from a loss, and the larger the need for adjustment. Hence, it is possible that the different crisis episodes affected significantly more those banks with higher leverage than less leveraged institutions. However, the estimated R-CADR associated with bank differences in leverage reported in Panel D show that banks with higher leverage only experience a significantly larger decline in returns the same day of the event (the control variable is the ratio of equity over assets, which is inversely related to leverage). To the extent that high leverage was perceived as a measure of riskiness during the crisis, these results do not support the view that a sudden change in risk attitude was significantly behind market behavior immediately after Lehman. However, these results cannot reject the hypothesis that risk reassessment may have played a long-term, persistent role during the crisis.

The failure of Lehman Brothers not only resulted in a large liquidity crunch with a sudden dry up of interbank loan markets, but also in potential losses for banks that were directly exposed to this institution, and in raised concerns about counterparty risk.[16] The results reported in Panel E plot the R-CADR between a bank that declared exposure to Lehman and a bank that did not. They show that, indeed, banks that were directly exposed to Lehman suffered a larger relative decline in their returns, of about two percentage points three days after the event. This finding may seem unsurprising, except for the fact that exposures were declared after Lehman's bankruptcy. When the bankruptcy was announced, there was a lot of uncertainty on the identity of Lehman's counterparties. Nonetheless, markets seem to have had some information on the exposure to Lehman of different banks. Although this does not provide direct evidence on the role of counterparty risk, I will show below some results that suggest that exposed banks faced difficulties to raise money after the episode, which is closer to the counterparty risk predictions.

The discussion so far referred to all types of banks together, regardless of their type, but different types of banks use wholesale funds to different extents, and it is possible that these differences cause the differential effect of the Lehman episode documented above. It is also possible that the composition of wholesale funds will differ across types of banks. For instance, it may have a shorter maturity in investment banks that rely heavily on repo operations. Finally, Lehman Brothers was an investment bank, and its failure may have signaled an increased probability of failure of this type of institutions. The results in panel F show that the returns of investment banks declined relatively more than those of commercial banks. Cumulative abnormal returns among investment banks declined by 2 percent more than those of

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[16] The probability that problems on the counterparties of a firm's financial transactions would affect the value of financial assets

commercial banks 3 days following Lehman. This finding is consistent with investment banks being more risky because, for instance, of their use of wholesale funds, or just for being investment banks. Further results below will show that the second explanation seems more plausible.

In summary, the results in Figure 5 confirm that, after controlling for other potentially relevant bank characteristics, the Lehman event affected significantly more those banks with higher wholesale dependence. Among the additional bank's characteristics considered, the size, exposure to Lehman, and type of a bank have a qualitative and quantitative impact on its post-event performance. Thus, in addition to wholesale dependence, two additional sources of international transmission may have played a role: a global re-evaluation of counterparty and bailout risk. Markets worldwide penalized banks that later declared to have been exposed to Lehman. This could be explained in a pure mechanical manner, since the failure of Lehman was unavoidably associated with losses for these banks. I will show additional evidence below that this cannot explain the whole phenomenon. The results also show that smaller banks suffered relatively larger losses, suggesting that they were perceived as more risky. A possible explanation of this result is that after Lehman's failure the market changed its assessment of the unconditional probability of bank failures. In such scenario, larger banks deemed too big to fail could offer a relatively safer heaven and were less penalized (everything else equal).

The previous results showed that investment banks, and banks exposed to Lehman did relatively worse than the rest. Before turning to other issues, the results reported in Table 3, further test whether this is a pure average effect or whether there are differential effects within these groups of banks that could shed more light on the transmission mechanisms.

I investigate this possibility by separately estimating the baseline model for investment banks, commercial banks, and banks exposed to Lehman. For each of these groups of banks, Table 2 reports the estimated R-CADR for a window of 10 days starting the day of the event (t=0). The results show no R-CADR between those investment banks with high and low wholesale dependence (Column (1)). In fact, the results show that none of the bank characteristics considered has much explanatory power for differences in returns across investment banks. This indicates that the impact of Lehman on investment banks was largely uniform, and is supportive of either the panic view or the correlated risks view of contagion among these types of banks. In contrast, among commercial banks, the R-CADR of those with high wholesale dependence are significantly negative (statistically and economically, Column (5)). In addition, the other bank characteristics that appeared significant in the overall results are also (marginally) significant here. For instance, larger and more profitable commercial banks did relatively better. Thus, in

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contrast to investment banks, among commercial banks, there are differences in abnormal returns among banks with different characteristics. This does not mean that panic did not play a role among these banks. Commercial banks as a group performed bad relative to the market, with an average CAR of 2.5 percent three days after Lehman (not reported). However, amidst this average decline, there are important differences across banks that are related to their exposure to different sources of risks, most notably to their wholesale dependence.

The last set of results in Table 2 explores the role of wholesale dependence among banks that were exposed to Lehman. If the decline in returns observed for this group of banks is purely due to their exposure, those with higher wholesale dependence should not do any worst than the rest. However, if their exposure to Lehman makes them more risky credits, they would have trouble trying to secure financing and those that relied more on wholesale funds would suffer more. The results show that, among banks exposed to Lehman, those with higher wholesale dependence did significantly worse than the rest. This evidence is highly consistent with exposed banks being considered more risky and having a harder time accessing wholesale funds, indicating that an increase in perceived counterparty risk may have had a quantitatively important role in the transmission of the crisis.[17]

A further check of the relevance of the mechanism is provided by looking at the differential response of wholesale dependent banks to the smaller liquidity crunch observed on August 9, 2007. As mentioned in section 2 above, this day marks the beginning of the turmoil in interbank markets and the quick disappearance of the ABCP market, although the raise in both the TED spread and the LIBOR-OIS spread were much smaller than following Lehman. Figure 6 reports the average R-CAR for the whole banking sector (Panel A), and the R-CADR associated with each bank characteristic (Panels B to F) following this event. It shows that, as in the case of Lehman, the global banking sector experienced a decline relative to the market immediately after the event, even after controlling for the pre-event trend (Panel A). Also similarly to the Lehman event, the results show that the R-CADR of banks with higher wholesale dependence experienced a relatively larger decline, although the magnitude of the decline is smaller than after Lehman, reaching only a 1 percent five days after the event, and not statistically significant at conventional levels (Panel B). As it was the case after Lehman, size and past profitability seemed to have played a role after August 9, 2007. In fact, the R-CADR associated with these two variables reach statistical significance during the window. As before too, the R-CADR associated with past profitability is quantitatively small. Notice, however, that despite

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[17] These results do not include other bank characteristics as further controls because there are only 47 banks with exposure to Lehman in the sample.

its smaller magnitude, the stock price decline of banks with high wholesale dependence is about two thirds of the average bank decline reported in Panel A, which is quantitatively similar to that obtained for Lehman. The quantitatively similar, albeit statistically weaker, pattern observed after this smaller liquidity crunch provides further support to the hypothesis that the transmission of the crisis across banks worldwide was related to wholesale dependence, but also suggests that other factors, such as size and balance sheet strength may have played a more important role during the earlier stages of the crisis.[18]

Taking stock, banks worldwide experienced a large abnormal return decline following Lehman, and that this decline was much more pronounced for banks that relied more heavily on wholesale sources of funds, even after controlling for other bank characteristics likely related to other transmission channels. In addition, to a lesser extent, there is a similar pattern following the smaller freeze of liquidity markets on August 9, 2007. These findings strongly suggest that the increasing reliance of banks worldwide on wholesale sources of funds played an important role in the international transmission of financial distress in the days following the demise of Lehman Brothers, when international interbank liquidity markets dried up, and after other liquidity crunch episodes.

5 Robustness

Several arbitrary measurement and specification choices are behind the baseline results. This section explores in detail the robustness of the findings to changes in some of these choices, such as changes in the event dates, the estimates of the abnormal returns, the measures of wholesale

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[18] The weaker evidence on the role of wholesale dependence on international transmission in the August 2007 episode is probably related to three factors. First, the liquidity crunch in August 2007 was smaller and slower than in the second half of September 2008 (only 0.4 percent increase in the TED spread three days after the event, compared to 1.6 percent during Lehman). Second, the August 2007 liquidity crunch affected a segment of wholesale funds (ABCP) that were heavily used by some financial institutions (SVP and conduits) linked to banks, but less so for commercial banks themselves. This may have delayed the response of bank returns to the shock to the ABCP market until market participants fully realized the connections between conduits and banks and the former had to tap into the credit guaranteed offered by the latter. In contrast, following the Lehman episode, the complete interbank market came to a standstill in a situation where alternative sources of funding, such as ABCPs had already dried. Third, the August 2007 episode occurred at the beginning of the crisis, when still most analysts and publications referred to the turbulences as the "subprime crisis" and the extent of contagion to other financial segments was still unclear. Thus, the transmission mechanism at that stage of the crisis was probably more closely linked to the exposure of banks to "toxic" assets than to their reliance on international liquidity markets.

dependence, the sample of countries and banks, and the event and estimation windows. For conciseness all the robustness checks are conducted on the simple univariate model, but they carry to the more complete model that controls for other bank characteristics (Eq. [6]).

An immediate concern in any event study is that the findings are simply random. Finding a 5 percent significant coefficient is a 5 percent event that should occur once in 20 days (the window used in the paper). Furthermore, abnormal returns of banks with higher wholesale dependence could be more negatively skewed than those with lower wholesale dependence, so that over any time interval their CADR will turn to be significantly negative with a higher frequency than the size of the test.[19] To test this concern I repeated the estimation for a random sample of 100 false event dates drawn between January 2006 and December 2008 where the TED spread did not experience any daily change larger than 20 basis points in a five-day window around the date. This threshold is still high, so it stacks the cards towards finding tests with biased size.[20]

Table 4 shows the empirical distribution of the p-values of the estimated CADR (columns (1) to (3)) and R-CADR (columns (4) to (6)) for each event day in the 20-day window obtained from these Montecarlo simulations. The average p-values move between 0.4 and 0.5 within the window, showing that low p-values are not typical (columns (1) and (4)). More interestingly, columns (2), (3), (5), and (6) show the 5th and 10th percentile of the empirical distribution of p-values obtained from the simulation. The 5th percentile fluctuates between 0.01 and 0.05, with a median of 0.03 (Columns (2) and (5)). This implies that 5 percent of the estimated CADR had a p-value lower than 0.03 (0.05 and 0.01 at t=0). Thus, this simple simulation suggests that the 5-percent critical values used to test the hypotheses above are slightly biased towards rejecting the null that the CADR are zero. However, the bias is quantitatively small considering the estimated significance of the coefficients (compare with Figure 4), and not surprising considering that the criteria to select non-event days are lax. A similar situation is observed in the distribution of the 10th percentiles of the distribution of p-values, whose values fluctuate between 0.04 and 0.11, with a median of 0.07 (Column (3)) and 0.09 (Column (6)). The test is still slightly biased at the 10 percent level, but the difference is smaller than in the previous case. In

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[19] This is, in principle, controlled by the use of the R-CADR.

[20] This is a weak requirement because a change of 20 basis points is larger than two standard deviations of the daily variations in the TED spread in this period. It means that 5-day periods with almost a 1 percent increase in the spread could be included in the sample of no-event periods. Still, even this high requirement left most of the 2007-2008 out of the sample. This is correct because the turmoil in interbank rates during this period makes very likely to find an "event" and significant differences in CAR among banks with different levels of wholesale dependence.

sum, these results indicate that even though a 5th percent significant CADR may occur with a probability slightly higher than 5 percent, the finding is still a low probability event under the null, which provides statistical reasons for its rejection.

Standard event studies typically estimate the parameters of the model (α's and β's) using data from immediately before the event, assuming that the event under study is the only significant disturbance to returns during the period. In contrast, the baseline results of this paper come from parameters estimated long before the event, because despite the time gap, those observations are more likely to capture accurately the statistical relations among variables during normal times. Nevertheless, I also constructed the abnormal returns using parameters estimated immediately before the event window to check for the relevance of this choice for the main findings of the paper. Panel A of Figure 7 summarizes the results, which are qualitatively and quantitatively similar to the baseline, although the decline in R-CADR is slightly smaller (reaching 2 percent three days after the event) and the statistical significance of the results is marginally reduced.

Including only countries with FTSE banking sector indexes in the sample ensures that in each country there are at least some banks with non-trivial market capitalization and shares' turnover. However, not all the banks included trade frequently, especially during turbulent times. Since the calculation of the stock market returns used in the baseline estimations did not correct for thinly traded stocks, the parameters may be biased, and the abnormal returns may exhibit excessive volatility. The reason is that standard "lumped" returns attribute all price changes to the first trading period after a spell of no trading, resulting in abnormally large returns the day of the trade. To address this problem, I re-estimated the parameters of the baseline model, as well as the abnormal returns, using trade-to-trade returns that assign a price differential to the whole period between two consecutive trades, as proposed by Maynes and Rumsey (1993). The results, reported in Panel B of Figure 7, show a similar, although slightly larger and more significant stock price decline for banks that relied more on wholesale funds during the Lehman episode, confirming and strengthening the baseline findings.

All the previous results used the ratio of retail-deposits to liabilities as an (inverse) measure of a banks wholesale dependence. This measure has the advantage of being as close as possible to the theoretically correct measure without sacrificing much coverage. Other measures that are probably better proxies of a bank's reliance on wholesale funds reduce the sample importantly, increasing the estimated standard errors. Nevertheless, panels C to E of Figure 7 show results for three such measures. The ratio of interbank loans (money borrowed from other banks

divided by money lent to other banks), the ratio of money market plus bank deposits to total liabilities, and the ratio of non-deposit liabilities plus bank deposits to liquid assets (a rough measure of maturity mismatch).[21] The results are qualitatively similar to the baseline. The overall R-CADR decline is slightly smaller, reaching about 1 percent in all cases. The statistical significance of the results is weaker than with the baseline measure, but three days after the event, the results are significant in all three cases.[22]

The sizes of the event and estimation windows are arbitrary choices in an event study. The estimation window has to be long enough for the structural parameters to be precisely estimated, but not as long as to cover structurally different periods (Armitage, 1995; Campbell et al., 1997). The event window must include the event day, enough days after the event to capture any lagged event impact, and enough days before the event to detect if there is a pre-event trend in the abnormal returns. Deciding to extend too much the window increases the risk of including other events. As argued above, given the paucity of events during the crisis, this is a real risk. Panel F of Figure 7 shows the R-CADR in a 20-day event window. The results are qualitatively similar to the baseline, but show that after a short lull a few days after Lehman, the CADR continue declining between 10 and 15 days after the event. This is consistent with the evolution of the interbank spreads that continuing increasing during this period reaching values of 4.6 (TED-Spread) and 3.6 (LIBOR-OIS) at day 20. Despite the natural widening of bands as the event window increase, the absolute CADR remain significant (not reported), and the R-CADR return to significance between day 10 and 17. The bankruptcy of Lehman started a liquidity crunch with lasting effects for wholesale dependent banks.

Finally, I also checked that the results are not driven by individual banks or countries. To this end, I re-estimated the unconditional model after dropping one country at a time and dropping one bank at a time. The empirical distribution of the results shows that the baseline findings are not crucially driven by individual observations or countries (see Appendix Figure 1). Furthermore, as argued above, the sample of this paper excludes US banks to focus on the indirect mechanisms of international contagion. Nonetheless, results including US banks are very

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[21] In all cases the measure included in the regression is the log of one plus the ratio.

[22] None of these measures could substitute the baseline measure. Horserace models including both the baseline measure and each of these three always yield similar results from the baseline. The main measure has useful information to separate banks that is not captured in these other measures. Interestingly, the results indicate than the availability of short-term assets does not affect much the results. It is as is these liquid assets cannot properly substitute for the increased cost of liquidity.

similar to those reported above, even though the number of banks doubles (see Appendix Figure 2).

6 Country Characteristics and Vulnerability to a Liquidity Crunch

The results assumed that, after controlling for a country's banks average abnormal return at each moment, the response of banks with a given level of wholesale dependence was constant across countries. However, some country characteristics may attenuate or amplify the impact of a liquidity crunch on wholesale dependent banks. This section briefly explores the role of several of these possibilities frequently mentioned in the policy discussion: deposit insurance, international reserves, quality of financial regulation, financial integration, and trade with the US.

To this end, I gathered data on measures of these characteristics across countries and created dummy variables that separate countries above and below the cross-country median level of each of them. These dummies were interacted with the product of wholesale dependence and event-time dummies and added to the specification as indicated in equation (9). The estimated coefficients measure how each characteristic affects the CADR between banks with different levels of wholesale dependence. For each characteristic, the results reported below display the difference in the R-CADR associated with wholesale dependence between countries with a value of the characteristic above and below the cross-country median, respectively. A negative (positive) coefficient implies that banks with high wholesale dependence did relatively worst in a country where that characteristic is above the median than in the typical country.[23]

Deposit insurance measures the ratio of the insured amount to GDP per capita (from Demirguc-Kunt et al., 2005). International reserves are the ratio of international reserves to total financial assets (from IFS and Beck et al., 2000). Regulation is a multi-dimensional concept, which I capture with a rough index of the power of the supervisor (from Barth et al., 2005). A higher index indicates higher power of the supervisor. The Ito and Chinn (2008) index captures capital account openness (a higher index indicates a more open country). Trade with the US is the average share of a country's exports directed to the US between 1990 and 2000 (from Feenstra et al. (2005)).

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[23] Results based on the difference in CADR between countries above and below the median are qualitatively similar, but in a few cases the pre-event trends render significant characteristics that are not significant based only on post event impacts. All results reported below come from the estimation of a single model that includes all these interactions, to control for colinearity between the characteristics.

Broad deposit insurance may reduce the risk of a depositor run and reduce the cost of retail deposits, and a high level of international reserves may help a country to withstand reversals in capital flows (Aizenman and Marion, 2003; Stiglitz, 2006) and allow the government to credibly bail out banks in trouble. Panel B of Figure 8 shows that the R-CADR of banks with high wholesale dependence are closer to those with low dependence in countries with high deposit insurance protection. Deposit insurance seems to reduce the vulnerability of wholesale dependent banks. However, the differences are not statistically significant. Similarly, the results do not show evidence that the level of international reserves helped reduce the impact of the crisis on wholesale dependent banks (Panel C).

The quality of financial regulation may also act as a buffer against the international transmission of shocks. In addition, banks in countries with better regulatory systems may have followed stronger prudential guidelines for any composition of its balance sheet. The results in Panel D show that banks with high wholesale dependence did not do relatively better after the event in countries with better regulation. Unreported results based on the CADR (instead of R-CADR) show that these banks did relatively better before the event, but their response to the event was similar across countries with different regulatory environments.

Despite the overall increase in banks' use of international wholesale markets, there is substantial heterogeneity in the use of these sources of funds across countries. While a worldwide increase in the cost of liquidity will likely increase its domestic cost even in countries with a relatively autarkic banking sector, it would occur through indirect channels, and one would expect a larger impact on wholesale dependent banks located in countries that are more open to capital flows. The results reported in Column (5) do not support this view. Immediately after the event, wholesale dependent banks suffered relatively less in countries that are more open. This differential response is significant at conventional levels one day after Lehman after accounting for the pre-event trend (Panel E). This is a puzzling result that suggests that conditional on the liquidity crunch having occurred, banks in countries with more open capital accounts had an easier job gathering liquidity.

The real exposure of a country's banking sector to the US, the source of the shock, is likely to be an important determinant of its performance. The results in Column (6) show that wholesale dependent banks performed relatively worst in countries that sent a larger share of their exports to the US, which I use as a proxy for US exposure. The R-CADR of wholesale dependent banks (relative to less dependent ones) is 2 percentage points lower in countries whose exports to the US (as share of total exports) are above the cross-country median. Banks in these countries may

have faced larger expected losses (e.g. due to troubles faced by exporting firms with which they had businesses), which made their reliance on wholesale funds especially troublesome.

In summary, in any cross-country exercise it is hard to disentangle the independent effect of characteristics that are highly correlated and that may relate to omitted variables. The exploratory results presented in this section aimed to weight the merits of some of the policy aspects that are more frequently heard in policy discussions. The results are disappointing and show that most of the variables considered have little explanatory power for the post-event behavior of wholesale dependent banks. Only two variables seem able to have some explanatory power. Banks that are relatively more dependent on wholesale funds did better in countries that are more open and traded relatively less with the US. Of course, all these country-level characteristics may have softened the impact of Lehman on a country's average banking sector performance, which the methodology of this paper cannot assess. In fact, results from Beltratti and Stulz (2009) show that the level of current account (which could play a similar role as the international reserves) helped increase the average returns of banks in a country in 2007-2008. Nonetheless, the results reported in this paper do not support the view that these variables may dampen the impact of a liquidity shock on wholesale dependent banks.

7 Are there real consequences?

The results reported so far show that the stock price of banks with higher wholesale dependence declined significantly more than those of their country peers with lower wholesale dependence, suggesting that the use of wholesale funds helped to propagate the crisis across countries. As mentioned in the introduction, the main advantage of looking at stock prices in an eventful period such as the 2007/2008 crisis is that this approach focuses on high frequency responses and isolates the impact of an event within a narrow window where one can safely assume that the event is the main news. Studying lower frequency data runs the risk of confounding the impact of the events with the policy responses they triggered such as the massive interventions by the Federal Reserve, the ECB, or the US and other governments, and also increases endogeneity concerns because even if the shock is exogenous, the policy responses may react to the pre-event bank characteristics. The main disadvantage of this approach is that it only shows the impact of the events on the financial value of banks but not the second round impact it has on the real economy. It is thus possible that the mechanism reported here does not matter for real production decisions. The regressions reported in Table 4 explore the consequences of the value decline of banks with higher wholesale dependence on their lending activity by estimating parameters of the following specification

$$Growth(Y)_{i,c,t-1,t+1} = \alpha_c + \beta \log(Y_{i,c,t-1}) + \gamma W_{i,c} + \delta X_{i,c,t-1} + \varepsilon_{i,c,t-1,t}$$

where Y represents either the level of loans, the level of assets, or the ratio of loans to assets. $Growth(Y)_{i,c,t-1,t+1}$ is the average monthly growth rate of Y for bank i from country c between the last balance sheet reported before Lehman ($t-1$) and immediately after Lehman ($t+1$). The expression $\log(Y_{i,c,t-1})$ is the log of initial value of the variable (to capture convergence effects), $W_{i,c}$ is the wholesale dependence of the bank, as defined above, and the vector $X_{i,c,t-1}$ contains bank-level characteristics that control for other possible determinants of bank performance during the crisis. Following the discussion above, the vector includes a bank's total assets, leverage, ROA, and dummies for whether a bank is an investment bank or is directly exposed to Lehman. In addition, I also estimate a regression where the dependent variable is the change in a bank's ratio of loan to assets. The parameters to be estimated are α_c (country fixed effects), β, γ, and δ. If banks with higher wholesale dependence do not only suffer a temporary decline in value, but also contract their loans relatively more, the parameter γ should be negative and statistically significant.

The results indicate that in all cases, banks with higher wholesale dependence reduced loans and assets by more than banks with lower dependence (columns (1) and (2)). The coefficient γ is statistically significant at conventional levels. Moreover, the magnitudes are meaningful: an increase in wholesale dependence equal to its interquartile range (0.31) would be associated with a decline in the monthly growth rate of loans of 0.7 percent (equivalent to 8.5% annual, Column (1)). The decline in assets growth, while statistically significant, is much smaller (Column (2)), implying that the ratio of loan to assets experiences a relatively larger proportional decline in banks with higher wholesale dependence (about 6% for the interquartile range), as Column (3) clearly shows. Finally, the negative relation between wholesale dependence and loan to assets also occurs when the latter is measured as the change in the loan to asset ratio (Column (4)). This ratio falls by 0.07 more in banks with high wholesale dependence than in banks with low wholesale dependence.

Similarly to the results on cumulative abnormal returns, the regressions show that size and the type of bank mattered for lending activity. The loans and the ratio of loan to assets declined relatively less on large banks and more on investment banks.

With the caveat that these are reduced form regressions, and that the before-after comparison does not allow me to separate shocks from policy responses, the correlations reported here are consistent with the mechanism of transmission through wholesale funds having meaningful real

consequences. This is reassuring and suggests that the mechanism described in this paper may have had real consequences.

8 Conclusions

The turmoil in the US subprime market quickly propagated across countries and asset classes, taking down large financial institutions across the world, and even jeopardizing whole financial systems. The speed and scope of propagation suggests that financial linkages were at the center of the transmission of shocks. Modern financial systems are interconnected in many complex ways that can help propagate and amplify shocks to any of its components. This paper focuses on one specific dimension of financial connections, the worldwide reliance of banks on global wholesale liquidity markets, and provides evidence that it played a quantitatively important role in the transmission of the crisis, especially in the critical days following the bankruptcy of Lehman Brothers. In doing so, it highlights another dimension of the typical trade-offs between efficiency and vulnerability involved in financial integration, but one that relates to the vulnerability of the banking sector, which plays a key role in the normal functioning of an economy. This vulnerability seems to have had consequences beyond the financial performance of different banks and financial institutions, and also had consequences for the real side of the economy by affecting their size and ability to intermediate loans.

While fully documenting the independent role of other transmission mechanisms is beyond the scope of this paper, the evidence gathered from the basic controls included in the analysis of the role of wholesale funds suggests that other risk factors also mattered for the international transmission of the shock. Within the 45 countries covered in the analysis, larger banks did relatively better. It is possible that larger banks had more diversified portfolios, but it is also possible that they were benefited from the belief that they were too big to fail. Investment banks were punished by markets in an indiscriminate way, suggesting a broad reassessment of the viability of their business model. Banks exposed to Lehman also performed relatively worst, especially those with high wholesale dependence. This indicates the role of counterparty risk on limiting their access to new funds. Furthermore, banks that were more profitable before the crisis (in terms of ROA) did somewhat better in the days following Lehman.

Overall, an important message from the results presented in this paper is that, despite the chaos and enormous degree of uncertainty that followed the bankruptcy of Lehman Brothers, markets were still able to discriminate among banks in a manner that is relatively consistent with fundamentals. Banks that relied relatively more on wholesale funds did significantly worst when the cost of these funds suddenly skyrocketed and their availability dried up as a result of an

exogenous event. This is inconsistent with the view that financial market participants panicked and started dumping assets indiscriminately and teaches us a lot about the transmission mechanism under operation. While panic may be behind some of the broad trends, markets were still able to discriminate and arbitrage, at least to a degree large enough to be captured by statistical tests conducted in a very volatile environment.

Some of the documented impacts are short lived and abnormal returns stabilize after a few days, but this is arguably due to the massive liquidity injections conducted on short notice by central banks across the world, especially in Europe and the US. Considering the magnitude of these interventions, finding significant differential return responses, such as those documented in this paper, is strong evidence of the vulnerability resulting from banks' reliance on non-deposit sources of funds. On the other hand, it is also evidence that an aggressive use of the lender (and liquidity provider) of last resort role of central banks can reduce the adverse consequences of this vulnerability, while maintaining the benefits for banks of diversifying the sources of funds. Regarding the role of other policy measures, like the degree of deposit insurance or international reserves, I find no evidence that they helped reduce the impact of the liquidity crunch on banks with high wholesale dependence. They may have had a broad effect on the whole banking sector, but they are not clearly associated with the type of return differentials one would have expected to observe.

This paper suggests that further thought is required on the relative safety of different sources of banks' funds. While demand deposits have historically being considered risky and received government insurance, other sources of funds have not. Yet, during this crisis, their systemic nature became apparent and governments had to extend protection to them too. Thus, money market lenders enjoyed higher interest rates than depositors during normal times, and ended up being equally protected during crises. Making the protection explicit, or clearly describing the contingencies that would trigger it would help to level the playing field.

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Table 1 - Use of Non-Deposit Sources of Funds Across Countries

Panel A shows summary statistics by country for the 772 banks that were present in the event study. Panel B shows summary statistics for the complete sample of banks. Panel C shows the within country correlation matrix of bank characteristics. Bank data come from the latest available balance sheet before June30, 2007 from the Bankscope database. The ratio of retail deposits to liabilities is measured as the ratio of Total Deposits minus Bank Deposits over Total Liabilities ((TotalDeposits-BankDeposits)/TotalLiabilities). Wholesale dependence is the transformation of the ratio of retail deposits to liabilities to -ln(1 + ratio of retail deposits to liabilities).

Panel A - Cross country summary statistics for the ratio of retail deposits to liabilities.

	(1)	(2)	(3)	(4)	(5)
		Ratio of retail deposits to liabilities			Wholesale
Country Name	Number of Banks	Mean	Median	Standard Deviation	Dependence
Argentina	6	0.58	0.62	0.29	-0.45
Australia	11	0.50	0.51	0.27	-0.39
Austria	7	0.51	0.55	0.25	-0.40
Belgium	2	0.36	0.36	0.23	-0.30
Brazil	14	0.42	0.36	0.22	-0.34
Canada	13	0.60	0.66	0.31	-0.45
Chile	7	0.63	0.70	0.26	-0.47
China	10	0.80	0.83	0.11	-0.59
Colombia	5	0.76	0.79	0.10	-0.56
Czech Republic	1	0.88	0.88		-0.63
Denmark	36	0.65	0.66	0.19	-0.49
Egypt	12	0.91	0.93	0.16	-0.64
France	35	0.25	0.24	0.23	-0.20
Germany	33	0.36	0.27	0.33	-0.28
Greece	13	0.76	0.79	0.14	-0.56
Hong Kong	13	0.58	0.78	0.40	-0.42
Hungary	2	0.34	0.34	0.47	-0.26
India	43	0.75	0.84	0.24	-0.55
Indonesia	19	0.73	0.84	0.30	-0.53
Ireland	4	0.40	0.45	0.15	-0.33
Israel	9	0.77	0.86	0.29	-0.55
Italy	29	0.39	0.46	0.26	-0.31
Japan	128	0.77	0.94	0.29	-0.56
Korea	40	0.67	0.73	0.23	-0.51
Malaysia	17	0.49	0.58	0.30	-0.38
Mexico	3	0.78	0.82	0.10	-0.57
Morocco	8	0.53	0.67	0.37	-0.40
Netherlands	6	0.38	0.34	0.33	-0.30
Norway	13	0.45	0.51	0.17	-0.36
Pakistan	33	0.60	0.75	0.30	-0.45
Peru	1	0.84	0.84		-0.61
Philippines	14	0.81	0.86	0.19	-0.59
Poland	13	0.76	0.77	0.13	-0.56
Portugal	5	0.57	0.55	0.14	-0.45
Russia	2	0.92	0.92	0.03	-0.65
Singapore	11	0.43	0.55	0.42	-0.32
South Africa	11	0.56	0.55	0.29	-0.43
Spain	10	0.58	0.57	0.06	-0.46
Sweden	8	0.38	0.41	0.18	-0.31
Switzerland	29	0.59	0.64	0.23	-0.45
Taiwan	35	0.52	0.68	0.35	-0.39
Thailand	18	0.67	0.86	0.37	-0.48
Turkey	18	0.56	0.71	0.33	-0.42
United Kingdom	25	0.31	0.32	0.34	-0.24

Panel B - Complete sample summary statistics for the ratio of retail deposits to liabilities.

	(1)	(2)	(3)	(4)	(5)	(6)
	Ratio of retail deposits to liabilities					Wholesale
	All Banks	Investment Banks	Commercial Banks	Public Banks	Foreign Banks	Dependence
Number of banks	772	95	677	82	43	772
Mean	0.60	0.36	0.63	0.75	0.69	-0.45
Standard Deviation	0.32	0.33	0.30	0.19	0.27	0.22
Median	0.69	0.28	0.72	0.80	0.77	-0.52
Interquartile difference (p75 - p25)	0.49	0.66	0.43	0.19	0.24	0.31

Panel C - Within country correlation of bank specific data.

	(1)	(2)	(3)	(4)
	Wholesale Dependence	Leverage	Total Assets	Profitability ROA
Wholesale Dependence	1.00			
Leverage	0.50	1.00		
Total Assets	-0.25	-0.59	1.00	
Profitability (ROA)	0.17	0.41	-0.21	1.00

Table 2 - Relative CADR (R-CADR) for Investment Banks, Commercial Banks, and Banks with Exposure to Lehman

The table shows the cumulative abnormal differential return relative to the pre-event average differential returns (R-CADR) between banks with high (75th percentile) and low (25th percentile) values of the characteristic listed on the top of each column. Columns (1) to (4) present results for investment banks only. Columns (5) to (8) for commercial banks only, and Column (9) shows results for banks with direct exposure to Lehman. The R-CADR reported in columns (1) to (4), and in columns (5) to (8) come from a model that included all the listed country characteristics simultaneously. The R-CADR in Column (9) comes from a model that only included wholesale dependence because of the relatively small number of banks that declared direct exposure to Lehman (47 banks). Heteroskedasticity robust errors clustered at the country-event day level are reported in parentheses.

| Event Time | Investment Banks (R-CADR) | | | | Commercial Banks (R-CADR) | | | | Banks Exposed to Lehman (CADR) |
| | Wholesale Dependence | Size | Profitability | Leverage | Wholesale Dependence | Size | Profitability | Leverage | Wholesale Dependence |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
-1	--	--	--	--	--	--	--	--	--
0	-1.53	2.39	0.28	3.41	-0.34	0.47	0.03	0.18	-2.64 **
	(1.61)	(2.78)	(0.27)	(2.21)	(0.31)	(0.43)	(0.03)	(0.21)	(1.30)
1	-1.18	0.51	0.34	2.24	-0.46	0.57	0.09	-0.02	-4.12 **
	(2.07)	(3.31)	(0.73)	(2.61)	(0.38)	(0.70)	(0.08)	(0.35)	(1.64)
2	-0.60	3.02	1.63	3.27	-1.22 **	0.59	0.18 *	-0.05	-6.68 ***
	(2.58)	(4.19)	(1.22)	(3.26)	(0.57)	(0.84)	(0.10)	(0.42)	(2.08)
3	-0.69	2.43	1.30	3.61	-1.59 **	1.53	0.30 **	-0.27	-10.03 ***
	(3.13)	(4.88)	(1.38)	(3.57)	(0.68)	(1.07)	(0.12)	(0.50)	(3.67)
4	1.41	5.18	0.64	4.06	-0.86	0.92	0.15	-0.44	-7.02
	(3.69)	(5.82)	(1.80)	(4.31)	(0.93)	(1.38)	(0.16)	(0.57)	(6.58)
5	2.48	4.96	0.79	4.81	-0.53	1.08	0.30 *	-0.75	-7.90
	(3.98)	(6.40)	(2.00)	(5.04)	(1.01)	(1.48)	(0.17)	(0.62)	(6.72)
6	1.96	3.18	0.87	2.96	-0.85	1.26	0.40 **	-0.68	-6.75
	(4.17)	(7.29)	(2.09)	(5.29)	(1.08)	(1.54)	(0.19)	(0.67)	(6.86)
7	1.76	0.59	0.36	0.96	-0.97	1.40	0.48 **	-0.64	-5.64
	(4.52)	(7.73)	(2.16)	(5.64)	(1.13)	(1.63)	(0.21)	(0.71)	(7.11)
8	2.05	0.27	0.29	1.03	-0.89	1.48	0.59 **	-1.11	-6.22
	(4.83)	(8.26)	(2.27)	(5.95)	(1.25)	(1.76)	(0.25)	(0.78)	(7.26)
9	1.46	2.40	0.32	4.28	-1.03	1.33	0.70 ***	-1.24	-6.68
	(5.22)	(8.77)	(2.35)	(6.30)	(1.29)	(1.83)	(0.27)	(0.82)	(7.45)
10	-1.85	0.96	0.09	6.83	-2.38 *	2.05	0.86 ***	-0.43	-9.31
	(6.02)	(9.74)	(2.43)	(6.94)	(1.42)	(2.05)	(0.30)	(0.90)	(7.69)

Table 3 - Robustness. Distribution of p-values of CADR and R-CADR for Fake Event Dates

The table shows several statistics for the empirical distribution of the p-values of the estimated cumulative abnormal returns (CADR) and relative cumulative abnormal returns (R-CADR) associated with a bank's level of wholesale dependence obtained from 100 simulations of the event study on fake event dates. Fake event dates were selected as days where there was no increase in the TED spread of more than 20 basis points in a 5-day window around the day. Results in columns (1) to (3) report the mean, 5th, and 10th percentile of the empirical distribution of CADR, respectively. Results in columns (4) to (6) show the same statistics for the R-CADR. Since in columns (4) to (6) cumulative abnormal differential returns are measured with respect to the pre-event average, results for the days before the event are omitted. In all columns, event day 0 denotes the day of the imputed fake event.

Event Day	Absolute CADR			CADR relative to pre-event trend		
	Average p-value	5th percentile	10th percentile	Average p-value	5th percentile	10th percentile
	(1)	(2)	(3)	(4)	(5)	(6)
-10	0.44	0.04	0.05	--	--	--
-9	0.46	0.03	0.06	--	--	--
-8	0.48	0.01	0.07	--	--	--
-7	0.46	0.01	0.06	--	--	--
-6	0.42	0.03	0.07	--	--	--
-5	0.44	0.05	0.09	--	--	--
-4	0.45	0.05	0.08	--	--	--
-3	0.45	0.05	0.08	--	--	--
-2	0.45	0.02	0.08	--	--	--
-1	0.48	0.04	0.10	--	--	--
0	0.48	0.05	0.09	0.45	0.01	0.04
1	0.46	0.03	0.08	0.47	0.05	0.07
2	0.45	0.04	0.06	0.46	0.03	0.09
3	0.46	0.04	0.08	0.46	0.03	0.09
4	0.48	0.03	0.09	0.45	0.04	0.06
5	0.47	0.03	0.06	0.47	0.03	0.11
6	0.48	0.03	0.05	0.49	0.04	0.09
7	0.47	0.02	0.05	0.49	0.06	0.11
8	0.47	0.02	0.03	0.50	0.03	0.10
9	0.47	0.02	0.05	0.50	0.03	0.10
10	0.48	0.02	0.04	0.50	0.03	0.09

Table 4 - Changes in Bank's Loans and Wholesale Dependence Around Lehman

The dependent variables are the average monthly growth rate of customer loans (Loans growth in Column (1)), the average monthly change in the amount of customer loans (Change in loans in Column (2)), the average monthly growth rate of the customer loans to assets ratio (Loans to Assets Growth in Column (3)), and the average monthly change in the customer loans to assets ratio (Change in Loans to Assets in Column (4)), all computed between the latest bank balance sheet before September 15, 2008, and the first balance sheet available after that date. Growth rates are expressed in percentage points and loans in billions of local currency. Initial loans correspond to the log of loans and loans to assets (columns (1) and (3)), and to the level of loans and loan to asset ratio (columns (2) and (4)). All these initial values are from the latest bank balance sheet before September 15, 2008. Wholesale dependence is measured as -ln(1 + ratio of retail deposits to liabilities), Size is measured as (log) total assets. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

| | (1) | (2) | (3) | (4) |
	Growth in Loans	Growth in Assets	Growth in Loans to Assets	Change in Loans to Assets
Wholesale Dependence	-2.3989**	-0.2059***	-2.1880**	-0.2645*
	(0.9404)	(0.0686)	(0.9425)	(0.1499)
Initial loans	-0.6173*	-0.0267	-0.4612	-0.0040***
	(0.3593)	(0.0360)	(0.2958)	(0.0012)
Size	0.7538**	0.0386	0.1665***	0.0163
	(0.3425)	(0.0340)	(0.0629)	(0.0119)
Leverage	5.1994	0.1134	5.3974	0.5848
	(4.0438)	(0.1608)	(3.9825)	(0.4486)
ROA	-3.4065	-0.3708	-1.6718	-0.6202
	(6.8681)	(0.3804)	(6.7728)	(0.8805)
Investment Bank	-2.8824***	-0.1024*	-2.6305***	-0.2525**
	(0.8512)	(0.0529)	(0.8139)	(0.1241)
Declared Exposure	0.0593	0.0056	-0.0227	-0.0464
	(0.3062)	(0.0208)	(0.2813)	(0.0640)
Country Fixed Effect	Yes	Yes	Yes	Yes
Observations	569	582	569	569
Adj. R-squared	0.284	0.302	0.246	0.247

Figure 1 - Selected Financial Indicators (2005-2010)

The figure shows the evolution of various financial market indicators for the US and selected countries during 2005-2010. Panel A shows the Ted Spread (difference between the 3-month US LIBOR and US Treasury Bill rate) and the LIBOR-OIS (difference between the 3-month US LIBOR and the overnight interest swap rate) in the US. Panel B shows the evolution of similar indicators for various other countries (typically the difference between the LIBOR in each country's currency and the interest rate of a sovereign bond in the same currency). Panel C shows the evolution of several stock market indices (from FTSE) for various regions of the world (the indexes are expressed in US dollars and normalized to 100 in December 31, 2004). Finally, Panel D shows the evolution of the Chicago Board of Options Exchange Market Volatility Index (VIX). The dashed lines show the market freeze of August 9, 2007 (on the left) and the bankruptcy of Lehman Brothers on September 15, 2008 (on the right). Data comes from Datastream.

A. Libor-OIS and TED Spread in the US
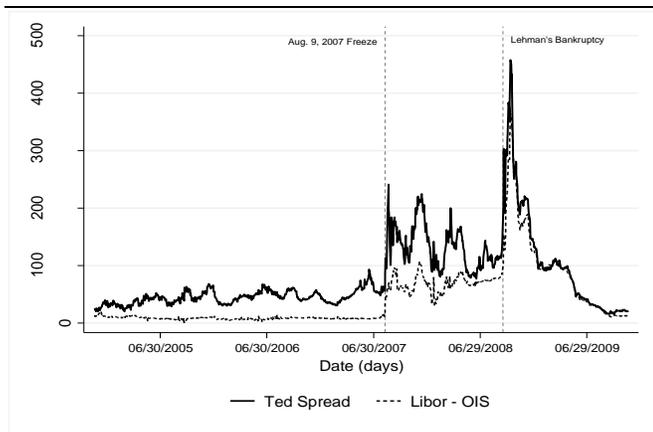
B. TED Spread in various Countries
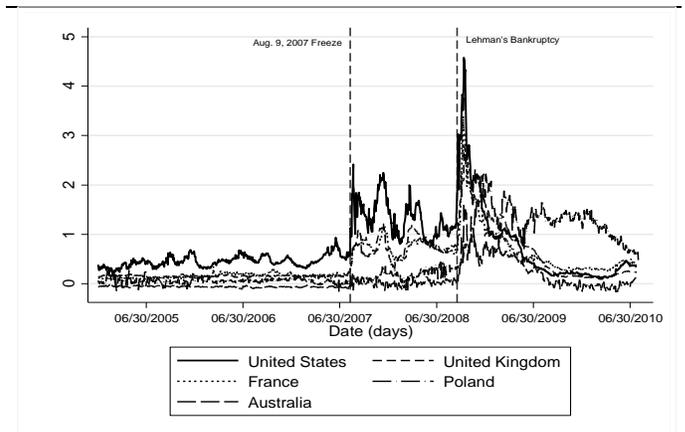
C. Stock Market Indexes, Several Regions
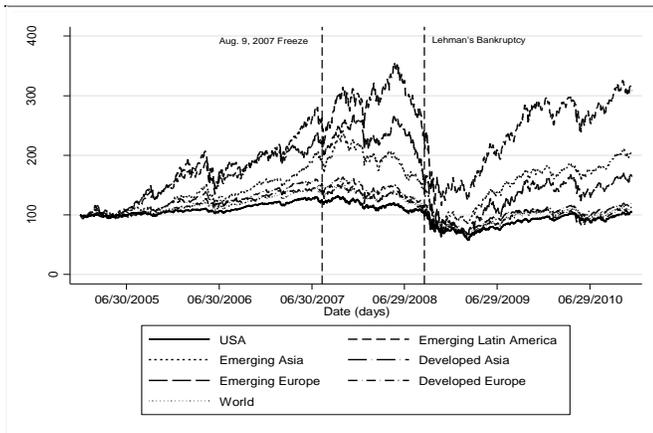
D. VIX Volatility Index (US)
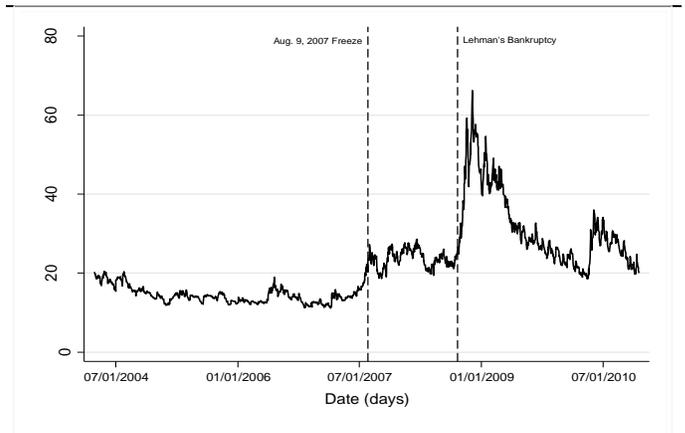
Figure 2 - Distribution of News Related to the Financial Crisis

All figures show the number of news in US main news sources that had the word crisis and either financial, finance or subprime from the Dow Jones Factiva database. Panel A shows the number of news each day fifteen days around September 15, 2008 using the US main sources. Panel B shows the number of news each day fifteen days around August 9, 2007.

Panel A - Main US sources August 31, 2008 to September 30, 2008.

Source: Factiva
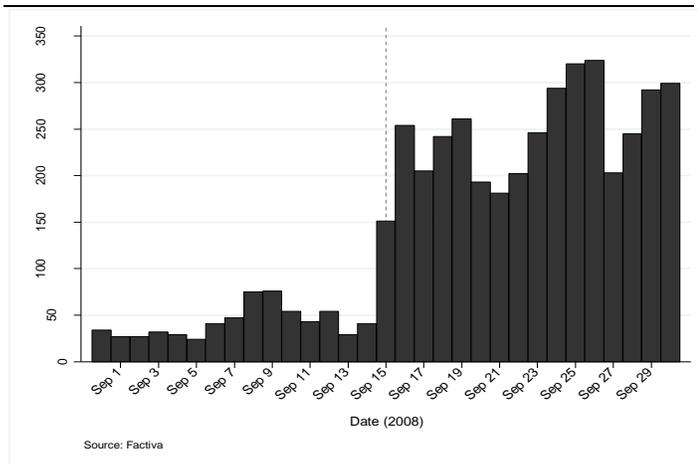
Panel B - Main US sources July 25, 2007 to August 24, 2007.

Source: Factiva
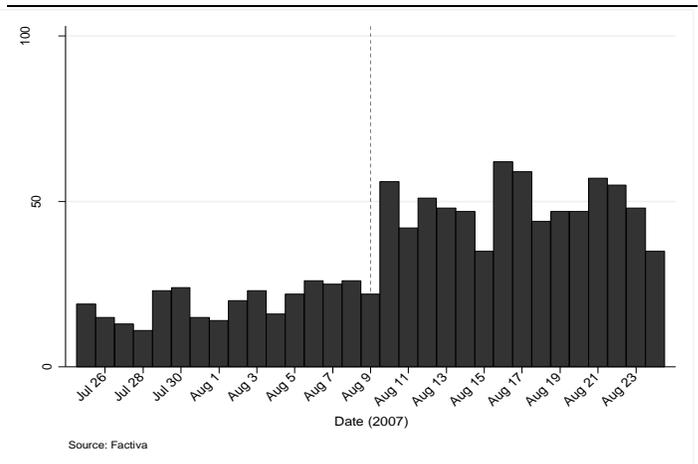
Figure 3 - Average Cumulative Abnormal Returns (CAR) of Global Banking Sector Around Lehman

Panels A and B show the average cumulative abnormal returns of the global banking sector in a window of ten days before and after the Lehman event of September 15, 2008, along their 90 percent confidence bands. Panel A shows the simple cumulative abnormal returns, and Panel B shows the cumulative differential return relative to the pre-event average abnormal return (the average abnormal return between t=-10 and t=-1). Panel C shows the point and cumulative estimates of the average abnormal returns for the event, along their standard errors. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Cumulative Abnormal Returns (CAR).
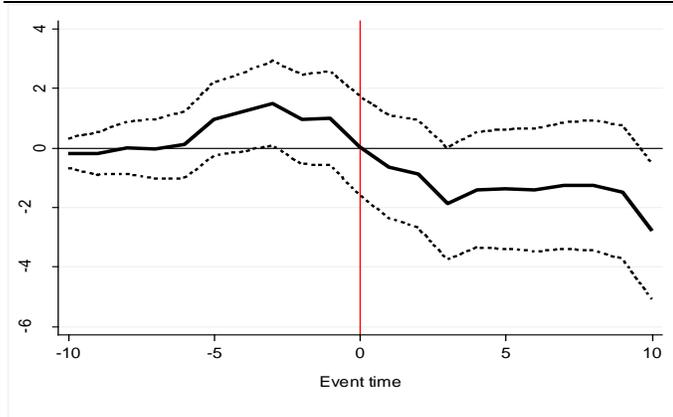
Panel B. Cumulative Abnormal Returns relative to pre-event (R-CAR)
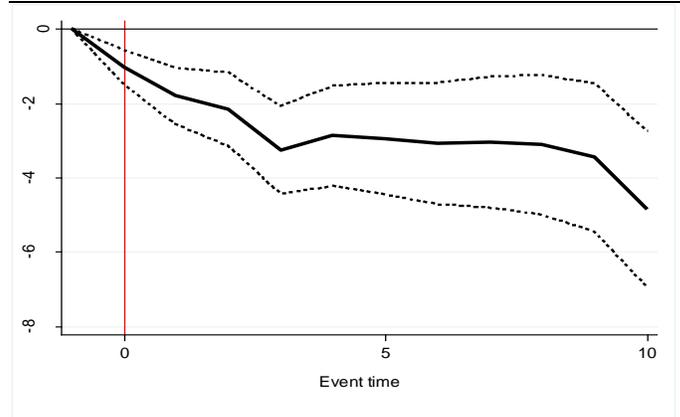
Panel C. Point and cumulative abnormal returns estimators (CAR and R-CAR)

Event Day	Point Estimators Mean	Point Estimators Std. Dev.	CAR Estimators Mean	CAR Estimators Std. Dev.	Event Day	Relative Point Estimators Mean	Relative Point Estimators Std. Dev.	R-CAR Estimators Mean	R-CAR Estimators Std. Dev.
-10	-0.19	0.31	-0.19	0.31	-10	-	-	-	-
-9	-0.01	0.31	-0.20	0.43	-9	-	-	-	-
-8	0.20	0.31	-0.01	0.53	-8	-	-	-	-
-7	-0.04	0.31	-0.05	0.61	-7	-	-	-	-
-6	0.15	0.31	0.10	0.68	-6	-	-	-	-
-5	0.87 ***	0.31	0.97	0.75	-5	-	-	-	-
-4	0.23	0.31	1.20	0.81	-4	-	-	-	-
-3	0.29	0.31	1.49 *	0.87	-3	-	-	-	-
-2	-0.55 *	0.31	0.95	0.92	-2	-	-	-	-
-1	0.03	0.31	0.98	0.97	-1	0.00	0.00	0.00	0.00
0	-0.93 ***	0.31	0.04	1.02	0	-1.03 **	0.40	-1.03 ***	0.29
1	-0.69 **	0.31	-0.64	1.06	1	-0.79 *	0.40	-1.82 ***	0.47
2	-0.25	0.31	-0.89	1.10	2	-0.35	0.40	-2.17 ***	0.60
3	-1.00 ***	0.31	-1.89 *	1.15	3	-1.10 ***	0.40	-3.27 ***	0.72
4	0.48	0.31	-1.41	1.19	4	0.38	0.40	-2.88 ***	0.82
5	0.01	0.31	-1.40	1.22	5	-0.08	0.40	-2.96 ***	0.91
6	-0.03	0.31	-1.42	1.26	6	-0.13	0.40	-3.09 ***	1.00
7	0.13	0.31	-1.29	1.30	7	0.04	0.40	-3.05 ***	1.07
8	0.02	0.31	-1.27	1.33	8	-0.08	0.40	-3.13 ***	1.15
9	-0.24	0.31	-1.51	1.37	9	-0.33	0.40	-3.47 ***	1.22
10	-1.29 ***	0.31	-2.80 **	1.40	10	-1.39 ***	0.40	-4.86 ***	1.28

Panel A shows the cumulative abnormal return (CAR) of banks with low and high wholesale dependence (25th and 75th percentile of wholesale dependence) in a window of ten days before and after the Lehman event of September 15, 2008. Panels B and C show the difference in total and relative cumulative abnormal returns (CADR and R-CADR) between a bank with high and low wholesale dependence (75th and 25th percentile of the global distribution of wholesale dependence) and its 90 percent confidence bands in a window of ten days before and after the event. Panel B shows the total cumulative abnormal differential returns (equivalent to the difference between the two lines in Panel A), and Panel C shows the cumulative differential return relative to the pre-event average abnormal return (the average abnormal return between t=-10 and t=-1). Panel D shows the point and cumulative estimates of the average abnormal differential returns for each of the events, total and relative, along their standard errors. The standard errors are robust to heteroskedasticity and clustered at the country-event day level. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Cumulative Abnormal Differential Returns (CAR) Banks with High and Low Wholesale Dependence
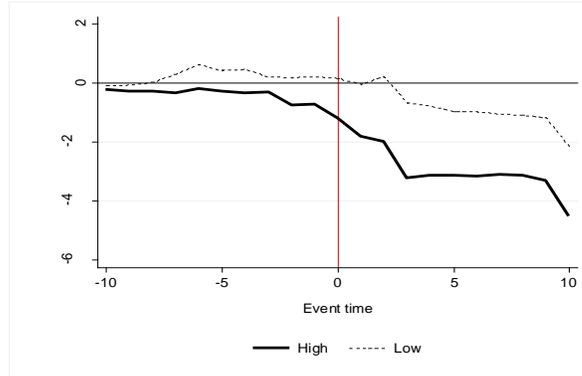
Panel B. Cumulative Abnormal Differential Returns (CADR)
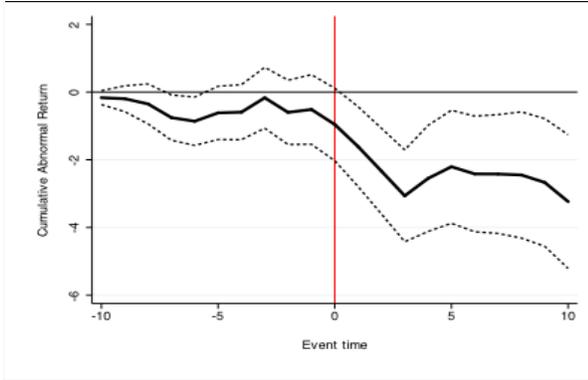
Panel C. Cumulative Abnormal Differential Returns relative to pre-event (R-C...
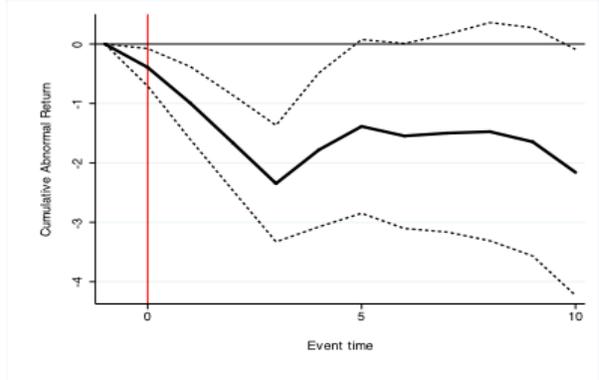
Panel D. Point and cumulative abnormal returns estimators, total and relative to pre-event (CADR and R-CADR)

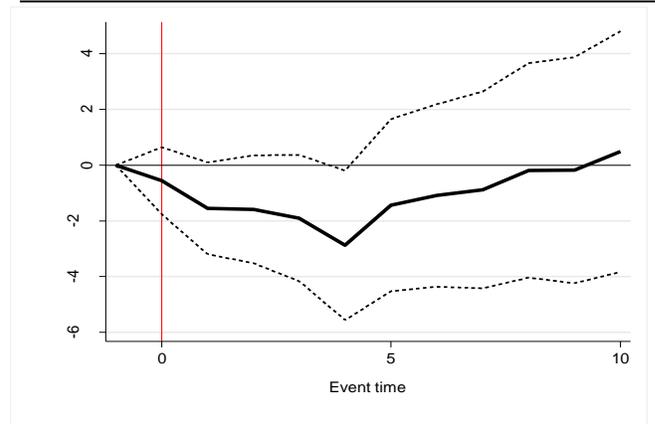| Event Day	Point Estimators (scaled) $(W^{high} - W^{low})*(\delta_{1,\tau})$		CADR Estimators		Event Day	Relative Point Estimates (scaled) $(W^{high} - W^{low})*(\delta_{1,\tau} - \delta_{1,PRE})$		Relative CAR Estimators (R-CADR)	
	Mean	Std. Dev.	Mean	Std. Dev.		Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
-10	-0.17	0.12	-0.17	0.12	-10	-	-	-	-
-9	-0.03	0.20	-0.20	0.23	-9	-	-	-	-
-8	-0.15	0.28	-0.35	0.36	-8	-	-	-	-
-7	-0.40 **	0.19	-0.75 *	0.41	-7	-	-	-	-
-6	-0.11	0.15	-0.86 **	0.44	-6	-	-	-	-
-5	0.25	0.20	-0.61	0.48	-5	-	-	-	-
-4	0.02	0.12	-0.59	0.50	-4	-	-	-	-
-3	0.43 *	0.24	-0.17	0.55	-3	-	-	-	-
-2	-0.43 **	0.19	-0.60	0.58	-2	-	-	-	-
-1	0.09	0.24	-0.51	0.63	-1	-	-	-	-
0	**-0.44 **	**0.18**	**-0.96**	**0.65**	**0**	**-0.39 **	**0.19**	**-0.39 **	**0.19**
1	-0.65 **	0.30	-1.61 **	0.72	1	-0.60 **	0.31	-1.00 ***	0.37
2	-0.72 ***	0.28	-2.33 ***	0.77	2	-0.67 **	0.28	-1.67 ***	0.49
3	-0.73 **	0.29	-3.07 ***	0.83	3	-0.68 **	0.30	-2.35 ***	0.60
4	0.51	0.48	-2.55 ***	0.96	4	0.57	0.48	-1.78 **	0.79
5	0.34	0.35	-2.21 **	1.02	5	0.40	0.35	-1.39	0.89
6	-0.21	0.22	-2.42 **	1.04	6	-0.16	0.22	-1.55	0.95
7	0.00	0.25	-2.42 **	1.07	7	0.05	0.25	-1.50	1.02
8	-0.03	0.38	-2.45 **	1.14	8	0.02	0.39	-1.47	1.12
9	-0.22	0.18	-2.67 **	1.15	9	-0.17	0.19	-1.65	1.17
10	-0.57	0.36	-3.24 ***	1.21	10	-0.51	0.36	-2.16 *	1.26

Figure 5 - Relative Cumulative Abnormal Differential Returns (R-CADR) of Banks with High and Low Wholesale Dependence Controlling for Bank Characteristics (Baseline Results)

The figure shows the relative cumulative abnormal differential returns (R-CADR) between a bank with high and low value of the bank characteristic listed on its top (75th and 25th percentile of the global distribution of control variable, respectively) and its 90 percent confidence bands. In all cases, bank-level abnormal returns come from a return model that controls for a country's market and banking sector returns, the standard errors used to construct the confidence bands are robust to heteroskedasticity and clustered at the country-event day level, and the estimation includes country-time fixed effects to control for daily differences in average abnormal returns across countries. Panel A shows the R-CADR associated with wholesale dependence. Panel B the R-CADR associated with size (log(total assets)). Panels C to F, show the R-CADR associated with profitability (log one plus return on average assets, ROA), leverage (log one plus equity/assets), a dummy that takes the value 1 for banks that declared exposure to Lehman, and a dummy that takes the value 1 for investment banks, respectively. All panels show results for an event window of ten trading days after the Lehman event of September 15, 2008.

A Wholesale funding dependence.

B. Size (Assets)

C. Profitability (ROA)

D. Leverage (Equity/Assets)

E. Declared exposure dummy

F. Investment bank dummy

Figure 6 - Relative Cumulative Abnormal Differential Returns (R-CADR) of Banks with High and Low Wholesale Dependence Controlling for Bank Characteristics. Credit Markets Freeze Event, August 9, 2007.

Panel A shows the relative cumulative abnormal return (R-CAR) of the global banking sector relative to its pre-event average abnormal return (the average abnormal return between t=-10 and t=-1) in a window of ten days before and after the Market Freeze event of August 9, 2007, along their 90 percent confidence bands. The rest of the panels show the relative cumulative abnormal differential returns (R-CADR) between a bank with high and low value of the bank characteristic listed on its top (75th and 25th percentile of the global distribution of control variable) and its 90 percent confidence bands. In all cases, bank-level abnormal returns come from a return model that controls for a country's market and banking sector returns, the standard errors used to construct the confidence bands are robust to heteroskedasticity and clustered at the country-event day level, and the estimation includes country-time fixed effects to control for daily differences in average abnormal returns across countries. Panel B shows the R-CADR associated with wholesale dependence. Panel C the R-CADR associated with size (log(total assets)). Panels D to F, show the R-CADR associated with profitability (log one plus return on average assets, ROA), leverage (log one plus equity/assets), and a dummy that takes the value 1 for investment banks, respectively. All panels show results for an event window of ten trading days around the Market Freeze event of August 9, 2007

Panel A. Average effect on banking sector
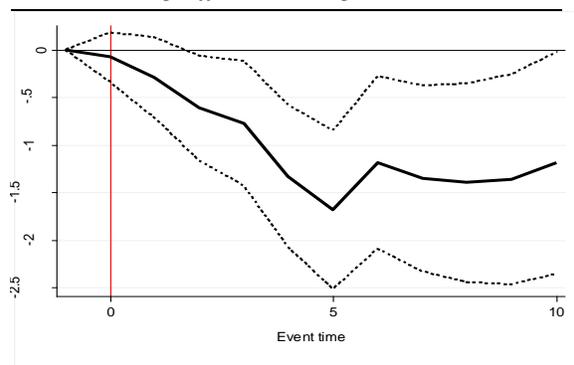
B. Wholesale funding dependence.
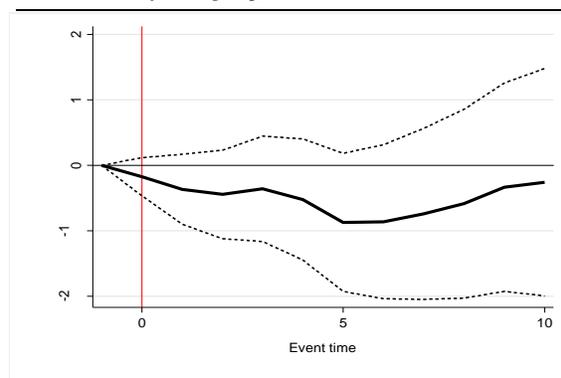
C. Size (log(Assets))
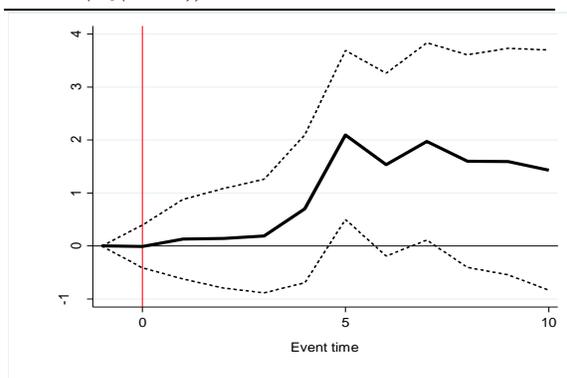
D. Profitability (ROA)
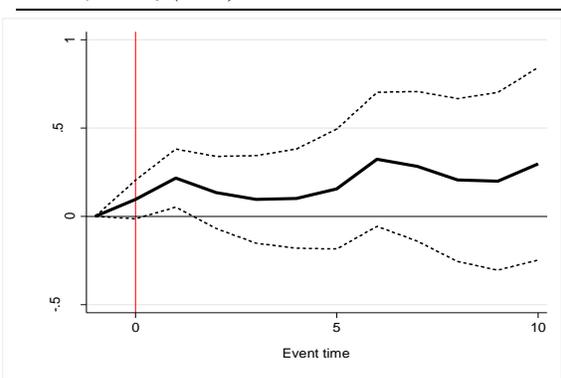
E. Leverage (Equity/Assets)
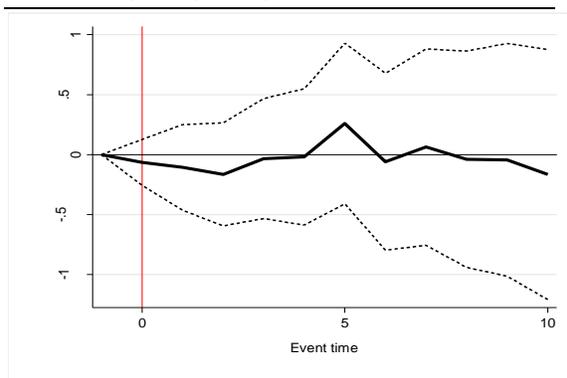
F. Investment Bank dummy
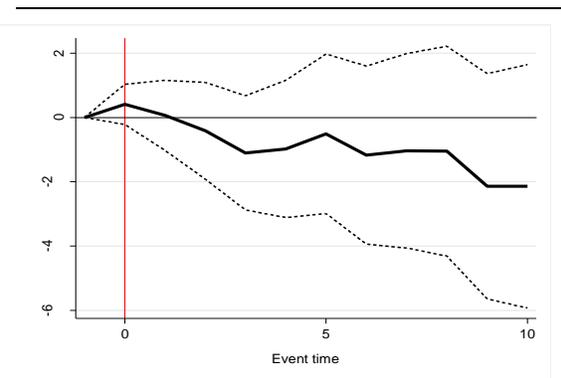
The figure shows the difference in relative cumulative abnormal returns (R-CADR) between a bank with high and low wholesale dependence (75th and 25th percentile of the global distribution of wholesale dependence) and its 90 percent confidence bands for different measures of abnormal returns and wholesale dependence. In all cases the bank-level abnormal returns come from a two factor return model that controls for a country's market and banking sector returns, and the standard errors used to construct the confidence bands are robust to heteroskedasticity and clustered at the country-day level. All differences are reported after controlling for country-time fixed effects to control for daily differences in average abnormal returns across countries. Panel A shows the R-CADR using an estimation window of 120 trading days immediately before the beginning of the event window. Panel B uses trade to trade returns to compute the return model and derive the abnormal returns. Panels C to E use the ratio of interbank loans (log one plus money borrowed from other banks divided by money lent to other banks), the ratio of (log one plus) money market plus bank deposits to total liabilities, and the ratio of (log one plus) non-deposit liabilities plus bank deposits to liquid assets, as measures of wholesale dependence, respectively. Finally, panel F displays the R-CADR computed using a window of 20 days before and after Lehman. All panels show results for the Lehman event of September 15, 2008.

A. Estimating return model just before Lehman
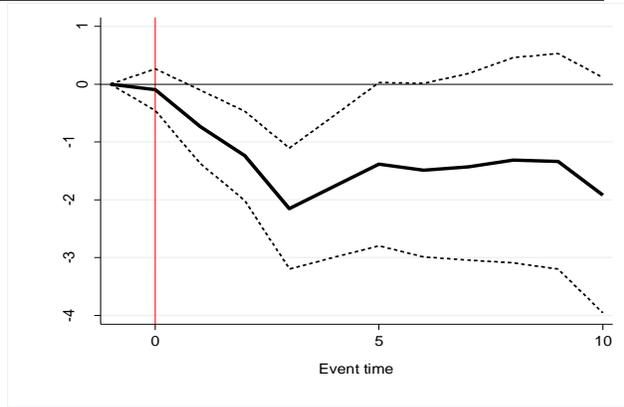
B. Trade-to-trade returns
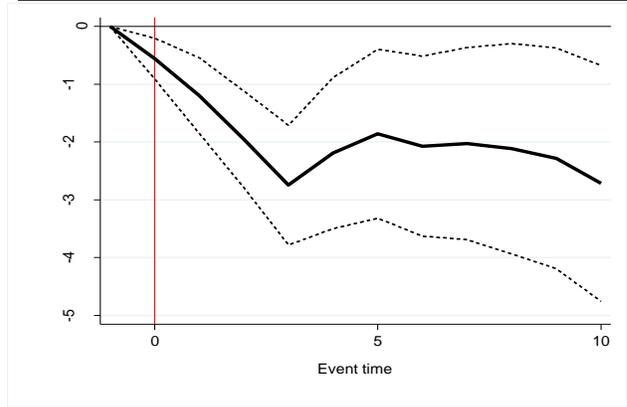
C. Interbank loans
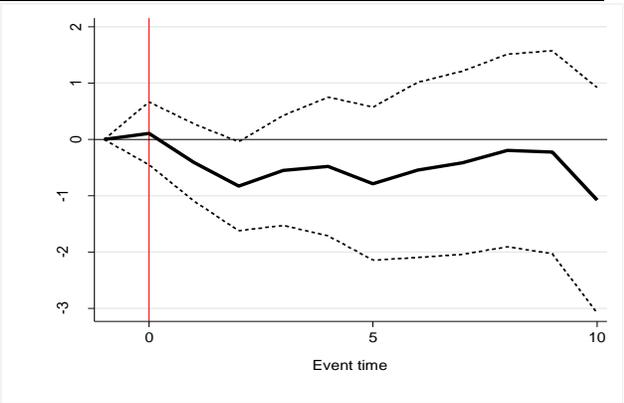
D. Money market plus bank deposits / liabilities
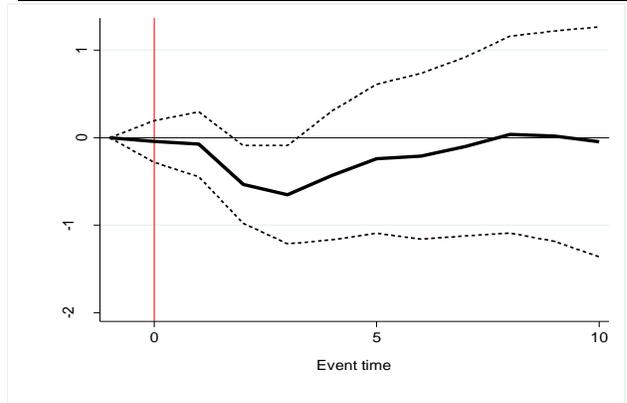
E. Non-retail-deposit liabilities to liquid assets
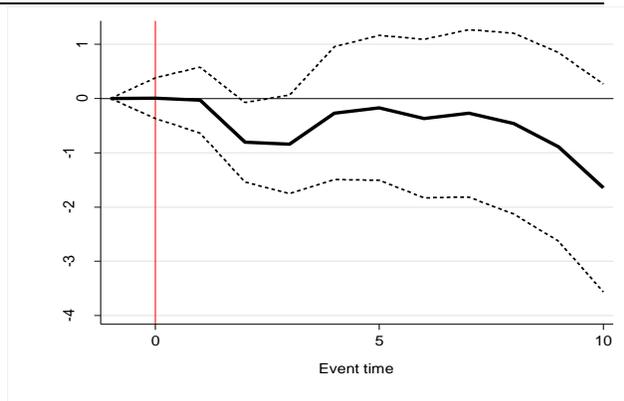
F. Twenty trading days window
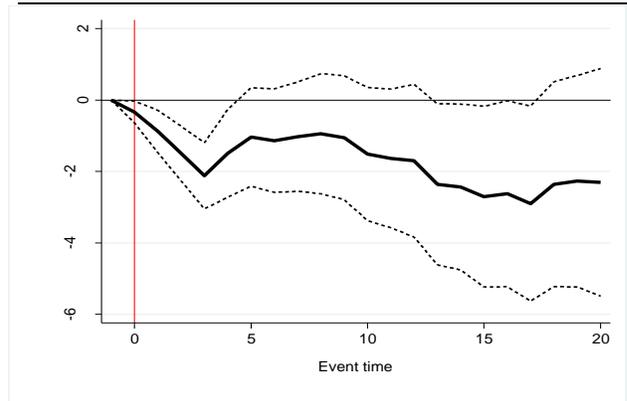
Figure 8 - The Impact of Country Characteristics on the Relative Cumulative Abnormal Differential Returns (R-CADR) of Banks with High and Low Wholesale Dependence

Panel A shows the relative cumulative abnormal differential returns (R-CADR) between a bank with high and low wholesale dependence (75th and 25th percentile of the global distribution of wholesale dependence) when all country level variables listed in the panels are set to zero (i.e. are below their cross country medians). Panels B to F show the impact of various country characteristics on that R-CADR. The thick line in each of these panels is the difference between the R-CADR in a country with a high value and a country with a low value of the characteristic listed on the top of the panel (above and below the cross country median, respectively). A positive significant value indicates that the characteristics significantly dampens the response of wholesale dependent banks (i.e. the figure in Panel A moves upward). Panel B shows results for the impact of deposit insurance, Panel C for the level of interantional reserves, Panel D for the power of the supervisory authority, Panel D for the degree of capital account openness, and Panel F for the trade exposure of the country to the US. The dashed lines correspond to the 90 percent confidence bands of the CADR. In all cases, bank-level abnormal returns come from a return model that controls for a country's market and banking sector returns, the standard errors used to construct the confidence bands are robust to heteroskedasticity and clustered at the country-event day level, and the estimation includes country-time fixed effects to control for daily differences in average abnormal returns across countries. All panels show results for an event window of ten trading days around the Lehman event of September 15, 2008.
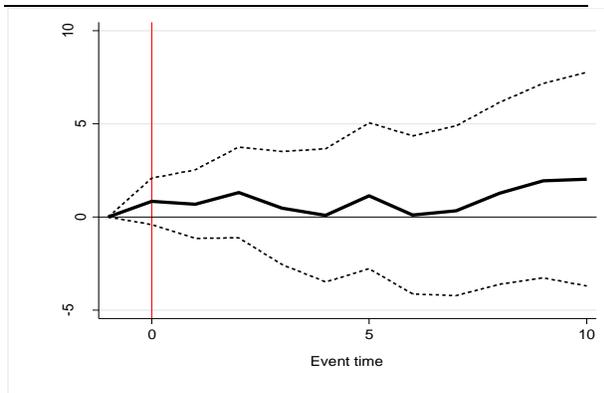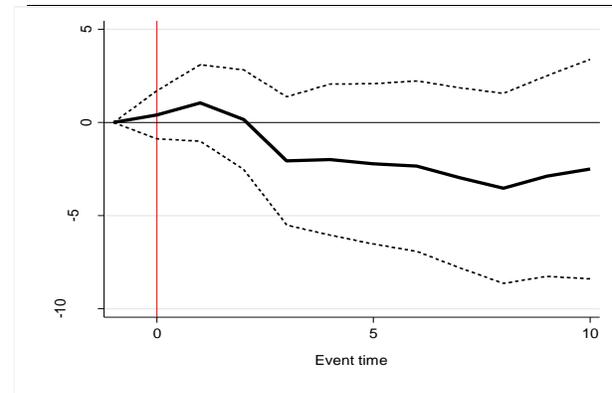

A. Baseline Wholesale dependence R-CADR
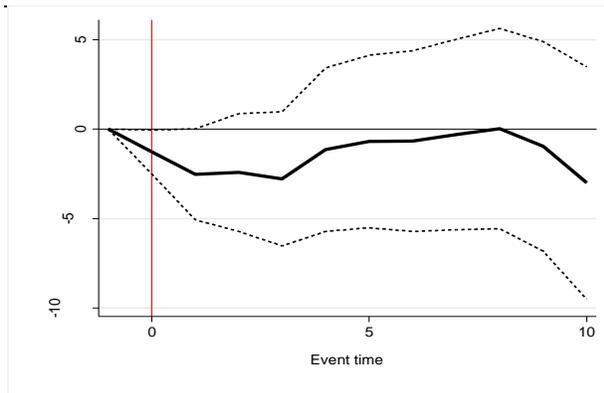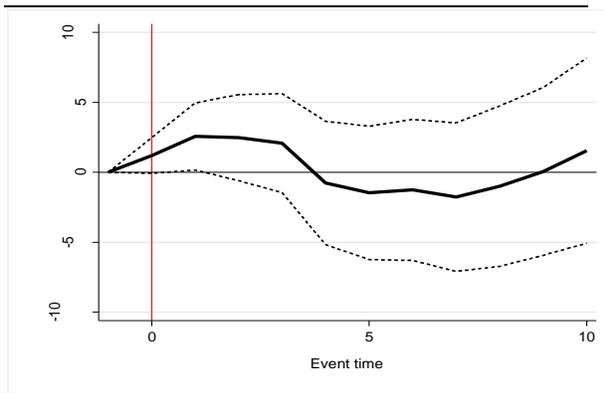

B. Δ(R-CADR)/Δ(Deposit insurance)
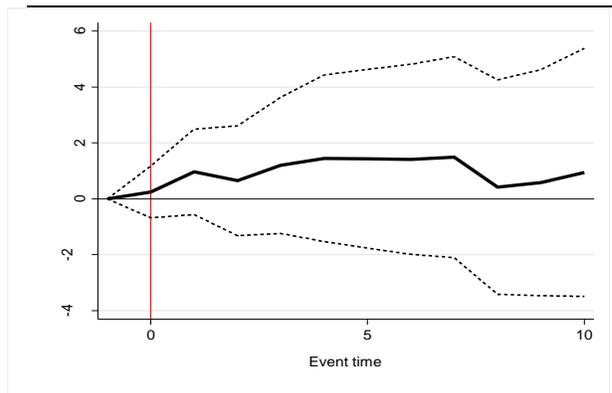
C. Δ(R-CADR)/Δ(International reserves)

D. Δ(R-CADR)/Δ(Power of the supervisory auth.)

E. Δ(R-CADR)/Δ(Capital account openness)

F. Δ(R-CADR)/Δ(Trade exposure to the US)
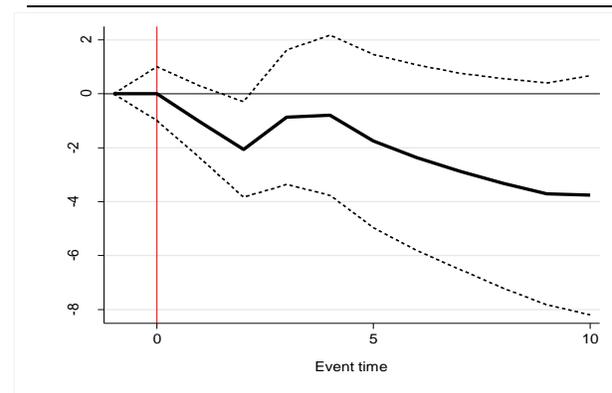
Appendix Table 1 - Data appendix

The table shows the main data sources used in the paper.

| Data	Source
Complete balance sheet data for banks in 45 countries from 2006 to 2008.	Bankscope
End of day data for listed banks stock price.	Bloomberg
End of day data for the FTSE Market Index and the FTSE Banking Index.	Datastream
Daily data on the TED spread and the LIBOR-OIS spread from 2005 to 2009.	Datastream
Number of news related to the financial crisis from Janaury 2007 to July 2009.	Dow Jones Factiva
Country index of Deposit Insurance.	Demriguc-Kunt et al. (2005)
Share of a country's exports to the US	Feenstra et al. (2005)
Bank ownership data (foreign/state).	Micco and Panizza (2006)
Data on country's international reserves.	IMF - International Financial Statistics
Data on country's financial system assets.	Beck et al. (2000)
Country index of independence of supervisory authority.	Barth et al. (2005)
Country index of capital account openness.	Ito and Chinn (2008)

Appendix Figure 1 - Changes in the sample

The line in each figure shows the empirical mean, and the shaded area the empirical range between the minimum and maximum of the cumulative abnormal differential returns (CADR) between a bank with high and low wholesale dependence (75th and 25th percentile of the global distribution of wholesale dependence). Panel A (B) shows the statistics obtained after dropping each of the 44 (670) countries (banks) in the sample at a time. All panels show results for the Lehman event of September 15, 2008.

Panel A - Dropping one country.
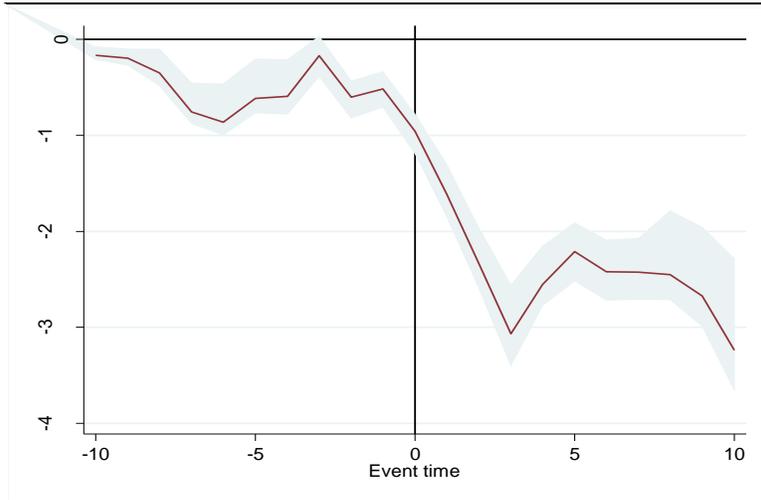
Panel B - Dropping one bank.
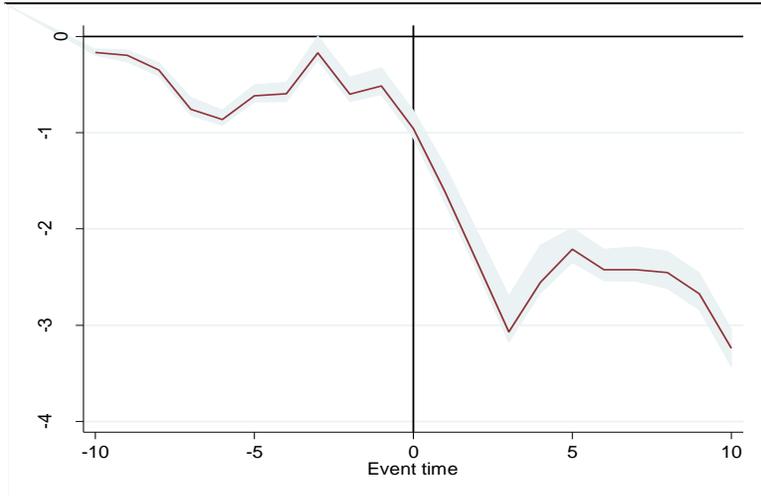
Appendix Figure 2 - Relative Cumulative Abnormal Differential Returns (R-CADR) of Banks with High and Low Wholesale Dependence. Including US banks and controlling by Bank Characteristics.

The figure shows the relative cumulative abnormal differential returns (R-CADR) between a bank with high and low value of the bank characteristic listed on its top (75th and 25th percentile of the global distribution of control variable, respectively) and its 90 percent confidence bands. In all cases, bank-level abnormal returns come from a return model that controls for a country's market and banking sector returns, the standard errors used to construct the confidence bands are robust to heteroskedasticity and clustered at the country-event day level, and the estimation includes country-time fixed effects to control for daily differences in average abnormal returns across countries. Panel A shows the R-CADR associated with wholesale dependence. Panel B the R-CADR associated with size (log(total assets)). Panels C to F, show the R-CADR associated with profitability (log one plus return on average assets, ROA), leverage (log one plus equity/assets), a dummy that takes the value 1 for banks that declared exposure to Lehman, and a dummy that takes the value 1 for investment banks, respectively. All panels show results for an event window of ten trading days after the Lehman event of September 15, 2008.
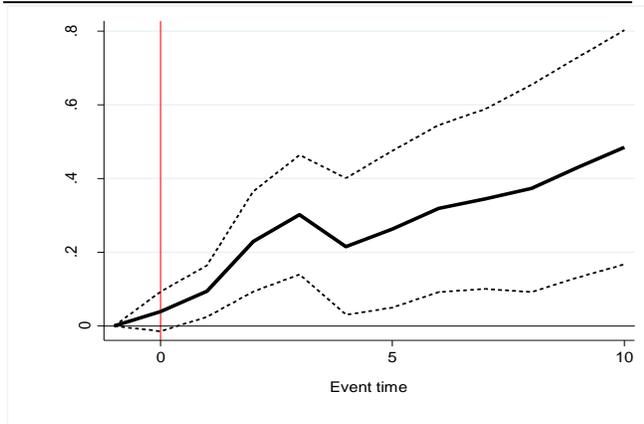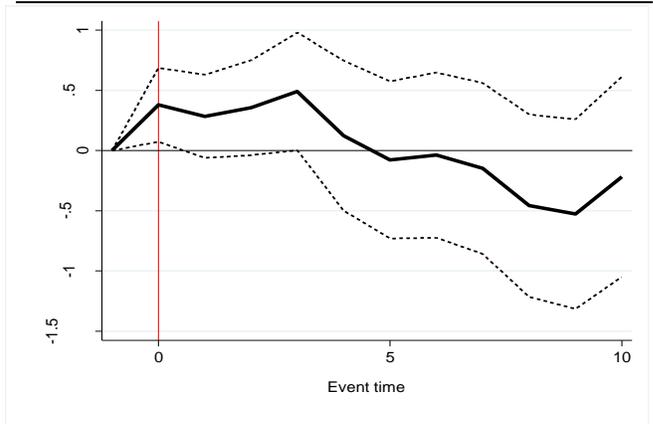
A Wholesale funding dependence.
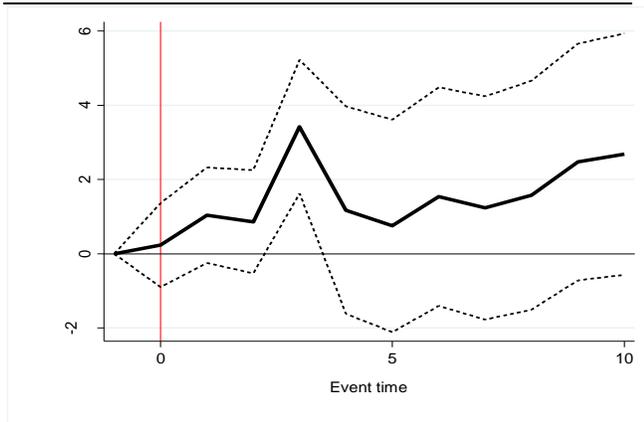

B. Size (Assets)

C. Profitability (ROA)

D. Leverage (Equity/Assets)

E. Declared exposure dummy

F. Investment bank dummy