Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

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2013-52

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April 2013

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We thank Christa Bouwman, Santiago Carbo-Valverde, Nicola Cetorelli, Robert DeYoung, Paolo Fulghieri, Elena Loutskina, Justin Murfin, Mitchell Petersen and Gunseli Tumer-Alkan for insightful comments and presentation participants at the Chicago Fed Bank Structure Conference, FDIC, OCC, IBEFA meetings, Bocconi University and Federal Reserve Board. Christine Coyer, Sean Flynn, Lieu Hazelwood, Michelle Welch and Eric Hardy provided research assistance. The opinions expressed do not necessarily reflect those of the Federal Reserve Board or its staff.

ABSTRACT

This paper investigates the mortgage lending of banks operating in multiple U.S. metropolitan areas during the housing market collapse of 2007-2009. Some metro areas in the U.S. suffered much greater mortgage defaults than others. We use this regional variation to identify whether high mortgage delinquencies in some markets affected multi-market banks' mortgage lending in other markets. Our results show that multi-market banks reduced local mortgage lending in response to delinquencies in other markets, consistent with the view that local economic shocks can be transmitted to other regions through banks' internal capital markets. This spillover effect was greatest in peripheral markets where multi-market banks do a small share of their lending. We find that securitized lending may have mitigated the decline in portfolio lending, but the effect on total lending is economically significant. The mechanism of the transmission appears to be through changes in bank capital and new information about the mortgage market.

JEL Classification: G21, G32, R12, R31

Keywords: Contagion, multi-market banks, mortgage lending, securitization

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1. Introduction

The geographic diversification of financial institutions has many benefits. Geographically diversified institutions are less exposed to local, idiosyncratic shocks (Hughes et al. 1996 and 1998). Also, due to their internal capital markets, these institutions can allocate capital more efficiently, helping insulate local economies from loan supply shocks that leave the profitability of local lending unchanged (Morgan, Rime, and Strahan 2004). However, there is a potential "dark side" of geographic diversification for local economies. By operating in multiple geographic regions, multi-market banks can create a financial linkage between otherwise unrelated local markets. This interconnectedness due to multi-market banks can result in contagion from one local market to another, with negative economic shocks being transmitted through the financial system.

The U.S. housing market collapse of 2007-2009 provides unique conditions for understanding how geographically concentrated shocks can spread to other regions. A key feature of the housing downturn is that some areas suffered much larger declines in home prices and increases in mortgage delinquencies than other areas. Metro areas in California, Arizona, Nevada, and Florida experienced very large decreases in housing prices and increases in mortgage delinquency rates. On the other hand, many areas in the middle of the country experienced only moderate declines in housing prices and increases in delinquency rates. These differences in the severity of the housing downturn raise the question of whether shocks in the hardest-hit housing markets spread to other areas of the country, and if so, how they spread.

In this paper we seek to shed light on the role of financial institutions in the spread of residential mortgage market shocks across U.S. cities during the crisis. We examine whether the geographic diversification of the banking sector increased the sensitivity of regional mortgage

markets to outside economic shocks. More specifically, we test the hypothesis that multi-market banks—those making mortgage loans in multiple metropolitan areas—transmitted mortgage default shocks across markets during the crisis by tightening loan supply in less affected markets. A finding that multi-market banks with heavy exposure to depressed housing markets contracted their mortgage lending in areas of the country with fewer mortgage losses would indicate adverse contagion across markets. In other words, heavy exposure to mortgage losses in one market could lead to reduced mortgage credit in other markets, which could slow housing activity and accelerate house price decline in those markets if the contraction was not fully offset by credit from other sources.

Our study builds on a long literature focusing mostly on international banking and the transmission of shocks across countries (e.g., Peek and Rosengren 1997 and 2000). The growing interconnectedness of global financial institutions is a key motivation to understand this issue, and the resulting transmission of shocks across country borders during the recent crisis has been well documented (Cetorelli and Goldberg 2011, Popov and Udell 2012). The advantage of our approach is that we narrow our focus to the financial market where the crisis began: the U.S. residential mortgage market. Our analysis exploits two important sources of heterogeneity in the U.S. mortgage market—variation in mortgage losses across regions due to differences in the severity of the housing downturn, and variation in multi-market banks' regional exposures to mortgage losses due to differences in the location of the banks' past lending. Specifically, we test whether an unusually large increase in mortgage delinquencies in one region causes multi-market banks that have been lending heavily in that region to reduce mortgage lending in the other regions in which they operate.

In principle, the effect of an adverse outside shock on a multi-market bank's local lending is ambiguous (Morgan, Rime, and Strahan 2004, deHaas and van Lelyveld 2010). The shock could *increase* the bank's local lending if it reduced the expected profitability of lending in the markets that experienced the shock—for example, if the shock reduced the creditworthiness or credit demands of borrowers in these markets. A multi-market bank faced with such a decline in the expected profitability of lending in outside markets might use its internal capital market to shift some of the lending to the local market, assuming the supply of funds to the banks was less than perfectly elastic and the expected profitability of lending in the local market remained unchanged or fell by less. We refer to this tendency for adverse loan demand shocks in other markets to cause a multi-market bank to increase its local lending as the *substitution effect.*

The alternative possibility, which we call the *spillover effect*, is that an adverse shock in other markets causes a multi-market bank to decrease its local lending. Such an effect could occur through two possible channels. In the first, which we will call the *capital channel*, the shock decreases the bank's overall capital or supply of deposits. To restore its capital-asset ratio to the desired level or to avoid replacing deposits with costlier non-deposit funds, the bank responds by restricting loan supply in all its markets, including those unaffected by the shock. The second way an adverse economic shock can reduce local lending, which we call the *information channel*, is by causing the bank to revise downward it beliefs about the profitability of local lending. For example, a decrease in the quality of borrowers in other markets may cause the bank to become more pessimistic about the quality of local borrowers, especially if the local market is one about which the bank has little independent information. In such cases, the bank may decrease lending in the local market in addition to the markets experiencing the shock.

We refer to the view that the spillover effect of regional or national economic shocks dominates the substitution effect as the *spillover hypothesis*. Our results strongly support this hypothesis for the U.S. mortgage market. For each metro market and bank, we calculate the growth during the recent crisis in the amount of mortgage loans originated by the bank and held in its portfolio. We show that for multi-market banks, such lending growth was negatively related to the increase in the average mortgage delinquency rate in the bank's other markets during the period leading up to the crisis. This finding implies that the tendency for outside shocks to reduce local lending through the capital or information channels outweighs any tendency for the bank to shift lending to the local market from markets in which lending has become less profitable. More generally, the empirical support we find for the spillover hypothesis suggests that the geographic diversification in banking may have a "dark side" by increasing the vulnerability of markets to outside economic shocks.

We also explore whether the sensitivity of a multi-market bank's local lending to outside economic shocks depends on how important the local market is to the bank's overall lending. We refer to a market that accounts for at least half of a multi-market bank's overall lending as a *core* market, and a market that accounts for less than half of overall lending as a *peripheral* market. We also distinguish between moderately peripheral markets, defined as those accounting for one to 50 percent of the bank's mortgage lending, and highly peripheral markets, those accounting for less than one percent of the bank's mortgage lending.

Whether the spillover of outside shocks occurs through the capital channel or the information channel, the effect on local lending should be stronger when the local market is more peripheral to the bank. For example, an increase in mortgage losses in other markets should have a greater tendency to reduce the bank's overall capital, and thus a greater tendency to

reduce the bank's local lending, if the markets in which losses increased account for a large share of the bank's overall mortgage lending—i.e., if the local market is peripheral. Similarly, a multi-market bank may lack good information about local conditions and base its estimate of local borrower creditworthiness partly on developments in its other markets. The greater the share of those markets in the bank's overall lending, the more weight it is likely to place on new information from them. In both cases, another factor may also come into play: lending may be more sensitive to outside economic shocks in peripheral markets than core markets because banks are more likely to "cut and run" from the markets in which they have less long-term interest. Consistent with these arguments, we find that outside economic shocks led multi-market banks to reduce local lending more if the market was peripheral than core, and more if the market was highly peripheral than moderately peripheral.

Another issue addressed in this paper is whether the transmission of shocks across markets is mitigated by banks' ability to offset changes in *portfolio lending* (loans originated and kept on the books) with changes in *securitized lending* (loans originated and sold to non-affiliates). Suppose, for example, that the spillover of outside shocks to local portfolio lending occurs through the capital channel. Then a bank that can easily shift between portfolio and securitized lending may not need to decrease its total mortgage lending in the local market as much in response to adverse loan supply shocks in its other markets. In particular, the bank may opt to sell some of the local loans it had been planning to originate and hold. By doing so, the bank could make the desired adjustment in the size and risk of its overall loan portfolio while earning fee income from loan sales. Thus, the ability of multi-market banks to shift between portfolio lending and securitized lending may dampen the response of total lending to the outside shock. Our results suggest that declines in local mortgage lending in response to outside

economic shocks were mitigated—but only partially—by a tendency for multi-market banks to increase local securitized lending at the same time they reduced local portfolio lending.

Lastly, we explore whether the spillover effect is due to the capital channel, the information channel, or both. If the capital channel is operative, the spillover from outside mortgage shocks to local mortgage lending should be greater for banks whose capital is more exposed to mortgage losses—i.e., for banks whose total mortgage holdings are large relative to their equity capital. If the information channel is at work, the spillover from outside mortgage shocks to local lending should be greater in markets that are distant from the bank's headquarters because bank management is less likely to have good information on such markets. For moderately peripheral markets, we find that mortgage defaults in other markets lead to greater declines in local lending at banks with greater capital exposure to mortgage losses and in markets located farther from the bank's headquarters. This evidence suggests that the capital and information channels both contribute to the cross-market spillover of mortgage-related shocks.

The remainder of our paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the data as well as some descriptive statistics and Section 4 explains the empirical methodology. Section 5 describes the regression results for the test of the spillover hypothesis, while Section 6 presents the results for the tests of the capital and information channels. Section 7 concludes.

2. Related literature

Previous research has examined the benefits of banks' geographic diversification for reducing the sensitivity of local bank lending to local economic shocks. Geographic deregulation of the U.S. banking sector led to a decline in state-level economic volatility, which suggests that

geographic diversification helps banks offset local supply shocks (Morgan, Rime and Strahan 2004). Consistent with this view of reduced local sensitivity, a severe downturn in the local economy reduces local small-business lending more at single-market banks than at multi-market banks with deposits in other markets (Keeton 2009). Geographic diversification also appears to reduce the dependence of local bank lending on local deposit-taking (Becker 2007). On the other hand, financially integrated metropolitan areas display greater volatility in housing prices and greater sensitivity to local housing price shocks, suggesting that geographic diversification facilitates the transfer of funds from depressed housing markets to booming ones (Loutskina and Strahan 2011).

A closely related set of studies focuses on the benefits of internal capital markets in bank holding companies. Financial frictions leading to costly external finance and the use of internal capital markets are important pre-conditions for expecting to find a transmission of shocks through multi-market banks. Previous findings indicate that bank holding companies use internal capital markets to reallocate resources efficiently among their subsidiaries, offsetting declines in deposits at liquidity-constrained banks by shifting deposits from unconstrained banks or down-streaming funds borrowed on external capital markets (Campello 2001, Ashcraft 2006, Huang 2008). Similarly, multinational banks use internal capital markets to manage the credit growth of their foreign subsidiaries (De Haas and van Lelyveld 2010).

Most of the existing research on geographic diversification and cross-market spillovers has focused on cross-border international banking, examining the impact of large shocks on banks with different degrees of international exposure. The U.S. subsidiaries of Japanese banking companies that suffered heavy losses in Japan during the 1990s significantly reduced their commercial real estate lending in U.S. markets (Peek and Rosengren 2000) and, after

Pakistan's unanticipated nuclear tests in 1998 and the ensuing liquidity shock, Pakistani banks with foreign funding significantly reduced their local lending (Khwaja and Mian 2008). Similarly, Schnable (2012) investigates the effect of the Russian debt crisis of 1998 on bank lending in Peru and finds that lending from foreign-owned banks fell more than lending from domestic banks without access to foreign credit. In the financial contagion literature, the tendency for a bank to reduce lending in one country after suffering an unexpected loss in another country is commonly referred to as the "common lender" effect (Van Rijckehem and Weder 2003).

More recent papers investigate the existence of international cross-market spillovers during the 2007-2009 financial crisis. Examining loan applications by small and medium-sized businesses in emerging Europe, Popov and Udell (2012) find that loan rejection rates increased most in those markets in which foreign banks with financially distressed parents had the highest presence. Emerging markets also experienced the biggest declines in lending from developed countries with the greatest vulnerability to dollar funding shocks, suggesting that global banking has made emerging markets more susceptible to loan supply shocks in the developed world (Cetorelli and Goldberg 2011). These international findings on the financial crisis are consistent with the view that geographic diversification increases the sensitivity of local lending to outside loan supply shocks.

Our work builds on the previous literature by studying the residential mortgage market and the role of multi-market banks in the spillover of housing market shocks across metro areas in the U.S. during the financial crisis. Using the regional variation in mortgage lending by multi-market banks and the corresponding exposures to large mortgage losses in certain markets, we can identify the changes in local bank lending due to external loan supply shocks. We also

believe our study is unique in testing whether the magnitude of the spillover from outside shocks depends on the share of the local market in the bank's total mortgage lending. As explained in the introduction, plausible explanations for the spillover effect suggest that the effect should be greater in local markets that account for a small share of the bank's overall lending (peripheral markets) than in markets that account for a large share of overall lending (core markets).[1]

Another contribution of our study is to investigate whether the spillover effect occurs through the adverse impact of the outside shock on the bank's overall capital or through an update in the bank's beliefs about the creditworthiness of local borrowers. A large empirical literature has examined the effect of shocks to bank capital on bank lending. Much of this literature grew out of the U.S. credit crunch of the early 1990s, when it became clear that heavy losses on commercial real estate loans contributed to a sharp cutback in bank lending due to reduced bank capital (Bernanke and Lown 1991, Sharpe 1995). Other studies have examined the effect of changes in bank capital on lending in more recent periods (Berrospide and Edge 2010, Francis and Osborne 2009, Mora and Logan 2010, Albertazzi and Marchetti 2010). Identifying the effect on bank lending of a decrease in bank capital is difficult because observed decreases in lending could be due to the deterioration in the creditworthiness of prospective borrowers rather than a decline in capital (Sharpe 1995). Similar to Peek and Rosengren (2000), we address the endogeneity issue by looking at the response of local lending to loan losses in outside markets rather than loan losses in the local market. In addition, we test whether the spillover effect is stronger for banks with high exposure of capital to mortgages, which would provide support for the existence of a capital channel.

[1] To avoid confusion, we use the term "overall lending" to refer to the sum of lending across all of a bank's markets and the term "total lending" to refer to the sum of the bank's portfolio and securitized lending.

Less attention has been paid in the literature to our alternative explanation for the spillover effect—a revision in the bank's beliefs about local conditions due to new information about conditions in the banks' other markets. It has been argued that large multi-market banks are not well suited to collecting "soft" information about borrowers, such as information about the borrower's character (Stein 2002, Canales and Nanda 2012). As a result, these banks may base local lending decisions on other information, such as the performance of loans in the other markets in which they operate. Lack of information about local conditions may be especially acute when the market is far from bank headquarters, as multi-market banks have been found in such case to exercise less control over the subsidiary and face greater difficulty collecting soft information (Berger and DeYoung 2006, Mian 2006). Such lack of information about conditions in distant markets could explain why multi-market banks do not appear to reduce local lending much in response to changes in local economic conditions (Keeton 2009). The information story is also consistent with the notion of a "wake-up call," in which multinational banks revise their perceptions of an entire class of loans based on losses in only some of the countries in which they operate (Van Rijckeghem and Weder 2003). [2] Our study contributes to the emerging literature on information problems at multi-market banks by testing whether the spillover effect increases with distance of the local market from bank headquarters. Such a finding would be consistent with the idea that a multi-market bank puts more weight on developments in other markets when it has less information about the local markets.

[2]Bank-specific loan losses in some markets could cause a multi-market bank to revise downward its perception of its screening ability, leading the bank to reduce lending in its other markets (Murfin 2010). However, this effect cannot explain the spillover effect in our case because our measure of mortgage delinquencies is for all banks in the market.

3. Data and sample statistics

Our mortgage lending data consist of regulatory filings collected annually under the Home Mortgage Disclosure Act (HMDA). These data include information on the location of the borrower, allowing us to compute mortgage originations at the county and metro-area levels. We include loans that are owner-occupied, conventional (i.e., not guaranteed by government agencies such as the Federal Housing Administration), and larger than $50,000.[3] For portfolio lending, we include only those loans that are either held by the originator or sold to an affiliate, and only those loans that are originated by banks, thrifts, or their affiliates. For total lending, we add those loans that are sold to government sponsored entities (GSEs such as Fannie Mae and Freddie Mac) or non-affiliates in the private sector (jointly referred to as securitized lending).

The markets in the study consist of 376 Metropolitan Statistical Areas (MSAs) and Metropolitan Divisions, based on the December 2003 definitions in terms of counties (Office of Management and Budget 2003) .[4] We use these definitions for all years to ensure consistency across time in the measurement of market-level variables. Although the mortgage origination data and mortgage delinquency data are both available at the county level, we define markets in terms of MSAs in line with previous findings that MSAs are more appropriate geographic boundaries for measuring bank competition (Rhoades 1982).

The data are aggregated by bank holding company and are adjusted for bank mergers to ensure that growth in a banking organization's mortgage originations in a market is not

[3] The $50,000 cutoff was adopted in the early stages of the project to ensure that only first-lien loans were included regardless of the period considered. The HMDA data include information on lien status but only since 2004.
[4] Eleven of the largest MSAs are subdivided into Metropolitan Divisions. For these MSAs, the Metropolitan Divisions are treated as separate markets.

artificially inflated by the acquisition of other banks' lending in that market.[5] For convenience, we often refer to lenders in the sample as banks, even though some are bank holding companies or stand-alone thrifts. We define single-market banks as those that originate at least 99 percent of their home mortgage loans in one metropolitan area. Multi-market banks are all others. Data on bank characteristics are taken from the quarterly bank and thrift Call Reports. These data include total assets, tangible equity capital, delinquencies on all loans other than residential mortgages, and the size of the residential mortgage portfolio.

The analysis focuses on the change in mortgage lending between two periods: the years 2006-2007, which we refer to as the pre-crisis period, and the years 2008-2009, which we refer to as the crisis period. In each comparison between periods, we restrict the sample to bank-market observations for which mortgage originations were positive in both periods. Thus, the analysis focuses on the infra-marginal decision of banks to increase or decrease lending in markets where they were consistently originating mortgages.

Table 1 reports the dollar volume of mortgage originations in the two periods for the roughly 3,500 hundred banks making up our sample. The data are broken down by type of bank (single-market vs. multi-market) and type of lending (portfolio, securitized, and total). Three facts stand out from the table. First, though single-market banks represent almost a quarter of banks in the sample, they account for only a tiny fraction of total mortgage originations due to their small size. Second, while portfolio lending declined at both types of banks in the sample from the pre-crisis to the crisis period, the decline was especially large at the multi-market banks that account for the vast majority of mortgage loans—67.5 percent versus only 1.2 percent for single-market banks. The overall magnitude of the decline in portfolio lending at multi-market

[5] In the merger adjustment, the acquired bank's originations in the initial period are added to those of the acquiring bank, a process sometimes referred to as "force-merging" of the banks' balance sheets.

banks suggests that the sample may provide a good opportunity for examining the effect of mortgage delinquencies in depressed markets on a bank's lending in healthier markets. Third, at multi-market banks, securitized originations declined somewhat less than portfolio originations between the two periods—51.2 percent versus 67.5 percent. This fact raises the possibility that above-average declines in local portfolio lending by some multi-market banks due to spillover effects may have been offset by below-average declines in local securitized lending by the same banks. Estimating our regression equations for total originations provides a check against this possibility.

Our measure of housing distress in each metro area is the percent of home mortgage borrowers in the area that were 90 days or more past due in their mortgage payments. The specific measure of the mortgage delinquency rate is from Trend Data, a database compiled by TransUnion from credit bureau data on individual consumers.[6] We believe this measure is a good proxy for housing distress, allowing us to investigate how such distress affects banks' mortgage lending in other markets. In areas with high delinquency rates, banks are more likely to suffer mortgage losses that deplete their capital and reduce their overall willingness to lend, as predicted by the capital channel for the spillover effect. In such areas, banks are also more likely to receive negative signals about the performance of their mortgage loans that cause them to revise downward their estimates of borrower quality in other markets, as suggested by the information channel for the spillover effect. Finally, banks with substantial loans in high-

[6] The data are described in detail in Barron, Ellihausen, and Staten (2000). Although Trend Data reports delinquency rates by metro area as well as county, the Trend Data definition of metro areas by county changes over time. As a result, we take the county-level changes in delinquency rates and use HMDA data on total portfolio originations in each county in the pre-crisis period to construct a weighted-average change in the delinquency rate for each metro area based on consistent metro area definitions.

delinquency areas may conclude that mortgage lending is more profitable in other markets, causing them to shift lending to those markets in accord with the substitution effect.

Figure 1 show that changes in mortgage delinquency rates during the two years leading up to the crisis varied significantly across metro areas and much more than in the previous two years. From the end of 2003 to the end of 2005, the mean change in the mortgage delinquency rate was .17, the median change was .14, and the standard deviation of the change was .38. During that period, 57 markets experienced increases in default rates over half a percent point. Over the next two years, from the end of 2005 to the end of 2007, the mean change in the default rate increased to .46, the median change to .24, and the standard deviation of the change to. 94. During this period, 138 markets experienced increases in default rates above one-half percent, more than twice as many as in the previous two years. The significant variation in housing distress across metro markets just prior to the crisis highlights the advantage of using differences in multi-market banks' exposure to mortgage losses in other markets to identify spillovers to local lending during the crisis.

For a particular bank and market, we represent a bank's outside exposure to mortgage losses by the change in the "other loss rate." For each market and multi-market bank originating mortgage loans in the market, this variable is the weighted-average change in the 90-day delinquency rate in all the *other* metro areas in which the bank originates mortgage loans. The weight for each of these other markets is its share in the bank's total pre-crisis portfolio originations outside the market in question. In each market, the change in the other loss rate varies among multi-market banks due to differences in the banks' exposure to housing distress in other markets. In the descriptive statistics, we also report changes in the "local loss rate." For each market, this variable is the average change in the 90-day delinquency rate in that market. In

contrast to the change in the other loss rate, it is the same for all banks originating mortgages in the market, including both single-market and multi-market banks.

We also differentiate bank/market observations in the sample by the share of the market in the bank's total pre-crisis portfolio originations. For multi-market banks, we refer to a market that accounts for 50 to 99 percent of the bank's total portfolio originations as a "core" market for the bank.[7] A market accounting for 1 to 50 percent of originations is referred to as "moderately peripheral," and a market representing less than 1 percent of the bank's originations as "highly peripheral." These categories are designed to test how the response of bank lending to outside shocks depends on the importance of the local market to the bank.

For the approximately 13,500 bank/market observations in our sample, Table 2 presents medians for bank size, growth in portfolio mortgage originations, the changes in the local loss rate, and the change in the other loss rate. These data are broken down by the degree to which the market is peripheral to the bank. Not surprisingly, median bank size increases with the extent to which the market was peripheral to the bank. At one extreme, single-market banks had median assets of only $146 million at the end of 2007. At the other extreme, banks lending in markets that were highly peripheral for them had median assets of $55 billion. Table 2 also shows that the growth of portfolio originations from the pre-crisis period to the crisis period was lower in markets that were more peripheral to the bank. In log terms, median loan growth ranged from a high of 5.9 percent at single-market banks to a low of -93.1 percent in highly peripheral bank-market observations.[8] Finally, although both local loss rates and other loss rates increased from

[7] By this definition, a bank whose lending is highly diversified across markets may have no core market.

[8] We obtain similar results when we use the median loan growth of total originations (sum of portfolio and securitized loan originations) from the pre-crisis to the crisis period.

the end of 2005 to the end of 2007, the other loss rate went up somewhat more than the local loss rate in core and moderately peripheral markets and significantly more in highly peripheral markets. In highly peripheral markets, the median change in the other loss rate was over three times the median change in the local loss rate.[9]

Table 3 reports the correlations in the sample among the growth in total originations, the change in the local loss rate, and the change in the other loss rate. As before, the data are broken down by how peripheral the market is to the bank. The third column shows that in all three types of markets in which multi-market banks originated loans, the growth in originations from the pre-crisis period to the crisis period was negatively correlated with the change in the other loss rate. Furthermore, the correlation was more negative in moderately peripheral markets than core markets, and more negative in highly peripheral markets than moderately peripheral markets. Although none of the correlations are large, these results are consistent with the spillover hypothesis, according to which outside shocks lead to declines in local lending through the capital or information channels.

It is important to note in Table 3 that for both core markets and moderately peripheral markets, the change in the other loss rate was highly correlated with the change in the local loss rate. Furthermore, in both types of markets, the growth in originations was just as negatively correlated with the change in the local loss rate as with the change in the other loss rate.[10] These facts suggest that the negative relationship between growth in originations and the change in the

[9]Whether measured by mean or median, the change in the other loss rate exceeded the change in the local loss rate in the sample as a whole. The reason is that the change in the other loss rate is a *weighted* average of the changes in delinquency rates in a bank's other markets, and these changes tended to be greater in markets in which banks originated more loans (the correlation across markets between the log of pre-crisis originations and the change in the delinquency rate was .38). .

[10] In highly peripheral markets, it was also true that the correlation between the two loss rates was positive and the correlation between the growth in originations and the change in the local loss rate was negative. However, both correlations were considerably smaller in absolute value than in core and moderately peripheral markets.

other loss rate may not be due to spillover of housing shocks across markets but to a tendency during the housing boom for some banks to lend almost exclusively to high-risk markets. A major advantage of our empirical strategy is that it can control for this effect by comparing, within each market, the lending growth of banks with big increases in the other loss rate to the lending growth of banks with small increases (or decreases) in the other loss rate.

4. Empirical methodology

Our empirical methodology is designed to identify the effect of outside economic shocks on local bank lending. To test the spillover hypothesis, we start with the following regression specification:

$$\begin{aligned}(1a)\quad \textit{Log Growth in Originations}_{i,m} = {} & a_m \cdot \textit{Market}_{i,m} + b \cdot \textit{Size}_i + c \cdot \Delta \textit{TCE}_i \\ & + d \cdot \Delta \textit{NRRE Delinquency Rate}_i \\ & + e_1 \cdot \textit{Multi-Market}_i + e_2 \cdot \textit{Multi-Market}_i \times \Delta \textit{Other Loss Rate}_{i,m} + \varepsilon_{i,m}\end{aligned}$$

The dependent variable is the log growth in bank i's mortgage originations in metro area m from the pre-crisis period (2006 and 2007 combined) to the crisis period (2008 and 2009 combined). By focusing on the change in lending from the pre-crisis period to the crisis period, we can specify the regression as a cross-sectional comparison of the response in banks' local mortgage lending to significant mortgage defaults in their other markets.

We control for local mortgage demand using market fixed effects. Specifically, the explanatory variables include a set of dummy variables, $\textit{Market}_{i,m}$, for the 376 metro areas in the sample. Our use of market dummies is similar to studies of cross-country spillovers in bank lending that use country fixed effects to control for loan demand (Kwaja and Mian 2008,

Cetorelli and Goldberg 2011, and Schnable 2012). We believe this approach controls for local demand in a cleaner fashion than including an incomplete and potentially endogenous set of measures of local demand, such as the change in the local loss rate or local housing prices.

The specification also includes controls for bank-level characteristics that could affect a bank's lending in all markets. *Size* is measured by the log of the bank's assets at the end of 2007. It is important to control for size to ensure that declines in mortgage lending by multi-market banks do not just reflect the widely observed tendency for large banks to cut back lending more than small banks during the crisis. To control for bank-wide loan supply shocks—those not specific to particular markets—we include in each regression measures of the change in the bank's book equity capital and the change in the bank's delinquencies on loans other than home mortgages. ΔTCE_i is the percentage-point change in the ratio of bank i's tangible equity capital to assets from the end of 2005 to the end of 2007. $\Delta NRRE\ Delinquency\ Rate_i$ is the percentage-point change over the same period in the delinquency rate on bank i's non-residential-real-estate loans, measured by the percent of loans other than residential real estate loans that are 90 days or more past due or non-accruing. This variable is included to capture losses that are not reflected in the bank's book equity capital because the loans have not yet been written off. If high values of ΔTCE and low values of $\Delta NRRE\ Delinquency\ Rate_i$ represent positive shocks to capital, the coefficient c should be positive and the coefficient d should be negative. However, a bank could have a high value of ΔTCE or a low value of $\Delta NRRE\ Delinquency\ Rate_i$ only because it was more conservative than other banks and more concerned about building up its capital buffer prior

to the crisis. The same conservatism could lead the bank to reduce mortgage lending more than other banks *during* the crisis, causing the coefficient *c* to be negative (DeHaas and Lelyveld).[11]

The dummy variable, $Multi\text{-}Market_i$, indicates whether bank *i* is a multi-market bank. We include this variable by itself to control for any differences in overall mortgage lending between single-market banks and multi-market banks. For example, multi-market banks may have a different business model or lending technology than single-market banks because they are originating mortgages across a wider geography (Berger and Udell 2006). We include single-market banks in the regression to estimate more precisely the effects of the market dummies and bank-level characteristics on lending. However, the results on the response of multi-market bank lending to outside shocks are robust to excluding single-market banks from the sample.

The main explanatory variable of interest is the mortgage default shock coming from outside the local market. This shock is captured by $\Delta Other\ Loss\ Rate_{i,m}$, which is the average change in mortgage delinquency rates prior to the crisis in all metro markets other than market *m* in which bank *i* originated loans. We interact this variable with the dummy variable $Multi\text{-}Market_i$ to identify the effect on a bank's local mortgage lending of greater exposure to mortgage losses in other markets. The sign and magnitude of the coefficient e_2 on the interaction term provides our first test of the spillover hypothesis. This coefficient should be negative if the spillover hypothesis holds—i.e., multi-market banks should reduce local mortgage lending more when mortgage delinquency rates in their other markets increase significantly.

We next estimate similar regressions that allow the effect of outside shocks on local lending growth to depend on how peripheral the local market is to the bank:

[11] Another possibility is that a positive shock to capital reduces a bank's incentive to take risk by reducing the moral hazard due to deposit insurance (Black and Strahan 2002). In principle, this effect could also lead to a negative relationship between bank capital and growth in mortgage lending. In this case, however, the capital channel would predict that outside loan losses should increase local mortgage lending, contrary to the spillover hypothesis.

(*1b*) $Log\ Growth\ in\ Originations_{i,m} = a_m \cdot Market_{i,m} + b \cdot Size_i + c \cdot \Delta TCE_i$

$+ d \cdot \Delta NRRE\ Delinquency\ Rate_i$

$+ e_1 \cdot Core_{i.m} + e_2 \cdot Core_{i.m} \times \Delta Other\ Loss\ Rate_{i,m}$

$+ f_1 \cdot Moderately\ Peripheral_{i.m} + f_2 \cdot Moderately\ Peripheral_{i.m} \times \Delta Other\ Loss\ Rate_{i,m}$

$+ g_1 \cdot Highly\ Peripheral_{i.m} + g_2 \cdot Highly\ Peripheral_{i.m} \times + \varepsilon_{i,m}$

The dummy variables $Core_{i.m}$, $Moderately\ Peripheral_{i.m}$, and $Highly\ Peripheral_{i.m}$ are our measures of the degree to which the market is peripheral to the bank. They enter the regressions in two ways—alone and interacted with the change in the other loss rate. The purpose of the standalone variables is to allow for the possibility that banks reduce lending by a greater amount in their more peripheral markets, even when they do not experience rising delinquencies outside those markets. The purpose of the interactive terms is to determine if the spillover effect of outside delinquencies is greater when the local market is more peripheral to the bank. As noted in the introduction, such a relationship is consistent with both the capital and information channels and with the notion that banks tend to "cut and run" from their least important markets when they reduce their overall lending. If the spillover effect is indeed greater in a bank's more peripheral markets, the coefficients on the interactive terms for these markets should be more negative. Specifically, g_2 should be more negative than f_2, and f_2 should be more negative than e_2.

Each regression specification is estimated for two categories of mortgage originations, portfolio lending and total lending (the sum of portfolio lending and securitized lending). Estimating equations (1a) and (1b) for the growth in portfolio lending indicates whether the spillover effect of outside shocks dominates the substitution effect, causing local portfolio

lending to fall. Estimating the same equations for the growth in total lending indicates whether banks offset this effect by changing their local securitized lending in the opposite direction.

Lastly, we examine the channel of the cross-market effects through bank capital and banks' information about markets. These specifications are the same as (1a) and (1b) with an additional variable for analyzing the channel through which the change in the other loss rate affects local mortgage originations. For example, when observations on a multi-market bank are not distinguished by how peripheral the market is to the bank, the equations estimated are:

$$
\begin{aligned}
(2)\quad & \textit{Log Mortgage Origination Growth}_{i,m} = a_m \cdot \textit{Market}_{i,m} + b \cdot \textit{Size}_i \\
& + c \cdot \Delta \textit{TCE}_i + d \cdot \Delta \textit{NRRE Delinquency Rate}_i \\
& + e \cdot \textit{RRE Loans to Equity}_i \\
& + f_1 \cdot \textit{Multi-Market}_i + f_2 \cdot \textit{Multi-Market}_i \times \Delta \textit{Other Loss Rate}_{i,m} \\
& + f_3 \cdot \textit{Multi-Market}_i \times \Delta \textit{Other Loss Rate}_{i,m} \times \textit{RRE/Equity}_i + \varepsilon_{i,m}
\end{aligned}
$$

$$
\begin{aligned}
(3)\quad & \textit{Log Mortgage Origination Growth}_{i,m} = a_m \cdot \textit{Market}_{i,m} + b \cdot \textit{Size}_i \\
& + c \cdot \Delta \textit{TCE}_i + d \cdot \Delta \textit{NRRE Delinquency Rate}_i \\
& + e \cdot \textit{Distance to HQ}_{i,m} \\
& + f_1 \cdot \textit{Multi-Market}_i + f_2 \cdot \textit{Multi-Market}_i \times \Delta \textit{Other Loss Rate}_i \\
& + f_3 \cdot \textit{Multi-Market}_i \times \Delta \textit{Other Loss Rate}_{i,m} \times \textit{Distance to HQ}_{i,m} + \varepsilon_{i,m}
\end{aligned}
$$

In equation (2), $\textit{RRE Loans to Equity}_i$ is the ratio at bank i of residential real estate loans held on the books to total equity. The coefficient f_3 on the interaction of this variable with $\textit{Multi-Market}_i$ and $\Delta \textit{Other Loss Rate}_{i,m}$ provides a test of whether the spillover effect is magnified by exposure of the bank's capital to losses on its home mortgage loans. A given increase in the bank's loss rate on mortgages in other markets should have a bigger impact on the bank's overall

capital when the bank is holding more residential real estate loans relative to capital. Thus, if bank capital is a channel through which outside economic shocks are transmitted to lending in the local market, f_3 should be negative and statistically significant. As before, we also estimate equation (2) taking into account whether the local market is core, moderately peripheral, or highly peripheral to the bank. This specification allows us to determine if the magnitude of the capital channel depends on the degree to which the market is peripheral to the bank.

In equation (3), *Distance to* $HQ_{i,m}$ is the distance in miles of the local market from the bank's headquarters. We include this variable as a measure of the degree to which the bank's management is informed about borrowers in the local market. Bank lending is an information intensive process that requires knowing both the characteristics of the borrower and the characteristics of the local market. Although prime mortgage lending likely does not require as much information of this type as some other types of lending, such as small business lending, the information-gathering process can be important, especially in times such as the recent crisis. Banks lending to distant markets are at an information disadvantage because loan borrower quality is harder to collect at a distance and loan decisions tend to be made at higher levels in large banks (Stein 2002, Mian 2006). A multi-market bank that suffers such an information disadvantage may rely more heavily on developments in its other markets to form an estimate of the creditworthiness of local borrowers. If so, the bank will tend to reduce local lending more in response to increased delinquencies in its other markets, causing the coefficient f_3 on the triple interaction term to be negative. We also estimate equation (3) distinguishing among markets that are core, moderately peripheral, or highly peripheral to the bank. This specification allows us to determine whether the effect of distance depends on how important the market is to the bank's overall mortgage lending.

5. Regression results for tests of spillover hypothesis

Table 4 shows the regression results for our tests of the spillover hypothesis. In Columns 1 and 2, the dependent variable is the growth in portfolio originations from the pre-crisis to the crisis period. Column 1 corresponds to equation (1a), in which all of a multi-market bank's markets are treated the same. Column 2 corresponds to equation (1b), in which the effect of outside shocks on local lending is allowed to depend on how peripheral the market is to the bank. In Columns 3 and 4, the dependent variable is the growth in total originations, including both portfolio lending and securitized lending. As before, the first of these columns corresponds to equation (1a) and the second to equation (1b).

Results for portfolio lending

The first three rows of Columns 1 and 2 show the estimated effects on portfolio lending of our bank-level variables: the size of the bank, the change in the bank's tangible equity-to-assets ratio prior to the crisis, and the change in the bank's non-residential-real estate delinquency rate prior to the crisis. In both regressions for the change in portfolio lending, the coefficient on bank size is negative and significant, suggesting that large banks reduced their mortgage lending more in the crisis than small banks. The coefficient on the change in the equity-to-assets ratio is negative and statistically significant in both regressions, implying that increases in book capital reduce bank lending. As suggested earlier, this result could reflect the fact that banks that deliberately built up their capital before the crisis were more conservative and reduced their mortgage exposure more during the crisis. Finally, the coefficient on the change in the non-residential-real-estate delinquency rate is negative in all three regressions, indicating that banks reduced their home mortgage lending in response to losses on other types

of loans, such as commercial and consumer loans. This result is consistent with the idea that high loan delinquencies reduce a bank's true capital, causing it to cut back on all types of lending even if the delinquencies have not yet been reflected in book capital.

The first variable of interest for the spillover hypothesis is the interaction of the change in the other loss rate with the multi-market dummy in Column 1. The negative and significant coefficient on this interaction term provides support for the view that multi-market banking increases the vulnerability of markets to outside economic shocks. In particular, the result suggests that the spillover effect of outside loan supply shocks dominates the substitution effect of adverse loan demand shocks. A 50 basis-point increase in the other loss rate would be well within the range of median changes in this variable shown in Table 2. The coefficient of -27.5 on the interactive variable indicates that such an increase in the other loss rate would be associated with about a 13.8 percent decrease in the bank's local lending. In other words, multi-market banks significantly reduced their lending in a local market when they suffered typical losses on their mortgage lending in other markets.

Our next variables of interest are the interactions in Column 2 of the change in the other loss rate with the dummy variables indicating how peripheral the local market is to the bank's mortgage lending operations. As expected, the spillover effect increases as the local market becomes more peripheral to the bank. The coefficient on the interaction of core markets with the change in the other loss rate is -22.8 and significant at the 5 percent level. In comparison, the coefficient on the interaction of highly peripheral markets with the change in other loss rate is much more negative, -80.5, and significant at the 1 percent level.[12] The latter result implies that a 50-basis point increase in the other loss rate would be associated with a 40 percent drop in local

[12] The difference between the two interaction coefficients is significant at the 1 percent level.

lending in these highly peripheral markets, an effect almost four times as large as when the local market is a core market for the bank.

Results for total lending

Our results so far suggest that a multi-market bank reduces portfolio mortgage lending in response to higher delinquency rates in its other markets. Columns 3 and 4 of Table 4 indicate whether banks increase their securitization lending enough to keep total lending from falling. The coefficients on the bank-level variables are roughly the same as before except for the coefficient on the delinquency rate on non-residential-real-estate loans, which is more negative. More importantly, we still find support for the spillover hypothesis when looking at total mortgage lending. The coefficient on the interaction of the multi-market dummy and the change in the other loss rate in column 3 is -15.2 and significant at the 1 percent level. This estimate implies that a 50 basis point increase in the other loss rate leads to a 7.5 percent decrease in the growth of total originations, a little more than half the decrease in the growth of portfolio originations. Thus, securitized lending only partially offsets the decline in portfolio lending following an increase in delinquency rates in other markets.

Column 4 indicates, as before, that the negative effect of the outside shock on growth in originations is bigger in more peripheral markets. The interaction coefficient for core markets is insignificant, implying that banks increase their securitized lending in such markets enough to offset the spillover effect on portfolio lending. This result makes sense for two reasons. First, the spillover effect on portfolio lending is relatively small in core markets, implying that only a modest increase in securitized lending is needed to maintain originations. Second, a multi-market bank may have a stronger incentive to maintain originations in its core market to protect its reputation and market share. The interaction coefficients for moderately peripheral markets

and highly peripheral markets are -15.6 and -46.1, respectively, both of which are significant at the 1 percent level.[13] The coefficient for highly peripheral markets implies that a 50-basis point increase in other loss rate is associated with a 23 percent drop in local lending in these markets. These effects are smaller than for portfolio lending, but still economically significant. Thus, while banks use securitized lending to partially offset reductions in portfolio lending, total lending still falls by a greater amount the more peripheral the market is to the bank.

6. Regression results for tests of information and capital channels

Tables 5 and 6 report the results for our tests of whether the spillover effect operates through the capital channel or the information channel. Table 5 refers to the test of the capital channel in equation (2), while Table 6 refers to the test of the information channel in equation (3). As before, each regression is estimated for both portfolio lending and total lending and both with and without measures of how peripheral the market is to the bank.

Test of capital channel

The variables in Table 5 that shed light on the importance of the capital channel are the triple interaction terms including the multi-market dummy variable, the other loss rate, and the bank's ratio of RRE loans to total equity. As noted earlier, the last ratio represents the overall exposure of capital to mortgage losses due to high past levels of mortgage lending by the bank. As explained earlier, if spillover occurs through the capital channel, the coefficients on the triple interaction terms should be negative. The reason is that a given increase in the other loss rate

[13] As in the regression for portfolio lending, the difference between the highly-peripheral interaction coefficient and the core interaction coefficient is significant at the 1 percent level.

should have a greater effect on the bank's overall capital, the higher is the bank's ratio of mortgage loans to capital.

In the regressions for growth in portfolio lending in Columns 1 and 2, the results suggest that spillover occurs partly but not entirely through the capital channel. In Column 1, the coefficient on the triple interaction term with the dummy variable for multi-market banks is negative and significant, consistent with the capital channel. It is important to note, however, that the coefficient on the interaction term *excluding* capital exposure is also negative and significant. Thus, even when a bank's capital is minimally exposed to mortgage losses, an increase in delinquencies in other markets reduces local portfolio lending, suggesting that outside shocks can be transmitted by other means besides changes in bank capital.

Column 2 shows that the tendency for high capital exposure to magnify the spillover effect of outside losses is concentrated in moderately peripheral markets. In these markets, the coefficient on the triple interaction term is -5.6 and highly significant, supporting the existence capital channel. But as in the regression for multi-market banks as a group, the coefficient on the interaction term excluding capital exposure is also negative and significant, supporting the existence of some other channel.

In contrast to moderately peripheral markets, the coefficients on the triple interaction terms in core and highly peripheral markets are insignificant. In core markets, the reason for the insignificant coefficient may be that reputational concerns and the low share of other markets in overall lending cause the spillover from losses in those markets to be too small for the amplification effect of high capital exposure to matter. In highly peripheral markets, lack of information about local borrowers and economic conditions may be so severe that outside losses have an especially large "wake-up" effect, swamping any effect on local lending of a decline in

overall capital. Note also that in highly peripheral markets, the coefficient on the interaction term excluding capital exposure is highly negative and significant, consistent with the view that spillover occurs in these markets but through changes in information rather than changes in capital.

The last two columns in Table 5 show that the results are similar for growth in total mortgage lending. In Column 3, the coefficient on the triple interaction term with the dummy variable for multi-market banks is negative and significant, though smaller than in the regression for growth in portfolio lending. In Column 4, the coefficient on the triple interaction terms is negative and significant in moderately peripheral markets and insignificant in core markets and highly peripheral markets. Thus, for both multi-market banks as a group and multi-market banks operating in moderately peripheral markets, the tendency for high capital exposure to amplify the spillover effect on portfolio lending is not fully offset by increases in securitized lending.

Test of information channel

In Table 6, the variables providing a test of the information channel are the triple interactions terms including the multi-market dummy variable, the other loss rate, and the distance of the market from the bank's headquarters. The last variable captures the idea that banks operate at an especially large information disadvantage in markets located far from headquarters due to the difficulty of collecting soft information at a distance and the tendency for loan decisions tend to be centralized in large, geographically dispersed banks. As noted in Section 4, if spillover occurs through the information channel, the coefficients on the triple interaction terms should be negative, because a bank with poor information about the local

market will put more weight on developments in its other markets in assessing the risk and profitability of local.[14]

Similar to the test for the capital channel, the results for portfolio lending in Columns 1 and 2 suggest that the spillover of outside shocks to local lending occurs partly but not exclusively through information effects. In Column 1, the coefficient on the triple interaction term with the dummy variable for multi-market banks is negative and significant, as predicted by the information channel. However, the coefficient on the interaction term *excluding* distance is also negative and significant, implying that an increase in delinquencies in outside markets reduces local lending even when the bank does not face an information disadvantage due to distance from headquarters.

As with the test for the capital channel, the tendency for distance to magnify the spillover effect of outside losses is confined to moderately peripheral markets. In Column 2, the coefficient on the triple interaction term for moderately peripheral markets is -5.1 and highly significant. This result suggests that the transmission of shocks to moderately peripheral markets occurs at least partly through the information channel. However, the fact the coefficient on the triple interaction excluding distance is also negative and significant implies that spillover to these markets involves other factors besides lack of good information on local conditions.

In highly peripheral markets, the coefficient on the triple interaction term excluding distance is negative and significant, while the coefficient on the term including distance is insignificant. As before, these finding may be due to banks in highly peripheral markets facing

[14] This idea can be tested for multi-market banks as a whole and for moderately peripheral and highly peripheral markets. However, it cannot be tested for core markets, because the vast majority of core markets are also the banks' headquarters markets. That is why there is not triple interaction term for core markets in Columns 2 and 4.

a severe informational advantage. In markets accounting for such a small share of their overall lending, banks may not find it cost-effective to collect any information about local conditions. As a result, banks may base their local lending decisions entirely on developments in their other markets, regardless of how close the local market is to headquarters. Put another way, the results in Column 2 do not imply that the information channel is unimportant in highly peripheral markets. They suggest instead that the information channel may be important in all markets that account for a tiny share of the bank's overall lending, regardless of the market's distance from headquarters.

As shown in the last two columns of Table 6, the results of the information test are somewhat different for the growth in total mortgage lending. In Column 3, the coefficient on the triple interaction term with the dummy variable for multi-market banks is still negative and significant but smaller than in the regression for growth in portfolio lending. This result suggests that for multi-market banks as a whole, the tendency for distance from headquarters to amplify the spillover effect on portfolio lending is not fully offset by increases in securitized lending. In Column 4, however, the coefficients on the triple interaction terms for moderately peripheral and highly peripheral markets differ appreciably from those in the regression for portfolio lending in Column 2. Specifically, the coefficient becomes insignificant for moderately peripheral markets and positive and significant for highly peripheral markets.

7. Conclusion

The U.S. mortgage market collapse during the financial crisis raised new questions about how markets are interconnected. This paper studies the evidence for mortgage-market contagion across U.S. cities through multi-market banks. We examine how large mortgage default shocks

in some metro areas of the U.S. spread to other metro areas through multi-market banks' lending decisions.

Our results generally indicate the presence of a spillover effect across metro areas during the crisis, with additional analysis shedding light on the mechanism of this transmission. Multi-market banks reduced their local mortgage lending in response to increased mortgage delinquency rates in other markets. This finding is consistent with the view that geographic diversification in banking increases the vulnerability of markets to outside economic shocks through spillovers of the shocks to local lending. We also find evidence that the spillover effect was bigger in the moderately and highly peripheral markets of multi-market banks than in the core markets. This finding shows that the exposure to contagion was greatest for the local mortgage markets where multi-market banks were doing only a small share of their overall lending. Our results also suggest that the cross-market transmission of economic shocks was mitigated—but only partially—by a tendency for multi-market banks to increase securitized lending at the same time they reduced portfolio lending.

Finally, we find evidence that the spillover of outside shocks occurred through both a capital channel and an information channel. Consistent with the capital channel, multi-market banks reduced local lending more if they held a large amount of mortgages relative to capital. But consistent with the information channel, multi-market banks also reduced local lending more if the market was far from bank headquarters. When we take into account how peripheral the local market is to the bank, we find that high ratios of mortgages to capital and high distance from headquarters amplify the spillover effect in moderately peripheral markets but not highly peripheral markets. For the latter, we suggest that the information channel may be important but

may not depend on distance from headquarters because information collection is not cost-effective in *any* market accounting for such a small share of the bank's overall lending.

The results of this paper raise important policy issues about the cross-market transmission of economic shocks through the banking system. The geographic diversification of banking has been shown to reduce the sensitivity of local markets to local economic shocks by facilitating inflows of funds from banks with operations in other markets. However, our results suggest that geographic diversification may have a "dark side" for local markets by increasing their sensitivity to shocks originating in banks' other markets. One way regulators can help protect markets from the adverse effects of cross-market spillovers is to ensure that borrowers have access to other banks that can offset the declines in local lending. Such measures could be designed to prevent economies from becoming dependent on non-local banks for lending to local borrowers. A more controversial approach would be to discourage or prevent banks from reducing local lending when they experience losses in other markets. For example, regulators in some countries have recently taken steps to "ring-fence" domestic banking operations from foreign parents in an effort to limit cross-border contagion. These measures require additional analysis to be evaluated. More generally, the benefits and costs of banks' geographic diversification should be studied in further detail to help inform the appropriate regulatory view on multi-market banking.

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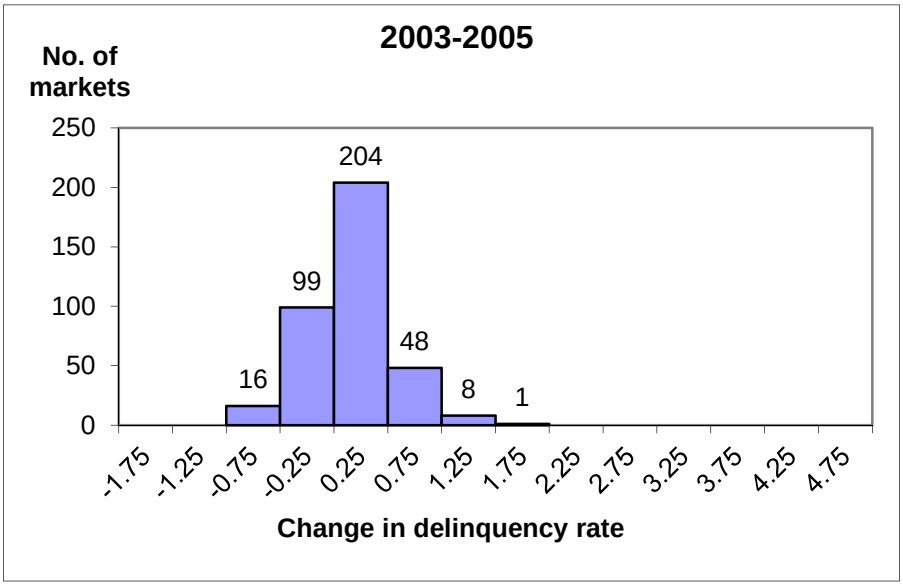
Figure 1: Changes in Mortgage Delinquency Rate by Metro Area

These histograms show the changes in mortgage delinquency rates for U.S. cities in the years leading up to the financial crisis. The markets are Metropolitan Statistical Areas (MSAs). The change in delinquency rate is the change over the two-year period in the percentage of mortgage borrowers who are 90+ days past due. The histogram showing changes from 2005 to 2007 is for our "pre-crisis" period. It illustrates the wide dispersion of mortgage losses across metro areas.



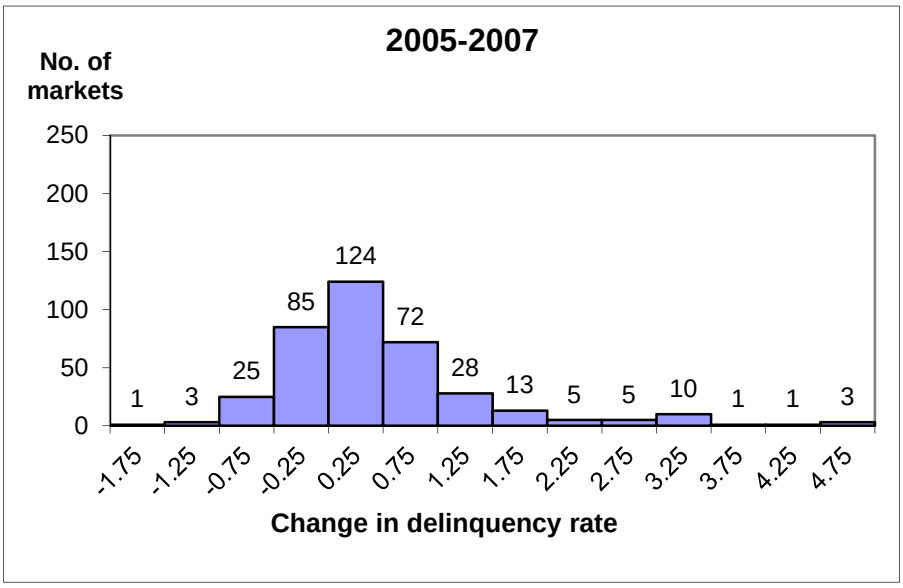


Table 1: Sample Statistics on Mortgage Lending in Pre-Crisis and Crisis Periods

Single-market banks are those that originated at least 99 percent of their home mortgage loans in a single market in 2006-2007. Multi-market banks are all others. The number of each type of institution in the sample is shown in parentheses. Sample is restricted to bank/market observations for which portfolio originations were positive in both pre-crisis and crisis periods.

Type of bank and type of lending	Originations in pre-crisis period (2006-2007), millions of dollars	Originations in crisis period (2008-2009), millions of dollars	Percent change
Single-market banks (1,292)	10,321.8	9,852.0	-4.6
Portfolio	5,636.5	5,547.5	-1.6
Securitized	4,685.4	3,170.8	-8.1
Multi-market banks (2,210)	941,871.3	383,139.7	-59.3
Portfolio	470,451.2	152,925.2	-67.5
Securitized	471,420.1	230,214.5	-51.2

Table 2: Sample Statistics on Bank Size, Growth in Portfolio Originations, and Changes in Loss Rates

The classification of a market as core, moderately peripheral, or highly peripheral depends on the bank's mortgage originations in the market as a share of the bank's total mortgage originations. The change in the local loss rate is the change in the mortgage delinquency rate in the market, while the change in the other loss rate is the weighted-average change in the delinquency rate in all other metro markets in which the bank originates loans. Sample is restricted to bank/market observations for which portfolio originations were positive in both pre-crisis and crisis periods.

Type of bank/market	Number of observations	Median bank size at end of 2007 (millions of dollars)	Median log growth of portfolio originations, pre-crisis to crisis period (percent)	Median change in local loss rate, end of 2005 to end of 2007 (percentage points)	Median change in other loss rate, end of 2005 to end of 2007 (percentage points)
Single-Market Bank	1,292	146	5.9	0.24	N/A
Multi-Market Bank, Core Market	1,773	329	-13.9	0.26	0.35
Multi-Market Bank, Moderately Peripheral Market	4,587	1,315	-33.7	0.37	0.54
Multi-Market Bank, Highly Peripheral Market	5,997	54,713	-93.1	0.26	0.90

Table 3: Correlations among Growth in Portfolio Originations and Changes in Loss Rates

Sample is restricted to bank/market observations for which portfolio originations were positive in both pre-crisis and crisis periods. The *, **, and *** indicate significance at 10%, 5% and 1% levels, respectively.

Type of bank/market	Number of observations	Correlation coefficients		
		Log growth in originations and change in other loss rate	Change in other loss rate and change in local loss rate	Log growth in originations and change in local loss rate
Single-Market Bank	1,292	N/A	N/A	.04**
Multi-Market Bank, Core Market	1,773	-0.09***	0.62***	-0.10***
Multi-Market Bank, Moderately Peripheral Market	4,587	-0.21***	0.52***	-0.20***
Multi-Market Bank, Highly Peripheral Market	5,997	-0.38***	0.10***	-0.05***

Table 4: Test of spillover hypothesis

This table reports regression estimates for equations (1a) and (1b) for both portfolio lending growth and total lending growth. Total lending is defined as the sum of portfolio lending and securitized lending. For each type of lending, the dependent variable is log growth in originations from the pre-crisis period (2006 and 2007) to the crisis period (2008 and 2009). Each specification has market fixed effects. All data are winsorized at the 1% level. Robust standard errors are in brackets, with *, **, and *** indicating significance at 10%, 5%, and 1%, respectively.

	Portfolio Lending Growth		Total Lending Growth	
	(1)	(2)	(1)	(2)
Bank Size (Log of Total Assets)	-15.635***	-17.132***	-13.322***	-14.091***
	[0.419]	[0.557]	[0.386]	[0.517]
ΔTangible Common Equity	-1.241***	-1.170***	-1.309***	-1.268***
	[0.267]	[0.264]	[0.246]	[0.245]
ΔNon-Residential Non-Performing Loan Rate	-2.480***	-2.189***	-7.048***	-6.891***
	[0.609]	[0.604]	[0.562]	[0.561]
Multi-Market Bank	17.931***		5.218	
	[3.857]		[3.554]	
Multi-Market Bank * ΔOther Loss Rate	**-27.531*** **		**-15.202*** **	
	[2.409]		[2.220]	
Core Market		-0.435		-7.364
		[5.706]		[5.301]
Core * ΔOther Loss Rate		**-22.843***		**-10.466**
		[12.278]		[11.406]
Moderately Peripheral Market		16.574***		5.086
		[4.310]		[4.004]
Moderately Peripheral * ΔOther Loss Rate		**-29.591*** **		**-15.588*** **
		[3.987]		[3.704]
Highly Peripheral Market		84.137***		42.751***
		[5.352]		[4.971]
Highly Peripheral * ΔOther Loss Rate		**-80.454*** **		**-46.131*** **
		[4.585]		[4.260]
Observations	13513	13513	13513	13513
Adjusted R-squared	0.21	0.23	0.19	0.20

Table 5: Test of capital channel

This table reports regression estimates for equation (2) for both portfolio lending growth and total lending growth. Total lending is defined as the sum of portfolio lending and securitized lending. For each type of lending, the dependent variable is log growth in originations from the pre-crisis period (2006 and 2007) to the crisis period (2008 and 2009). Each specification has market fixed effects. All data are winsorized at the 1% level. Robust standard errors are in brackets, with *, **, and *** indicating significance at 10%, 5%, and 1%, respectively.

	Portfolio Lending Growth		Total Lending Growth	
	(1)	(2)	(3)	(4)
Bank Size (Log of Total Assets)	-16.713***	-20.628***	-13.832***	-15.563***
	[0.422]	[0.597]	[0.391]	[0.559]
ΔTangible Common Equity	-1.273***	-1.153***	-1.324***	-1.275***
	[0.265]	[0.261]	[0.246]	[0.244]
ΔNon-Residential Non-Performing Loan Rate	-2.191***	-2.202***	-6.916***	-6.904***
	[0.605]	[0.598]	[0.561]	[0.561]
Residential Real Estate Loans	-3.318***	-8.348***	-1.703**	-4.131***
/ Total Equity (RRE/Equity)	[0.857]	[0.870]	[0.794]	[0.815]
Multi-Market Bank	22.584***		7.501**	
	[3.868]		[3.587]	
Multi-Market Bank	-10.011***		-7.261**	
* ΔOther Loss Rate	[3.518]		[3.262]	
Multi-Market Bank	**-4.192*** **		**-1.855** **	
*** ΔOther Loss Rate * RRE/Equity**	[0.884]		[0.820]	
Core Market		4.563		-4.905
		[5.652]		[5.298]
Core Market		-25.547		-3.872
* ΔOther Loss Rate		[29.330]		[27.490]
Core Market		**4.093**		**-2.505**
*** ΔOther Loss Rate * RRE/Equity**		[14.482]		[13.574]
Moderately Peripheral Market		26.599***		9.695**
		[4.296]		[4.027]
Moderately Peripheral Market		-5.678		3.959
* ΔOther Loss Rate		[6.605]		[6.191]
Moderately Peripheral Market		**-5.608*** **		**-5.758*** **
*** ΔOther Loss Rate * RRE/Equity**		[2.093]		[1.961]
Highly Peripheral Market		105.605***		52.252***
		[5.479]		[5.135]
Highly Peripheral Market		-68.104***		-44.358***
* ΔOther Loss Rate		[5.991]		[5.615]
Highly Peripheral Market		**0.143**		**1.154**
*** ΔOther Loss Rate * RRE/Equity**		[1.095]		[1.026]
Observations	13513	13513	13513	13513
Adjusted R-squared	0.23	0.25	0.19	0.2

Table 6: Test of information channel

This table reports regression estimates for equation (3) for both portfolio lending growth and total lending growth. Total lending is defined as the sum of portfolio lending and securitized lending. For each type of lending, the dependent variable is log growth in originations from the pre-crisis period (2006 and 2007) to the crisis period (2008 and 2009). Each specification has market fixed effects. All data are winsorized at the 1% level. Robust standard errors are in brackets, with *, **, and *** indicating significance at 10%, 5%, and 1%, respectively.

	Portfolio Lending Growth		Total Lending Growth	
	(1)	(2)	(3)	(4)
Bank Size (Log of Total Assets)	-13.519***	-15.193***	-12.469***	-13.190***
	[0.473]	[0.574]	[0.438]	[0.536]
ΔTangible Common Equity	-1.340***	-1.393***	-1.351***	-1.373***
	[0.266]	[0.263]	[0.246]	[0.245]
ΔNon-Residential Non-Performing Loan Rate	-2.503***	-2.355***	-7.063***	-6.916***
	[0.605]	[0.601]	[0.561]	[0.561]
Distance to Headquarters (Distance to HQ)	3.044***	-1.902***	1.044**	-2.172***
	[0.563]	[0.549]	[0.522]	[0.512]
Multi-Market Bank	9.968**		2.322	
	[3.930]		[3.643]	
Multi-Market Bank	-15.237***		-10.648***	
* ΔOther Loss Rate	[2.642]		[2.450]	
Multi-Market Bank	**-5.111*** **		**-1.876*** **	
*** ΔOther Loss Rate * Distance to HQ**	[0.514]		[0.477]	
Core Market		-0.215		-6.938
		[5.677]		[5.294]
Core Market * ΔOther Loss Rate		-24.301**		-11.632
		[12.209]		[11.385]
Moderately Peripheral Market		16.824***		6.631
		[4.341]		[4.048]
Moderately Peripheral Market		-14.937***		-9.509**
* ΔOther Loss Rate		[4.598]		[4.288]
Moderately Peripheral Market		**-5.086*** **		**-0.949**
*** ΔOther Loss Rate * Distance to HQ**		[1.158]		[1.080]
Highly Peripheral Market		85.666***		49.878***
		[5.857]		[5.462]
Highly Peripheral Market		-79.211***		-56.800***
* ΔOther Loss Rate		[5.513]		[5.141]
Highly Peripheral Market		**0.163**		**1.844*** **
*** ΔOther Loss Rate * Distance to HQ**		[0.543]		[0.506]
Observations	13513	13513	13513	13513
Adjusted R-squared	0.22	0.24	0.19	0.2