International Liquidity Provision During the Financial Crisis: A View from Switzerland

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The authors document the provision of liquidity in Swiss francs (CHF) by the Swiss National Bank (SNB) to banks located outside Switzerland during the recent financial crisis. What makes the Swiss case special is the size of this liquidity provision—at times, 80 percent of all short-term CHF liquidity provided by the SNB—and the measures adopted to distribute this liquidity. In addition to making CHF available to other central banks via swap facilities, the SNB also allows banks outside Switzerland to directly participate in its repurchase agreement transactions. Although this policy was adopted for reasons predating the 2007-09 financial crisis, it proved tremendously helpful during the crisis by providing the European banking system direct access to the primary funding facility for CHF. (JEL E41, E52, F33, F34)

In the years leading up to 2007, banks across the globe dramatically increased their balance sheet exposure to foreign currencies. This led to increased trading between banks with a need to refinance in the foreign currency and domestic banks with deposits and consequently sufficient funds to lend in that currency (i.e., extensive cross-border trading). With the onset of the financial crisis and the successive drying-up of the repurchase agreement (repo) market and especially the unsecured interbank money market (see Guggenheim, Kraenzlin, and Schumacher, 2011), the private sector no longer provided this liquidity, thus requiring a coordinated action by the world's major central banks.

In particular, the provision of dollar liquidity to non-U.S. banks by the Federal Reserve garnered ample attention in the global financial press (for a discussion, see, for example, Goldberg, Kennedy, and Miu, forthcoming). Much less noticed was the Swiss National Bank's (SNB) large-scale provision of Swiss franc (CHF) liquidity to the banking system throughout the European Union and beyond.

In this article, we document the CHF liquidity provision by the SNB to banks located outside Switzerland. What makes the Swiss case special is not only the size of the liquidity provision to banks outside Switzerland (at times, 80 percent of all short-term CHF liquidity provided by the SNB), but also the measures adopted to distribute this liquidity.

In addition to providing CHF to other central banks via swap facilities, the SNB allows foreign banks to directly participate in its repo transactions. Although this policy was adopted for reasons predating the recent financial crisis, it proved

tremendously helpful during the crisis when it gave the European banking system direct access to the primary funding facility for CHF.

Finally, the Swiss case is exceptional because from March 2009 to June 2010, faced with deflation risks and zero interest rates, the SNB intervened in the foreign exchange market as part of its unconventional policies. The resulting large-scale inflow of CHF to the financial sector flooded the international banking system with CHF liquidity. As a consequence, demand for the liquidity provided by the SNB's open market operations virtually ceased to exist. We believe that, although liquidity provision itself was not an objective of the foreign exchange interventions, the transactions may have contributed to stabilizing the European banking system.

THE ORIGINS: SWISS FRANC LOANS IN AUSTRIA AND CENTRAL AND EASTERN EUROPE

Because of the traditionally low interest rates in Switzerland and the low-exchange-rate volatility observed since the introduction of the euro (EUR), many households and firms across Central and Eastern Europe (CEE) relied on CHF-denominated loans as a source of cheap funding. The resulting aggregate exposure was substantial: By early 2009, households and non-banking-sector firms in CEE economies had accumulated the equivalent of CHF 120 billion worth of debt denominated in Swiss currency. In Austria, primarily because of its geographic proximity to Switzerland, total exposure was then over CHF 80 billion. Non-banks in the other countries of the euro zone also relied on such loans. In total, the exposure of non-Swiss European banks amounted to about CHF 400 billion in late 2008.[1]

The size of the exposure has raised many concerns about the financial stability of the banking sector, given the possibility of continued CHF strength or even appreciation. (Most notable are concerns expressed by Krugman, 2009.) Since few of the debtors have any CHF income, such an appreciation could cause large-scale default and the resulting loan losses could strain the banking sector in these economies.[2] However, a second financial stability concern related to the CHF loans has received surprisingly little attention—with the notable exception of Pann, Seliger, and Übeleis (2010)—namely, the resulting funding and liquidity risk faced by non-Swiss banks.

SYSTEMIC SWISS FRANC SHORTAGES DURING THE CRISIS

CHF-denominated loans obtained by non-banks outside Switzerland are typically granted by non-Swiss banks that, in turn, finance themselves by borrowing from financial institutions in Switzerland. As in all bank business, these non-Swiss banks provide long-term loans yet finance themselves on a short-term basis. Their ability to roll over maturing CHF positions became stressed when the interbank money market progressively dried up following the onset of the financial crisis in August 2007, particularly after the collapse of Lehman Brothers in September 2008 (see Guggenheim, Kraenzlin, and Schumacher, 2011).

In international currency markets, any bank can potentially obtain financing in any foreign currency either by going directly to the interbank money market or by obtaining funds from its central bank and swapping the received funds into the desired foreign currency. In principle, these two methods should ensure the rate at which a currency is funded is the same.

During the recent financial crisis, however, interbank money markets *temporarily* faltered.

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[1] Why lenders that issued these loans were not more concerned with the embedded default risk might seem puzzling. However, a microeconomic study of loan issuance to private households in Austria (see Beer, Ongena, and Peter, 2008) finds that banks did screen potential borrowers and awarded CHF-denominated loans only to the more solvent clients (also see Auer et al., 2009). In addition, many such loans contained provisions giving the banks the right to coerce conversion of a loan to the local currency if the exchange rate exceeded a certain trigger level. The combination of these two features probably explains why lenders were not concerned with default risk when issuing these loans.

[2] The aggregate exposure of CEE and Austria to low-interest-rate currencies had already caused losses of around $60 billion (U.S. dollars) for these nations in 2008-09 alone; see Auer and Wehrmüller (2009). Note that empirical studies by Beer, Ongena, and Peter (2008); Brown, Ongena, and Yesin (2011); Brown, Peter, and Wehrmüller (2009); and Puhr, Schwaiger, and Sigmund (2009) show that the debtors tend to be creditworthy, thus suggesting that such concerns are less relevant than the sheer magnitude of the aggregate exposure suggests.

Figure 1

Difference Between Unsecured and Secured Overnight Interbank Rate for CHF Funds and EUR Funds
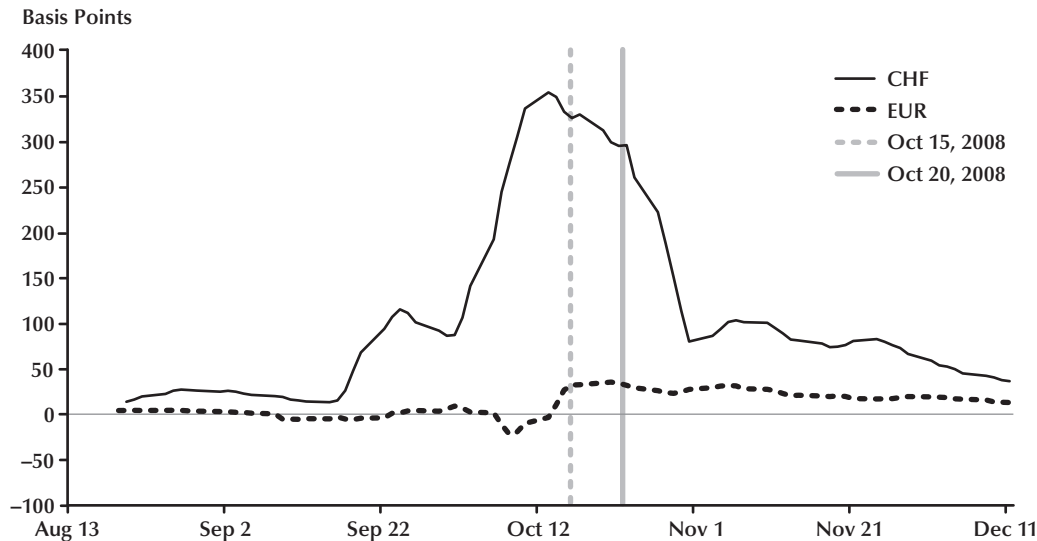
NOTE: The figure shows the evolution of the difference between the unsecured and secured overnight interbank rate for Swiss franc (CHF) funds and euro (EUR) funds from August to November 2008 (5-day moving average). The two horizontal lines correspond to the announcement (October 15, 2008) and the actual start (October 20, 2008) of EUR/CHF swap auctions by the European Central Bank, Magyar Nemzeti Bank (the central bank of Hungary), and the National Bank of Poland.

For example, Figure 1 documents the strains in the CHF money market beginning in October 2008. The figure plots the difference between the unsecured and secured overnight interbank rate for both CHF funds and EUR funds. While these two spreads are historically rather low and co-move closely, the spread on CHF rose steeply during October 2008, reaching values well over 300 basis points. Consequently, the movement in the CHF money market is a result of an increase in liquidity and not credit risk premia since the latter would be reflected in both currencies.

The CHF-specific spike in the cost of obtaining unsecured funds was caused by a combination of the need by banks outside Switzerland to continuously roll over maturing interbank loans and the shrinking supply for these funds. Most Swiss banks and a considerable number of non-Swiss banks have access to the Swiss repo system—the prevailing secured money market in Swiss francs. In a calm market environment, these banks would

have immediately exploited this profit opportunity and provided unsecured funds to banks without access to the Swiss repo system.

However, against the backdrop of the global financial crisis and the fear of counterparty default risk, this situation did not occur and the spread between secured and unsecured CHF funds remained elevated for several trading days. Without access to the Swiss repo system, even banks with ample collateral could not obtain secured funding from the SNB or the secured interbank market. In Switzerland, only a negligible amount of repo transactions are traded outside the Swiss repo system (i.e., over the counter).

The lower cross-border trading could have posed a substantial danger to the stability of the financial sector at large. If banks across the euro zone and CEE were unable to obtain CHF in the money market, then non-Swiss banks, in turn, could try to reduce their exposure by liquidating CHF loans they had made to their clients. Given

the banking tensions at the time, this move would have driven many debtors into default and could have started a disorderly winding-down of CHF loans, with increasing default rates implying the need for additional loan-loss provisions, thereby increasing pressure to liquidate CHF exposure. This vicious cycle could have had dire consequences for the banking system and the real economy.

PHASE I: INTER-CENTRAL BANK SWAP FACILITIES

The drying-up of liquidity distribution in foreign currency posed a problem more challenging than the breakdown of the domestic interbank money market: No central bank, on its own, can provide a large amount of liquidity in a foreign currency in a timely manner.[3] First, the European Central Bank (ECB) and the central banks in CEE obviously cannot create CHF liquidity without issuing their own debt securities in the respective currency. Second, the SNB can create CHF liquidity but cannot supply this liquidity to banks lacking access to the Swiss repo system or banks with insufficient SNB-eligible collateral, which in 2007 was the case for most banks involved in CHF-denominated lending in CEE.[4]

To overcome this market friction, the SNB jointly announced with the ECB and subsequently with the Narodowy Bank Polski (the National Bank of Poland) and the Magyar Nemzeti Bank (the central bank of the Republic of Hungary) that all these central banks would directly distribute CHF-denominated funds to their counterparties.[5] Since (i) nearly all banks that require funding of some CHF exposure are registered with one of

these four central banks and (ii) the conditions for these funds are similar across these countries, in effect the private sector instantly gained access to the primary source of CHF: the SNB.[6]

As Figure 1 clearly shows, on the value date of the first swap transaction, the CHF tensions in the unsecured money market ceased once the CHF auctions were implemented by the partner central banks. In other words, the swap transactions were effective in reducing the liquidity premium and in returning the interest rate spread for Swiss francs to a level similar to that for euro funds.

Figure 2 documents the extent to which banks located in the European Union used the EUR/CHF swap facility. With the introduction of the facility, demand for CHF in the euro zone jumped to around CHF 40 billion and stayed there for about 6 months. Thereafter, demand for Swiss francs under the EUR/CHF swap facility leveled off and ceased after January 2010.

## PHASE II: ENHANCING FOREIGN BANKS' DIRECT ACCESS TO THE REPO SYSTEM

Figure 1 demonstrates that the EUR/CHF swap was a functioning measure to address short-run liquidity mismatches. Since swaps are just a means to distribute liquidity more effectively, they involve no direct costs, but they do still have limits. First, their maximum volume is agreed upon in advance, so they are not as flexible as measures controlled by only one central bank. Second, the swap agreement itself to some extent fractionalizes the market for CHF liquidity since

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[3] The SNB also issued its own debt certificates in U.S. dollars (SNB USD bills). The U.S. dollars were subsequently used to finance the SNB's loan to its stabilization fund. The outstanding volume peaked at $20 billion USD. A central bank can thus obtain foreign currency and subsequently provide liquidity to its counterparties. Depending on the urgency and extent of lending, however, it may prove difficult.

[4] In general, the establishment of access to the Swiss repo system takes several months. Hence, banks with CHF exposure but no access to the Swiss repo system could not establish access quickly enough.

[5] Although the central bank swap agreements are bilateral, it is sometimes the case that funding is "recycled" to other countries. This is an especially relevant channel for international CHF liquidity provision as it is likely that banks in the euro area, particularly Austrian banks, forwarded CHF funds to their subsidiaries across CEE. Thus, the CHF funding was indirectly available to more countries.

[6] The Hungarian central bank offered slightly different conditions than the other central banks. See Goldberg, Kennedy, and Miu (2011), Auer and Kraenzlin (2009), and Aizenman and Pasricha (2010) for a discussion of various swap line agreements around the globe.

Figure 2

Volume of CHF Loans to Euro Zone Banks via the EUR/CHF Swap Facility
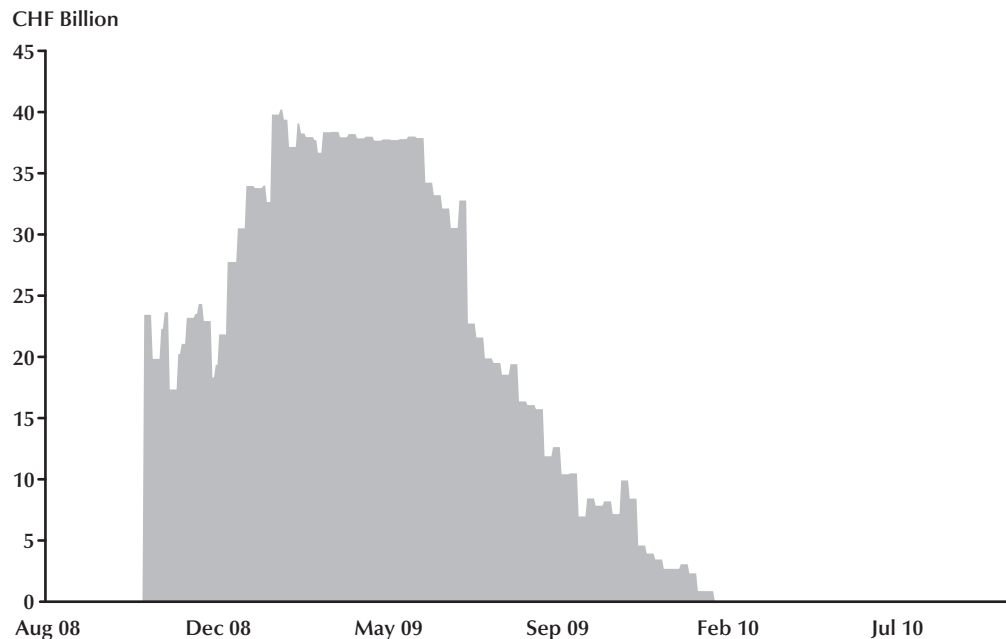
the total supply of CHF is split across different selling platforms.[7]

Finally, swap agreements also involve some loss of control over monetary policy because, in essence, the monetary base is partly controlled by a foreign central bank. The main worry of policy-makers is that such swap agreements could create inflationary pressure because opening new means to distribute liquidity can increase the total supply of money. For example, the maximum amount of a swap is agreed upon months in advance. Since the receiving central bank may auction off the maximum amount (but is not obliged to do so), uncertainty in the growth of the money supply is increased.[8] Given these shortcomings, the SNB, the ECB, and the euro zone member central banks, as well as all other affected central banks, advised banks with major exposure to the CHF to seek access to the SNB's repo system.[9]

The SNB is also legally empowered to provide liquidity to banks outside Switzerland.[10] The original intent in allowing foreign banks to access the Swiss repo system was to (i) reduce

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[7] A further potential worry is that these agreements could entail a larger counterparty default risk. This is not the case. First, there is no risk involved for the central bank distributing the funds since the receiving central banks guarantee these transactions. Second, there is also no effect on counterparty default risk for the receiving central bank since it transacts with its regular counterparties against the regular collateral basket.

[8] Two main reasons explain why the loss of control of the monetary base is rather contained. First, the central bank that originates the funds can sterilize the effect on the monetary base by issuing its own debt certificates or providing liquidity, thereby absorbing open market operations. While ceding some control over monetary policy to other central banks is of little concern in the current low-inflation environment, such concerns will definitely become a first-order political topic once inflationary pressures resume and central banks must refocus on their core task of maintaining price stability.

[9] In particular, the Austrian financial authorities (the Austrian National Bank and the Austrian Financial Market Authority [Finanzmarktaufsicht]) have assumed a key role in persuading commercial banks in Austria to seek access to the Swiss repo system.

[10] The repo system used by the SNB is also the same system in which the majority of interbank CHF repo transactions are conducted. Hence, even banks without access to the SNB could use the interbank repo market for refinancing purposes.

Figure 3

Use of the SNB Repo System by Banks Within and Outside Switzerland

Total Outstanding SNB Repo Volume (CHF Billion)

No. of Banks
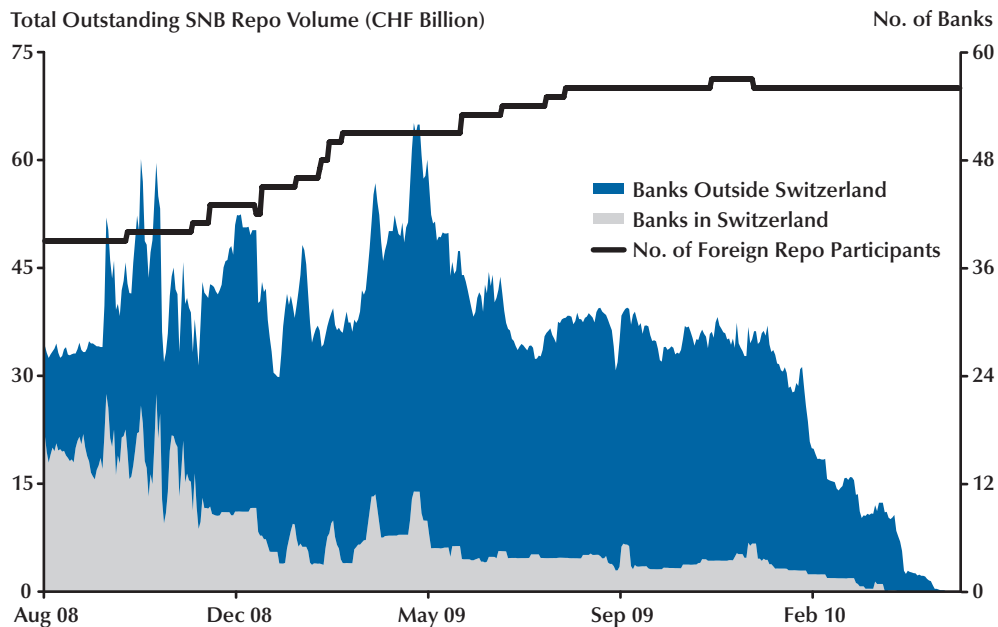
the dependence on the few large Swiss financial institutions, (ii) improve the general liquidity in the banking system, and (iii) thereby facilitate the steering of a longer-term money market rate—namely, the 3-month CHF London Interbank overnight rate (LIBOR).

This pre-crisis policy also proved useful in addressing cross-border liquidity shortages during the financial turmoil. The solid black line in Figure 3 plots the evolution of the number of banks in the Swiss repo system located outside Switzerland (right axis). As of mid-November 2010, 59 such banks had established access to the Eurex Repo electronic trading platform, a necessary condition to participate in the SNB's repo auctions. Of these 59 banks, 23 were located in Austria, 16 in Germany, and 6 in the United Kingdom.[11]

Figure 3 also documents the volume of CHF liquidity obtained directly from the SNB by foreign banks, which temporarily exceeded CHF 60 billion. The comparatively small volume of CHF

liquidity obtained by Swiss banks makes clear just how sizable the foreign demand was: For most of 2009 and early in 2010, well over 70 percent of the liquidity demand was from outside Switzerland. With the money obtained indirectly through EUR/CHF swaps, short-term CHF liquidity held by non-Swiss Banks rose to 90 percent.

Figure 4 highlights the importance of direct access to the SNB repo system for banks located outside Switzerland (see also Kraenzlin and von Scarpatetti, 2011). This figure presents an area diagram (stacked) showing total provision of CHF liquidity to banks located outside Switzerland. The figure shows the volume supplied within the Swiss repo system (light blue) and the volume supplied via EUR/CHF swaps (dark blue).

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[11] The SNB also accepts securities denominated in foreign currency. High credit standards and a highly efficient risk management procedure imply that the SNB does not apply haircuts. Banks located outside Switzerland thus can deliver non-CHF-denominated securities in SNB repo transactions. It is unclear to what extent this possibility has contributed to the high use of the SNB repo facility by this group of banks observed during 2009 and early 2010.

Figure 4

Total Liquidity Provision to Banks Outside Switzerland
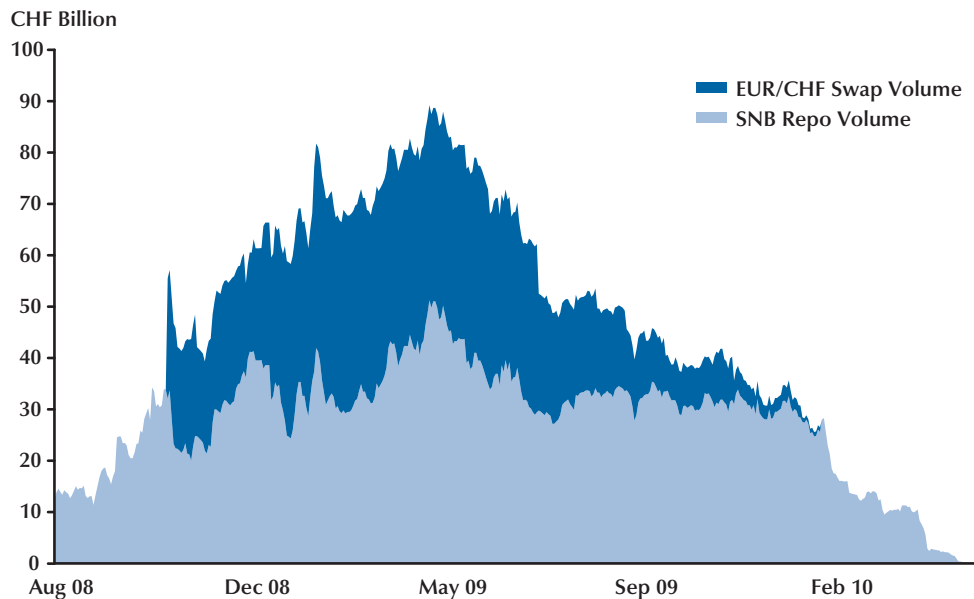
PHASE III: EXCHANGE RATE INTERVENTIONS

Figures 3 and 4 document not only the extent of the CHF shortage during 2008 and 2009, but also that this demand decreased substantially starting in mid-2009; demand vanished completely in mid-2010. Although it is tempting to attribute this to a resurgence of activity in the interbank money market, this is not fully the case. Rather, starting in March 2009, the SNB intervened in the foreign exchange market, eventually building up a foreign reserve position worth over CHF 200 billion, compared with a pre-2009 level of less than CHF 50 billion.

While the exchange rate interventions were part of the SNB's unconventional measures to avert deflation risks in Switzerland, an unintended side effect of the interventions was the resolution of the international CHF liquidity shortage: The supply of the additional CHF 150 billion is available to the banking system on a permanent basis and, consequently, the majority of banks are awash with CHF liquidity.

Figure 5 puts the extent of the liquidity provision via the exchange rate interventions in perspective. The figure shows the combined total of CHF liquidity supplied to banks located within and outside Switzerland. The three key elements of this supply are the Swiss repo system (dark gray area), the EUR/CHF swaps (light gray area), and the SNB exchange rate interventions (black area).

Figure 5 documents that the exchange rate interventions were so sizable that they in effect created enough liquidity that demand for liquidity via repo and swap transactions ceased altogether. In fact, the SNB currently absorbs liquidity to implement monetary policy. This is done, on the one hand, through weekly issuance of the SNB's own money market bills (SNB bills) and, on the other hand, through daily one-week repo auctions (see also Anderson, Gascon, and Liu, 2010, and SNB, 2011).

The exchange rate interventions thus proved helpful from a financial stability perspective. Using loans denominated in a low-interest-rate currency such as the CHF is essentially a carry

Figure 5

Total Supply of CHF Liquidity
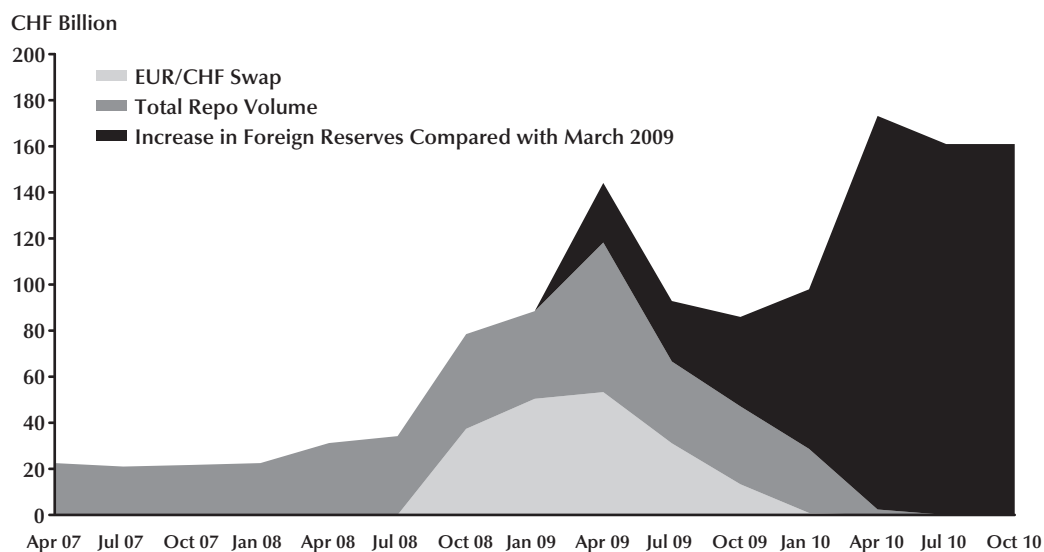
SOURCE: Data for reserve levels are from the SNB's *Monthly Statistical Bulletin.*

trade strategy. Such strategies are always subject to the danger of a disorderly winding-down of positions: If the losses stemming from an appreciation of the CHF become too large such that counterparty default risks surface, carry traders can no longer refinance their positions and must liquidate them; this, in turn, causes a further appreciation of the CHF. The combination of swap facilities, enhanced direct access to the primary source of CHF liquidity, and exchange rate interventions was instrumental in ensuring that, to date, such sizable disruptive winding-downs have not taken place and are unlikely in the near future.

CONCLUSION

Small frictions in how the private sector distributes liquidity internationally can have large effects on the interest rate paid. The rapid, coordinated, and large policy response by central banks across Europe may have avoided a disorderly winding-down of the carry trade positions built up by European households and firms in the years leading up to the recent financial crisis.

International liquidity mismatches involving Swiss francs are currently of little concern, which may be an unintended side effect of the liquidity injection via SNB interventions in the foreign exchange market. The establishment of access to the Swiss repo system by banks outside Switzerland also contributed to this relatively calm environment. As of this writing, the private sector thus has won time to reduce its CHF exposure in an orderly way.

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Banking Industry Consolidation and Market Structure: Impact of the Financial Crisis and Recession

David C. Wheelock

The number of U.S. commercial banks and savings institutions declined by 12 percent between December 31, 2006, and December 31, 2010, continuing a consolidation trend begun in the mid-1980s. Banking industry consolidation has been marked by sharply higher shares of deposits held by the largest banks—the 10 largest banks now hold nearly 50 percent of total U.S. deposits. However, antitrust policy is predicated on the assumption that banking markets are local in nature, and enforcement has focused on preventing bank mergers from increasing the concentration of local banking markets. The author finds little change over time in the average concentration of local banking markets or the average number of dominant banks in them, even during the recent financial crisis and recession when numerous bank failures and several large bank mergers occurred. Concentration did not increase substantially, on average, in markets where mergers occurred among banks when both the acquiring and acquired banks had existing local offices, though rural markets generally saw larger increases in concentration from such mergers than did urban markets. Although the structures of local banking markets, on average, have changed little since the mid-1980s, deposit concentration has continued to increase at the level of U.S. Census regions. As technology evolves and the costs of obtaining banking services from distant providers fall further, local market characteristics may become less relevant for analysis of competition in banking. (JEL G21, G28, L41)

The recent financial crisis and recession produced a sharp increase in the number of commercial bank and savings institution failures in the United States. Mergers of non-failed commercial banks and savings institutions (hereafter "banks") eliminated still more banks, and in total, the number of U.S. banks fell by 12 percent between December 31, 2006, and December 31, 2010.[1] Over the same period, the share of total U.S. deposits held by the 10 largest commercial banks rose from 44 to 49 percent, continuing a trend that began in the

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[1] The Federal Deposit Insurance Corporation (FDIC) often resolves bank failures by arranging mergers of failed institutions with other banks. These are referred to as "assisted" mergers. Mergers that do not involve failed institutions are referred to as "unassisted" mergers. During 2007-10, 270 commercial banks and 54 savings institutions, representing 4 percent of commercial banks and savings institutions in operation at the end of 2006, failed; unassisted mergers absorbed another 893 commercial banks and 109 savings institutions. These data refer to FDIC-insured commercial banks and savings institutions located in U.S. states and the District of Columbia and were obtained from *Historical Statistics on Banking*, Tables CB02 and SI02 (http://www2.fdic.gov/hsob/index.asp).

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early 1990s toward greater concentration of total U.S. deposits among the largest banks.[2]

Federal law prohibits any bank from obtaining more than 10 percent of total U.S. deposits or more than 30 percent of a single state's total deposits by acquiring other non-failed banks, and some states have imposed even lower deposit share limits.[3] Further, antitrust enforcement prevents mergers of non-failed banks that would significantly increase the concentration of local banking markets. However, antitrust policy does not (i) prevent acquisitions of *failed* banks that increase local market concentration or (ii) attempt to limit increases in concentration that do not result from mergers. Nonetheless, during the 1990s, local urban banking markets generally did not become significantly more concentrated, despite increases in the deposit shares of the largest U.S. and regional banks (Amel, 1996, and Dick, 2006).

Banking industry consolidation has since continued, spurred in part by the recent financial crisis and recession. This article examines changes since 1999 in the concentration of U.S. banking markets, defined both at the local level (metropolitan statistical areas [MSAs] and non-MSA rural counties) and at the Census-region level. It examines whether the characteristics of urban and regional banking markets observed during the 1990s continued over the subsequent decade. The article focuses in particular on the years 2006-10 to gauge whether trends in banking market structures continued during the financial crisis and recession. The resolution of failed banks during 2007-10 did not increase the concentration of most local banking markets (Wheelock, 2011). However, unassisted mergers accounted for more of the decline in the number of U.S. banks during 2007-10 than did bank failures, and therefore

potentially had a larger impact on the structures of banking markets.

Following the approach of Dick (2006), this article uses both the Herfindahl-Hirschman index (HHI) and the number of dominant firms in a market—that is, the minimum number of banks that, combined, hold at least 50 percent of a market's total deposits—to measure market concentration. However, unlike Dick (2006), this article examines trends in the concentration of rural banking markets as well as MSAs, and it includes both commercial banks and savings institutions in the analysis of market concentration (for comparison, the article also reports results for commercial banks only).[4] Further, the article investigates the impact of unassisted mergers on banking market concentration during 2007-10. The results show that, in general, local banking markets did not become significantly more concentrated during 2006-10 but, as Dick (2006) finds for the 1990s, concentration increased markedly at the level of U.S. Census regions.

The next section investigates trends in bank deposit concentration for both local banking markets (MSAs and rural counties) and Census regions. The following section examines trends in the number of dominant banks, again at the levels of local banking markets and Census regions. Subsequently, the article examines the impact of unassisted mergers during 2007-10 on the concentration of deposits for MSAs and rural counties. The final section provides study conclusions.

BANKING CONCENTRATION: LOCAL AND REGIONAL PATTERNS

The recent decline in the number of U.S. banks has continued a trend dating back to the mid-1980s (Figure 1). Hundreds of banks failed in the late 1980s and early 1990s. Many more were absorbed through unassisted mergers, spurred by the relaxation of legal restrictions on bank

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[2] In both 1984 and 1993, the 10 largest banks held 15 percent of total U.S. bank deposits. However, by 1999, the 10 largest banks held 28 percent of total U.S. bank deposits. These data are for December 31 of the year indicated for U.S. commercial banks located in the 50 states and the District of Columbia.

[3] Caps on deposit shares were imposed by the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994. Adequately capitalized banks may exceed the caps by acquiring failing or FDIC-assisted banks. Banks may also exceed the caps through internally generated growth. See Spong (2000) for additional details.

[4] Regulators consider the presence of savings institutions when evaluating the implications of proposed bank mergers on market competition but down-weight the shares of deposits held by savings institutions by one-half in formal analysis of market concentration. See Gilbert and Zaretsky (2003) for analysis of the methods and assumptions used by regulators in evaluating banking market competition.

Figure 1

Number of U.S. Commercial Banks and Savings Institutions (1984-2010)

Number of Institutions

■ Commercial Banks
□ Savings Institutions
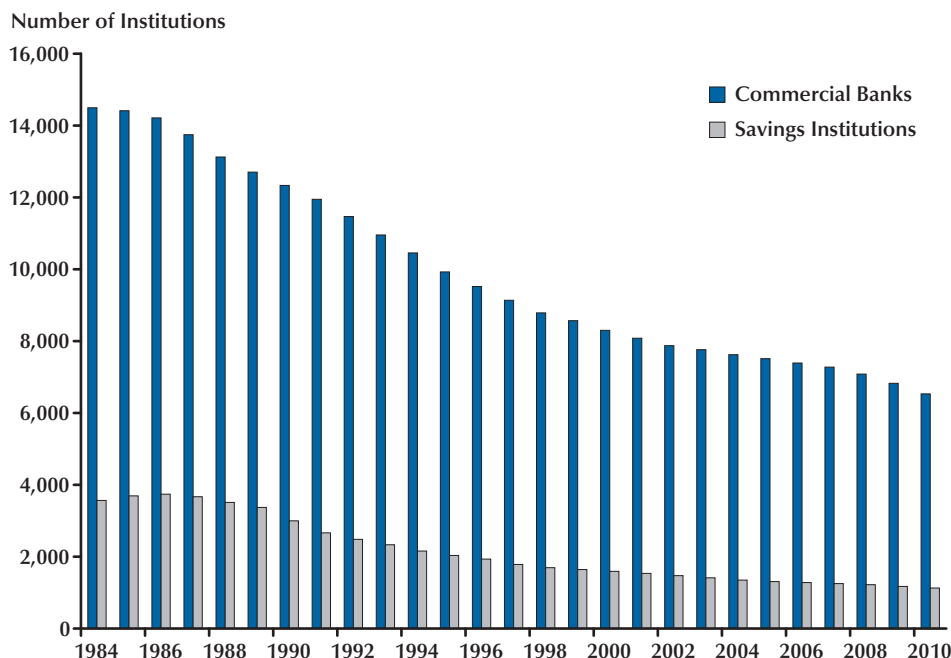
branching by many states and the federal government (Amel, 1996).[5] The number of U.S. commercial banks reached a post-World War II peak of 14,495 banks in 1984. By the end of 2010, the number had fallen to 6,532. Similarly, the number of Federal Deposit Insurance Corporation (FDIC)-insured savings institutions fell from 3,566 to 1,128 over the same period (the number of savings institutions peaked at 3,740 in 1986).

Despite an increase in the share of total U.S. deposits held by the very largest banks, the concentration of deposits among banks in local markets changed little, on average, from the mid-1980s through the 1990s (Amel, 1996, and Dick, 2006). Furthermore, the advent of interstate bank branching in 1997 had little immediate impact on either

local banking market concentration or state-level measures of banking market competition (Dick, 2006, and Yildirim and Mohanty, 2010).[6]

Bank regulators use Department of Justice (DOJ) guidelines for market concentration to evaluate the competitive effects of proposed bank mergers and acquisitions. Proposed transactions that would substantially increase market concentration are subject to more scrutiny and are more likely to be rejected on antitrust grounds than transactions that would not increase concentration significantly. Regulators use data on deposits held by individual bank branch offices, which banks are required to report on June 30 of each year, to measure the concentration of local banking markets.[7]

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[5] The Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 permitted interstate branching beginning in 1997 but gave states the option to restrict de novo branching by banks headquartered in other states. The Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 (Section 613) substantially removed remaining restrictions on interstate branching by eliminating this option.

[6] Yildirim and Mohanty (2010) find that state banking markets could be characterized as monopolistically competitive both before and after deregulation; however, they also find that the level of competition declined in 30 states after deregulation, increased in 10 states, and did not change significantly in 10 others.

[7] Summary of Deposits data are available from the FDIC (http://ww2.fdic.gov/sod/index.asp).

Ordinarily, proposed mergers are not challenged on competitive grounds unless they would result in a post-merger HHI value of more than 1800 points and an increase in the index of more than 200 points in the relevant banking market.[8]

A premise of antitrust enforcement is that banking markets are local in nature, and regulators calculate pro forma HHI values for local banking markets (typically MSAs or non-MSA rural counties) to evaluate the competitive implications of proposed bank mergers.[9] In the past, legal restrictions on branching and high transportation and communications costs made it difficult and costly for the public to obtain services from geographically distant banks. Further, many studies found that deposit interest rates were lower, and loan interest rates were higher, in more concentrated local banking markets, suggesting that concentration was an important determinant of the competitiveness of banking markets.[10] However, branching deregulation, along with advances in information-processing and communications technologies, have reduced the cost of obtaining financial services from distant banks and raise the question whether larger geographic areas, such as states, Census regions, or even the nation as a whole, are more relevant for evaluating banking competition. Nonetheless, studies find that (i) households and small businesses, to a substantial degree, continue to obtain their financial services from

banks located in their communities[11] and (ii) the structure of local banking markets continues to affect the level of competition within those markets. For example, Hannan and Prager (2004) find that banks that operate in a single MSA or non-MSA county market offer lower deposit interest rates when those markets are more concentrated. However, the study also finds that the relationship between local concentration and deposit interest rates is weaker in markets where the share of banks operating in more than one market is higher. Still, the authors conclude that market structure continues to influence the competitive behavior of banks operating in local markets.

Dick (2006) investigates whether the level of bank concentration changed significantly between 1993 and 1999 across MSAs and Census regions to assess the impact on banking market concentration of the removal of most restrictions on interstate branching in 1997. She finds that the mean and median HHI values for MSAs *declined* slightly between 1993 and 1999, whereas HHI values increased for all nine Census regions, with the percentage increases ranging from 17 percent in the Pacific region to 421 percent in the South Atlantic region.

Local Market Concentration

The patterns that Dick (2006) observes for 1993-99 continued in later years. Table 1 reports summary information about the distribution of HHI values across MSAs in 1999, 2006, and 2010. The values reported in Panel A of Table 1 are based on total deposits data for commercial banks only, as in Dick (2006), whereas those reported in Panel B are based on data for both commercial banks and savings institutions.[12] The information in Panel A shows that both mean and median HHI values declined by more than 100 points between

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8 The HHI is calculated as the sum of the squared market shares of each firm competing in a market—that is, $HHI = \Sigma_i market\ share_i^2$, where there are $i = 1, \ldots, n$ firms in the market and $market\ share_i$ is the percentage of market output (deposits in the present context) produced by the ith firm. Guidelines for the use of the HHI in antitrust enforcement are established by the DOJ (www.justice.gov/atr/public/guidelines/6472.htm).

9 Regulators have defined some U.S. banking markets over larger geographic areas, such as multiple counties, and occasionally they redefine markets based on changes in commuting patterns, trade areas, transportation networks, and so forth. Current definitions for all U.S. banking markets are available from the Federal Reserve Bank of St. Louis (http://cassidi.stlouisfed.org/).

10 The relationship between concentration and competition is potentially ambiguous. For example, if barriers to entry and exit are sufficiently low, then even a monopolist will not earn excess profits in the long run because other firms will enter and drive down the market price if the incumbent firm sets its price above marginal cost (Baumol, Panzar, and Willig, 1988). See Berger et al. (2004) for further discussion of the relationship between market concentration and competition and a review of recent research on the determinants and effects of concentration and competition in banking.

11 See Gilbert and Zaretsky (2003) for references to these studies.

12 All subsequent tables in this article are divided similarly: Information reported in Panel A is based on data for commercial banks only, whereas information reported in Panel B is based on data for both commercial banks and savings institutions. Bank regulators usually weight the deposits of savings institutions by 0.5 in calculating HHI values to measure the concentration of banking markets. However, this article assigns them full weight but also presents results based on data that exclude savings institution deposits altogether.

Table 1

Descriptive Statistics for the HHI (MSAs)

Bank type	1999	2006	2010
Panel A (commercial banks)			
No. of markets	361	361	366
Minimum	516	515	539
Maximum	8006	8346	6666
Mean	1911.8	1760.7	1703.8
Q1	1375	1255	1188
Median	1746	1588	1459
Q3	2198	1971	1902
Standard deviation	905.92	867.02	860.39
Panel B (commercial banks and savings institutions)			
No. of markets	361	361	366
Minimum	374	408	488
Maximum	5726	8145	7247
Mean	1530.6	1527.1	1535.8
Q1	1139	1089	1089
Median	1439	1346	1318
Q3	1750	1705	1689
Standard deviation	626.25	835.85	841.60

NOTE: Q1 is the first quartile of the distribution of the data; Q3 is the third quartile. Five cities were defined as MSAs between June 30, 2006, and June 30, 2010: Lake Havasu (AZ) and Palm Coast (FL) were designated as MSAs in December 2006; Cape Girardeau (MO), Manhattan (KS), and Mankato-North Mankato (MN) were designated as MSAs in November 2008.

1999 and 2006 for commercial banks, whereas the information in Panel B shows that median HHI values declined by 93 points and mean HHI values declined by 4 points for commercial banks and savings institutions.[13] Thus, for commercial banks, the decline in mean and median HHI values between 1993 and 1999 at the MSA level noted by Dick (2006) continued through 2006. Further, these trends also continued during 2007-10, despite the financial crisis and recession and resulting wave of bank failures and mergers.

Table 2 reports similar information for non-MSA (i.e., "rural") banking markets. Rural banking markets generally are more concentrated than urban markets. For example, the median HHI value for non-MSA counties in 2010 was 3195 (based on data for commercial banks only), whereas the median HHI value for MSAs was

[13] Many commercial banks and savings institutions are controlled by bank (or thrift) holding companies, which may have a controlling interest in more than one bank in a given market. Bank regulators and the DOJ consider common control of multiple banks in a market when evaluating proposed bank mergers. However, in this article no adjustment is made for common control of multiple banks in a market in calculating measures of market concentration, which seems consistent with Dick's (2006) approach. Although failing to adjust for common ownership would tend to lead to understatement of the HHI, on average, holding companies have increasingly tended to merge their multiple bank subsidiaries into a single bank, which lessens this bias in more recent years and, more importantly, would tend to upwardly bias the unadjusted changes in HHI over time. Hence, on average, increases in unadjusted HHI likely overstate the extent to which concentration has increased. Since the observed increases in unadjusted HHI in local banking markets have been small, on average, the average increase in concentration taking account of common control of multiple banks in a market would likely be even smaller.

Table 2

Descriptive Statistics for the HHI (Non-MSA Rural Counties)

Bank type	1999	2006	2010
Panel A (commercial banks)			
No. of markets	2023	2024	2015
Minimum	830	891	839
Maximum	10000	10000	10000
Mean	4032.6	3821.5	3791.6
Q1	2405	2268	2243
Median	3399	3199	3195
Q3	5054	4831	4740
Standard deviation	2274.11	2187.70	2171.10
Panel B (commercial banks and savings institutions)			
No. of markets	2027	2026	2017
Minimum	739	735	704
Maximum	10000	10000	10000
Mean	3684.3	3587.8	3594.9
Q1	2143	2073	2126
Median	3010	2955	2965
Q3	4558	4392	4405
Standard deviation	2236.58	2153.05	2144.41

NOTE: Q1 is the first quartile of the distribution of the data; Q3 is the third quartile.

1459. However, as with MSA markets, mean and median HHI values for rural markets declined between 1999 and 2010. Thus, in mid-2010, the mean and median concentrations of both MSA and rural banking markets were substantially lower than in 1999 (and in 1993 for MSA markets) even though there were far fewer banks and savings institutions in the United States in 2010 than in either 1993 or 1999.

Regional Concentration

That the substantial reduction in the number of banks in the United States from the 1990s through 2010 did not increase the average concentration of local banking markets is consistent with the active enforcement of antitrust policy by bank regulators and the DOJ, whose officials generally deny bank merger applications that would substantially increase the concentration of local banking markets. However, antitrust policy is not applied in banking over larger geographic areas, such as Census regions (though, as noted previously, federal law prohibits individual banks from holding more than 10 percent of total U.S. bank deposits, or 30 percent of a state's total deposits, if that level of deposits is obtained through acquisitions of non-failed banks). Dick (2006) finds that HHI values increased substantially between 1993 and 1999 for all nine U.S. Census regions.

Table 3 reports HHI values for U.S. Census regions for 1999, 2006, and 2010.[14] HHI values vary widely across U.S. Census regions. For 2010, HHI values range from 341 for the East South

[14] Dick's (2006) data exclude savings institutions and rural market deposits. By contrast, the information reported in Table 3 is based on data that include both MSA and rural deposits. However, HHI values and trends are not qualitatively different from those reported in Table 3 if rural deposits are excluded from the analysis.

Table 3

HHI Values (Census Regions)

Census region	1999	2006	2010
Panel A (commercial banks)			
New England	1419	1194	1377
Middle Atlantic	577	914	997
East North Central	135	284	381
West North Central	167	712	554
South Atlantic	589	845	639
East South Central	233	297	341
West South Central	285	501	508
Mountain	370	645	796
Pacific	1295	1155	1183
Panel B (commercial banks and savings institutions)			
New England	571	539	669
Middle Atlantic	371	618	718
East North Central	101	226	315
West North Central	145	631	492
South Atlantic	473	600	517
East South Central	215	277	319
West South Central	229	416	446
Mountain	310	723	650
Pacific	784	781	1069

NOTE: U.S. Census regions include the following states: New England (CT, ME, MA, NH, RI, VT); Middle Atlantic (NJ, NY, PA); East North Central (IN, IL, MI, OH, WI); West North Central (IA, KS, MN, MO, NE, ND, SD); South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA, WV); East South Central (AL, KY, MS, TN); West South Central (AR, LA, OK, TX); Mountain (AZ, CO, ID, NM, MT, UT, NV, WY); and Pacific (AK, CA, HI, OR, WA).

Central region to 1377 for the New England region (Panel A). However, regional HHI values increased between 1999 and 2010 in each region except the New England and the Pacific regions, with the largest increases occurring between 1999 and 2006. When savings institutions are included in the analysis (Panel B), the interregional range of HHI values was narrower. In addition, HHI values rose between 1999 and 2010 in all regions. Thus, regardless of whether savings institutions are included in the analysis, HHI values increased in most, if not all, regions, indicating increased concentration at the regional level. Further, in most regions, a higher percentage of the increase in HHI values occurred during 1999-2006 than

during 2006-10. Thus, the financial crisis and recession did not generally cause a substantial increase in banking concentration, as reflected in HHI values, at either local or regional levels.

DOMINANT AND FRINGE FIRMS

In addition to changes in market concentration, Dick (2006) also investigates changes over time in the number of "dominant" and "fringe" banks in urban and regional banking markets. She defines dominant banks as the smallest set of banks that jointly hold at least half of a market's total deposits. All other banks in a market are fringe banks. Similarly, regionally dominant banks

Table 4

Descriptive Statistics for the Number of Dominant Banks (MSAs)

Bank type	1999	2006	2010
Panel A (commercial banks)			
No. of markets	361	361	366
Minimum	1	1	1
Maximum	8	7	7
Mean	2.7	2.9	3.0
Q1	2	2	2
Median	3	3	3
Q3	3	3	3
Standard deviation	0.91	1.03	1.03
Panel B (commercial banks and savings institutions)			
No. of markets	361	361	366
Minimum	1	1	1
Maximum	11	9	7
Mean	3.2	3.3	3.2
Q1	3	3	3
Median	3	3	3
Q3	4	4	4
Standard deviation	1.08	1.14	1.07

NOTE: Q1 is the first quartile of the distribution of the data; Q3 is the third quartile. Five cities were defined as MSAs between June 30, 2006, and June 30, 2010: Lake Havasu (AZ) and Palm Coast (FL) were designated as MSAs in December 2006; Cape Girardeau (MO), Manhattan (KS), and Mankato-North Mankato (MN) were designated as MSAs in November 2008.

are those that jointly hold at least half of a region's total deposits. Dick (2006) finds that most urban markets had two or three dominant banks in both 1993 and 1999. Further, the average number of fringe banks fell slightly (from 19 banks to 18 banks), but the median number of fringe banks was 11 banks in both years.

Table 4 reports summary statistics on the number of dominant banks across MSAs for 1999, 2006, and 2010.[15] The mean and median number of dominant banks, based on data for only commercial banks or for both commercial banks and savings institutions, changed little between 1999 and 2010. The ranges also varied little across time.

Table 5 shows the frequency distribution of the number of dominant banks for each year. In 1999, 15 (of 361) MSAs had only one dominant bank (Panel A). That number had increased slightly by 2010, when 23 (of 366) MSAs had only one dominant bank. However, the number of MSAs with four or more dominant banks also increased over time, from 48 (of 361) in 1999 to 86 (of 366) in 2010.

As shown in Panel B of Table 4, the mean number of dominant banks in MSA markets is slightly larger if savings institutions are included in the analysis, but the median remains at three banks from 1999 to 2010 and the mean and median numbers changed little between 1999 and 2010. Furthermore, the number of markets with four or more dominant banks increased from 107 (of 361) in 1999 to 124 (of 366) in 2010 (see Table 5). Hence,

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[15] As in calculating the HHI, this article makes no adjustments for cases in which a single owner has a controlling interest in more than one bank in a given market in calculating the number of dominant banks in that market (see footnote 13).

Table 5

Distribution of the Number of Dominant Banks (MSAs)

	1999		2006		2010	
	Frequency	%	Frequency	%	Frequency	%
Panel A (dominant commercial banks)						
1	15	4.2	19	5.3	23	6.3
2	157	43.5	117	32.4	88	24.0
3	141	39.1	149	41.3	169	46.2
4	35	9.7	53	14.7	62	16.9
5	9	2.5	17	4.7	16	4.4
6	3	0.8	3	0.8	7	1.9
7	—	—	3	0.8	1	0.3
8	1	0.3	—	—	—	—
Total MSAs	361		361		366	
Panel B (dominant commercial banks and savings institutions)						
1	7	1.9	15	4.2	15	4.1
2	83	23.0	66	18.3	69	18.9
3	164	45.4	153	42.4	158	43.2
4	76	21.1	83	23.0	84	23.0
5	22	6.1	34	9.4	30	8.2
6	5	1.4	6	1.7	9	2.5
7	3	0.8	2	0.6	1	0.3
8	—	—	1	0.3	—	—
9	—	—	1	0.3	—	—
10	—	—	—	—	—	—
11	1	0.3	—	—	—	—
Total MSAs	361		361		366	

NOTE: Five cities were defined as MSAs between June 30, 2006, and June 30, 2010: Lake Havasu (AZ) and Palm Coast (FL) were designated as MSAs in December 2006; Cape Girardeau (MO), Manhattan (KS), and Mankato-North Mankato (MN) were designated as MSAs in November 2008.

the results indicate that the decline in the number of banks in the United States since 1999 has not caused the number of dominant banks in most MSA banking markets to fall.

Rural (non-MSA) banking markets tend to be more concentrated than urban banking markets. Furthermore, Wheelock (2011) finds that acquisitions of failed banks by in-market competitors resulted in substantial increases in concentration in some rural banking markets during 2007-10 but no significant increases in any large urban markets. Table 6 reports information on the number of dominant banks in rural markets in 1999, 2006, and 2010. The mean and median numbers of dominant banks in rural markets are smaller than those of MSA markets, reflecting the tendency toward greater deposit concentration of rural banking markets. However, as with MSAs, the distributions of dominant banks in rural markets changed little between 1999 and 2010 (Table 7). Thus, as reflected in both HHI values and the distributions of dominant banks, and regardless of whether savings institutions are included in the analysis, the market structure of

Table 6

Descriptive Statistics for the Number of Dominant Banks (Non-MSA Rural Counties)

	1999	2006	2010
Panel A (commercial banks)			
No. of markets	2023	2024	2015
Minimum	1	1	1
Maximum	5	5	5
Mean	1.7	1.8	1.8
Q1	1	1	1
Median	2	2	2
Q3	2	2	2
Standard deviation	0.69	0.73	0.74
Panel B (commercial banks and savings institutions)			
No. of markets	2027	2026	2017
Minimum	1	1	1
Maximum	6	5	6
Mean	1.9	1.9	1.9
Q1	1	1	1
Median	2	2	2
Q3	2	2	2
Standard deviation	0.77	0.80	0.78

NOTE: Q1 is the first quartile of the distribution of the data; Q3 is the third quartile.

Table 7

Distribution of the Number of Dominant Banks (Non-MSA Rural Counties)

	1999		2006		2010	
	Frequency	%	Frequency	%	Frequency	%
Panel A (dominant commercial banks)						
1	835	41.28	780	38.54	788	39.11
2	962	47.55	960	47.43	947	47.00
3	202	9.99	247	12.20	242	12.01
4	22	1.09	34	1.68	35	1.74
5	2	0.10	3	0.15	3	0.15
Total rural markets	2023		2024		2015	
Panel B (dominant commercial banks and savings institutions)						
1	699	34.48	694	34.25	705	34.95
2	979	48.30	927	45.76	951	47.15
3	298	14.70	354	17.47	306	15.17
4	46	2.27	40	1.97	49	2.43
5	3	0.15	11	0.54	5	0.25
6	2	0.10	—	—	1	0.05
Total rural markets	2027		2026		2017	

Table 8

Number of Regional Dominant Banks by Census Region

Census region	1999	2006	2010
Panel A (commercial banks)			
New England	2	3	3
Middle Atlantic	7	5	5
East North Central	25	13	9
West North Central	58	20	11
South Atlantic	8	4	5
East South Central	14	13	15
West South Central	16	8	8
Mountain	9	6	5
Pacific	3	3	3
Panel B (commercial banks and savings institutions)			
New England	9	8	6
Middle Atlantic	11	7	6
East North Central	35	17	12
West North Central	64	27	15
South Atlantic	13	7	7
East South Central	16	15	16
West South Central	20	11	9
Mountain	12	5	6
Pacific	5	5	4

most local U.S. banking markets did not change substantially between 1999 and 2010, despite continued consolidation of the banking industry as a whole.[16]

Regionally Dominant Banks

Dick (2006) finds that the number of regionally dominant banks declined by an average of 55 percent across Census regions from 1993 to 1999. Table 8 reports on the number of regionally dominant banks in each Census region for 1999, 2006, and 2010. As shown in the table, the pattern identified by Dick (2006) continued over the subsequent decade in most regions, especially when savings institutions are included in the analysis (Panel B).[17] The decline in the number of regionally dominant banks was especially pronounced

[17] Dick (2006) does not include savings institutions in her analysis. She apparently also includes only banks located in MSAs in her analysis of regionally dominant banks. The exclusion of rural banks and bank branches has a larger impact on the calculation of the number of regionally dominant banks in regions with higher percentages of deposits held outside MSAs. The West North Central region had the highest percentage of bank deposits held outside MSAs in 1999 at 38 percent. If rural banks are excluded from the analysis, the West North Central region had 13, rather than 58, regionally dominant banks in 1999 (the omission of savings institutions has a much smaller impact on the number of regionally dominant banks). By contrast, in regions with a high percentage of deposits held in MSAs, the omission of rural banks has a much smaller impact on the number of regionally dominant banks. The Pacific region had the smallest percentage of deposits held outside MSAs in 1999. If rural banks are omitted from the analysis, the number of regionally dominant banks remains three.

[16] Similarly, the average number of fringe banks did not change substantially over time in either MSA or rural banking markets.

Table 9

MSA and Regionally Dominant Banks by Census Region

Census region	Mean No. of MSA-dominant banks			Mean No. of MSA- and regionally dominant banks in MSAs		
	1999	2006	2010	1999	2006	2010
Panel A (commercial banks)						
New England	1.8	1.8	1.9	0.8	1.1	1.3
Middle Atlantic	2.6	2.5	2.5	0.9	0.6	0.8
East North Central	2.6	2.9	3.0	1.2	1.3	1.5
West North Central	3.2	3.6	3.6	2.1	1.9	1.6
South Atlantic	2.8	2.9	3.0	1.4	1.5	1.8
East South Central	3.0	3.4	3.2	1.9	2.1	2.2
West South Central	2.9	3.0	3.0	1.8	1.4	1.5
Mountain	2.4	2.7	2.6	1.4	1.6	1.2
Pacific	2.4	2.6	3.0	1.2	1.4	1.7
Panel B (commercial banks and savings institutions)						
New England	2.8	3.1	2.9	1.2	1.5	1.6
Middle Atlantic	3.3	3.4	3.2	1.4	0.9	0.9
East North Central	3.2	3.1	3.2	1.6	1.7	1.7
West North Central	3.6	3.8	3.9	2.4	2.1	1.8
South Atlantic	3.1	3.2	3.3	1.6	1.6	1.8
East South Central	3.2	3.5	3.4	2.0	2.3	2.4
West South Central	3.2	3.1	3.1	1.9	1.5	1.4
Mountain	2.8	2.9	2.8	1.7	1.4	1.3
Pacific	3.2	3.3	3.1	1.6	2.0	1.8

in the West North Central region, where the number of regionally dominant banks fell from 58 in 1999 to 20 in 2006, and to just 11 in 2010 (Panel A). That is, in 1999, the largest 58 banks together held 50 percent of the West North Central region's deposits, but in 2006 the largest 20 banks held 50 percent of the region's deposits, and in 2010 the largest 11 banks held 50 percent of the region's deposits. The number of regionally dominant banks also fell substantially between 1999 and 2010 in the East North Central, South Atlantic, and West South Central regions. Many states in these four regions had prohibited or severely restricted branching within their borders and were among the last states to loosen their branching laws before the Riegle-Neal Interstate Banking

and Branching Efficiency Act was enacted in 1994. Consequently, those states tended to have large numbers of small- and medium-sized banks and experienced more consolidation of their banking systems during the 1990s than did many states in the New England, Middle Atlantic, and Pacific regions, which had long been more open to statewide branching and were among the first to enter into regional interstate banking compacts.[18]

Notably, even in regions with more regionally dominant banks in 1999, the decline in the number of regionally dominant banks during 1999-

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[18] Kroszner and Strahan (1999) and Garrett, Wagner, and Wheelock (2005) investigate the determinants of the timing of state deregulation of branching and interstate banking laws in the 1970s, 1980s, and 1990s.

2006 generally was much larger than during 2006-10. For example, the number of regionally dominant banks in the West South Central region fell from 16 to 8 between 1999 and 2006 but was still 8 in 2010 (based on data for commercial banks only). Hence, the financial crisis and recession of 2007-09 apparently did not add momentum to the ongoing trend toward greater concentration of a region's bank deposits in fewer banks.

Table 9 provides further information about patterns of regionally dominant banks across regions and over time. The table reports regional averages for MSAs in 1999, 2006, and 2010 on (i) the number of MSA-dominant banks and (ii) the number of banks that are dominant in both the MSA and its region.[19] As Dick (2006) finds for 1993 and 1999, the average number of dominant banks varies more across regions than it does across time within regions. For example, based on data for commercial banks only, MSAs in the New England region had an average of 1.8 dominant banks in 1999 and 2006 and 1.9 dominant banks in 2010, whereas MSAs in the West North Central region had an average of 3.2, 3.6, and 3.6 dominant banks in 1999, 2006, and 2010, respectively.

Dick (2006) also finds that the mean number of banks dominant in both an MSA and its region increased between 1993 and 1999. However, as shown in Table 9, that trend did not continue past 1999. The mean number of banks dominant at both the MSA and regional levels changed little between 1999 and 2010 in most regions, regardless of whether savings institutions are included in the analysis. Again, there was more variation across regions than over time. MSAs in the New England and Middle Atlantic regions tended to have the smallest numbers of banks that were dominant in both the MSA and its region, whereas

the East South Central region generally had the highest average number of such banks.

IMPACT OF MERGERS ON MARKET CONCENTRATION (2007-10)

The recent financial crisis and recession led to a wave of bank failures and mergers that contributed to the ongoing consolidation of the U.S. banking industry. As shown previously, the average concentration of local banking markets did not increase during 2006-10. This section examines the impact on specific banking markets of unassisted bank mergers during those years. Wheelock (2011) finds that acquisitions of failed banks by in-market competitors (i.e., banks that already had branches in the markets served by the failed bank) during 2007-10 did not substantially increase concentration in most local banking markets. However, such acquisitions had a substantial impact in a few, mostly rural, banking markets. This section examines the impact on market concentration of acquisitions of non-failed banks by in-market competitors during those years.

Several large unassisted mergers involving banks operating in the same local markets occurred during 2007-10. Table 10 lists the 10 largest unassisted bank mergers during 2007-10, ranked by the total deposits held by the acquired institution as of the most recent June 30 before the merger. For example, Wachovia Bank NA, which merged with Wells Fargo Bank NA in March 2010, held $394 billion of deposits on June 30, 2009.

Although Wachovia Bank NA merged with Wells Fargo Bank NA in March 2010, the Board of Governors of the Federal Reserve System approved the application of Wells Fargo & Company to acquire Wachovia Corporation and its subsidiaries, including Wachovia Bank NA, on October 12, 2008. Wachovia Bank and Wells Fargo Bank had offices in common in several banking markets in Arizona, California, Colorado, Nevada, and Texas. In evaluating the competitive implications of an acquisition of Wachovia Corporation by Wells Fargo, the Board of Governors used deposit and market share data for June 30, 2007 (adjusted to

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[19] Banks that are dominant both within an MSA and within the region in which the MSA is located are banks that are (i) among the group of banks holding at least 50 percent of the deposits of the MSA and (ii) among the group of banks holding at least 50 percent of the deposits of the region. For example, in 2010, the largest five banks in the St. Louis MSA held just over 50 percent of the MSA's deposits. Four of those banks were among the largest 11 banks that together held just over 50 percent of the deposits of the West North Central Census region. Hence, there were four banks in the St. Louis MSA that were dominant in both the MSA and Census region.

Table 10

Ten Largest Unassisted Bank Mergers (2007-10)

Acquired bank	Acquiring bank	Date of holding company acquisition approval	Date of merger	Total deposits of acquired bank ($ thousands)	Total deposits of acquiring bank ($ thousands)
Wachovia Bank, NA	Wells Fargo Bank, NA	October 12, 2008	March 20, 2010	394,189,000	325,417,000
National City Bank	PNC Bank, NA	December 15, 2008	November 7, 2009	101,141,375	84,171,396
Wachovia Mortgage, FSB	Wachovia Bank, NA	September 29, 2006	October 12, 2007	73,243,232	314,850,000
Countrywide Bank, FSB	Bank of America, NA	June 5, 2008	April 27, 2009	63,336,672	642,252,215
Fifth Third Bank*	Fifth Third Bank	March 12, 2001	September 30, 2009	41,454,606	31,948,335
Commerce Bank, NA	TD Bank, NA	March 13, 2008	June 1, 2008	40,126,588	28,092,910
North Fork Bank	Capital One, NA	November 8, 2006	August 1, 2007	38,059,484	20,567,194
LaSalle Bank, NA	Bank of America, NA	September 14, 2007	October 17, 2008	29,594,901	642,252,215
Merrill Lynch Bank & Trust Co., FSB	Bank of America, NA	November 26, 2008	November 2, 2009	28,965,596	817,989,321
LaSalle Bank Midwest, NA	Bank of America, NA	September 14, 2007	October 17, 2008	25,011,471	642,252,215

NOTE: *Fifth Third Bank (Grand Rapids) and Fifth Third Bank (Cincinnati) were both subsidiaries of the Fifth Third Financial Corporation when they merged under the charter of Fifth Third Bank (Cincinnati) in 2009. Hence, Fifth Third Bank (Cincinnati) is listed as the acquirer and Fifth Third Bank (Grand Rapids) as the acquired bank.

reflect mergers and acquisitions through October 3, 2008).[20] Wachovia Bank had only small shares of most MSA banking markets in states where Wells Fargo Bank operated, and consequently the proposed acquisition would have had little impact on concentration in most markets. However, Wachovia Bank and Wells Fargo Bank both had significant market shares in a few small MSA and rural banking markets. For example, they had the two largest market shares in the Santa Cruz, California, banking market with 27 percent (Wachovia) and 19 percent (Wells Fargo) shares. However, in their application to acquire Wachovia, Wells Fargo proposed to divest one of Wachovia Bank's branches in the Santa Cruz market to an out-of market depository institution. Further, in evaluating the competitive implications of the proposed merger, the Board of Governors noted the presence of several other banks and credit unions with significant market shares in the Santa Cruz market, as well as the recent entry into the market of two other depository institutions. Hence, the Board determined that the merger would not adversely harm competition in the Santa Cruz market.[21] The Board of Governors made similar determinations about the few other banking markets where both Wachovia Bank and Wells Fargo had relatively large market shares.

Although both Wachovia Bank NA and Wells Fargo Bank NA were controlled by Wells Fargo & Company when the banks were formally merged in March 2010, an indication of the impact of the merger on concentration in the Santa Cruz and other markets is obtained by comparing deposits and market share data for June 30, 2009, and June 30, 2010. Based on data for June 30, 2009, the HHI value for the Santa Cruz MSA was 1295, indicating that the market was moderately concentrated by DOJ guidelines. Had Wachovia Bank

and Wells Fargo Bank been merged as of that date, and assuming no other differences in the market, the HHI value would have been 1832. Hence, a simple pro forma analysis suggests that the merger would produce a larger increase in market concentration than permitted by DOJ guidelines. However, the divestiture of one of Wachovia Bank's branches in the Santa Cruz market reduced the impact of the merger on market concentration. In the event, the HHI value for the Santa Cruz market rose by only 202 points, from 1295 to 1497, between June 30, 2009, and June 30, 2010, and hence the market remained only moderately concentrated.[22]

The acquisition of National City Bank by PNC Bank NA in November 2009 was the second-largest merger in terms of total deposits of the acquired bank during 2007-10. The Board of Governors approved the application of The PNC Financial Services Group, Inc. (the parent company of PNC Bank NA) to acquire National City Corporation (the parent of National City Bank) on December 15, 2008. The Board relied on deposit and market share data as of June 30, 2008 (adjusted to reflect mergers and acquisitions through November 4, 2008) to evaluate the competitive implications of the acquisition on individual banking markets.

National City Bank and PNC Bank competed directly in 10 banking markets in Florida, Kentucky, Ohio, and Pennsylvania, and both had substantial shares of the Erie and Pittsburgh, Pennsylvania, markets. In its merger application, PNC proposed to divest several National City Bank branches in both the Pittsburgh and Erie markets. In addition, the Board of Governors determined that a substantial portion of the deposits held by PNC Bank in Pittsburgh were deposits of customers located outside the Pittsburgh market, including various municipalities and governments, and escrow accounts for mortgages and other transactions outside the market. Consequently, the Board determined that, in effect, PNC had a lower effective share of the Pittsburgh

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[20] The statement by the Board of Governors regarding the application by Wells Fargo & Company to acquire Wachovia Corporation and Wachovia's subsidiary banks and non-banking companies is available on the Board's website (www.federalreserve.gov/newsevents/press/orders/orders20081021a1.pdf).

[21] Credit unions are not required to report branch-level deposits data and, hence, ordinarily they are excluded from calculation of market concentration measures, such as the HHI. However, the Board may consider the presence of credit unions in a market when evaluating applications for bank mergers.

[22] The change in HHI from one year to the next reflects all transactions that occurred in a market during the year, not just the merger of Wachovia Bank and Wells Fargo Bank, as well as fluctuations in market shares associated with other deposit inflows and outflows.

Table 11

Descriptive Statistics for the HHI in Overlapping Markets for Bank Mergers (2007-10)

	MSAs			Non-MSA rural counties		
	HHI before*	HHI after†	Difference‡	HHI before*	HHI after†	Difference‡
Panel A (Jan. 1, 2007–June 30, 2007)						
No. of markets	51	51	51	34	34	34
Minimum	408.48	384.15	–223.25	1121.30	1092.81	–2163.01
Maximum	4625.70	4402.45	635.33	6147.01	4265.75	1727.43
Mean	1296.11	1327.00	30.89	2134.62	2358.65	224.03
Q1	910.27	891.98	–49.77	1579.61	1760.57	46.96
Median	1155.46	1114.97	–10.25	1934.33	2204.36	127.08
Q3	1495.06	1486.63	65.40	2538.31	2774.86	321.55
Standard deviation	659.00	705.13	151.71	935.73	899.10	598.69
Panel B (July 1, 2007–June 30, 2008)						
No. of markets	116	116	116	47	47	47
Minimum	384.15	445.02	–244.30	977.23	1007.49	–272.30
Maximum	6559.93	6504.27	1945.82	4590.82	5691.28	2145.23
Mean	1312.70	1432.69	119.99	2124.46	2351.43	226.97
Q1	938.47	957.36	–0.06	1334.08	1493.10	30.26
Median	1165.13	1220.19	48.21	1799.53	1823.53	111.92
Q3	1450.68	1606.12	140.10	2773.81	2859.65	227.27
Standard deviation	753.37	855.27	298.28	968.02	1123.69	430.44
Panel C (July 1, 2008–June 30, 2009)						
No. of markets	66	66	66	31	31	31
Minimum	445.02	439.99	–867.48	1113.50	1092.08	–156.84
Maximum	5631.98	5768.96	4684.56	4078.06	7956.74	3878.67
Mean	1398.88	1474.41	75.53	1971.28	2309.60	338.32
Q1	889.74	922.43	–65.89	1414.71	1493.24	2.68
Median	1189.65	1190.35	4.73	1843.44	2074.01	148.49
Q3	1489.83	1522.02	49.27	2254.19	2550.92	374.04
Standard deviation	933.90	1050.60	611.76	723.49	1331.83	721.43
Panel D (July 1, 2009–June 30, 2010)						
No. of markets	78	78	78	21	21	21
Minimum	439.99	488.17	–2289.39	943.52	992.73	–421.80
Maximum	6802.87	7246.76	1551.94	3909.51	7410.51	3501.00
Mean	1462.61	1555.52	92.91	2100.92	2540.99	440.06
Q1	939.94	1033.07	4.67	1429.57	1542.64	81.51
Median	1230.18	1296.63	103.94	1892.44	1896.29	174.93
Q3	1441.67	1615.89	225.36	2333.82	2963.18	470.81
Standard deviation	1016.31	1074.24	397.97	840.29	1516.96	816.02

Table 11, cont'd

Descriptive Statistics for the HHI in Overlapping Markets for Bank Mergers (2007-10)

	MSAs			Non-MSA rural counties		
	HHI before*	HHI after†	Difference‡	HHI before*	HHI after†	Difference‡
Panel E (Jan. 1, 2007–June 30, 2010)						
No. of markets	311	311	311	133	133	133
Minimum	384.15	384.15	–2289.39	943.52	992.73	–2163.01
Maximum	6802.87	7246.76	4684.56	6147.01	7956.74	3878.67
Mean	1365.87	1455.02	89.15	2087.64	2373.46	285.82
Q1	925.60	955.38	–25.91	1429.57	1542.64	38.49
Median	1177.98	1247.80	31.20	1837.30	2062.67	134.45
Q3	1476.66	1600.65	146.01	2531.96	2719.63	301.14
Standard deviation	851.16	935.48	394.31	880.71	1183.03	616.44

NOTE: The summary statistics exclude all market overlaps for mergers that occurred after June 30, 2010. *"HHI before" corresponds to the HHI value on the June 30 before the merger date; †"HHI after" corresponds to the HHI value on the June 30 after the merger date; ‡"Difference" corresponds to the change between the HHI value from the June 30 before the merger date and the HHI value on the June 30 after the merger date.

banking market than suggested by the Summary of Deposits data used in calculating market HHI values.[23] Furthermore, the Board noted that a large number of banks (57) would remain in the Pittsburgh market after the merger of PNC and National City, and that 6 banking organizations had entered the Pittsburgh market during the previous 4 years. Similarly, considering the proposed branch divestitures and the presence of several other competitors, including four community credit unions, the Board determined that competition in the Erie market would not be adversely affected by PNC's acquisition of National City Bank.[24]

Between January 1, 2007, and June 30, 2010, unassisted bank mergers occurred in 311 MSAs and 133 rural counties where both merger part-ners had existing offices. Table 11 presents summary information about changes in HHI values from the most recent June 30 before a merger to the June 30 immediately following the merger in those markets.[25] Thus, Panel A of the table reports summary statistics for HHI values on June 30, 2006, and June 30, 2007, and the difference in HHI values between those dates, for markets where mergers occurred between January 1, 2007, and June 30, 2007. Panel B reports summary statistics for HHI values on June 30, 2007, and June 30, 2008, and the difference in HHI values between those dates, for markets where mergers occurred between July 1, 2007, and June 30, 2008. Panels C and D report similar information for markets where mergers occurred between July 1, 2008, and June 30, 2009, and between July 1, 2009, and June 30, 2010, respectively. Panel E presents summary statistics for all markets where mergers occurred between January 1, 2007, and June 30, 2010.

The Board of Governors approved many of the bank mergers that occurred between January 1,

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[23] Many banking organizations book the deposits of out-of-market customers at their headquarters location, which distorts market share and HHI values as measures of local market concentration, and is one reason why the Board of Governors and DOJ consider other indicators of market competition in addition to HHI values when evaluating bank merger applications.

[24] The order approving the merger of acquisition of National City Corporation by PNC Financial Services Group, Inc. is available on the Board of Governor's website (http://www.federalreserve.gov/newsevents/press/orders/orders20081215a1.pdf).

[25] Branch-level deposits data for June 30, 2011, are not yet available to calculate changes in HHI values in markets in which mergers occurred between July 1 and December 31, 2010.

2007, and June 30, 2007, in 2006 or before. In doing so, the Board would have relied on deposits and market share information from before June 30, 2006, when evaluating the competitive implications of those mergers. Nonetheless, comparison of HHI values based on data for June 30, 2006, and June 30, 2007, shows how mergers that occurred between January 1, 2007, and June 30, 2007, affected market concentration, regardless of when those mergers were approved. Similarly, comparison of HHI values based on data for June 30, 2007, and June 30, 2008, shows the impact of mergers that occurred between July 1, 2007, and June 30, 2008, on market concentration, regardless of when the Board of Governors approved those mergers. Hence, the data underlying the summary information reported in Table 11 include mergers that were consummated during the period indicated, regardless of when the mergers were approved.

As reported in Panel E, for MSAs, for the entire period January 1, 2007, through June 30, 2010, the mean and median changes in HHI values over the 12-month periods during which one or more bank mergers occurred were 89 and 31 points, respectively. For individual years, the mean (median) changes range from 31 points (–10 points) to 120 points (104 points). The range of changes in HHI values was very wide, from –2289 points to 4685 points across all MSAs where one or more unassisted mergers of banks occurred between January 1, 2007, and June 30, 2010. Of course, mergers are just one cause of changes in HHI values from one year to the next. Other reasons for changes in HHI values include bank failures, de novo entry, reassignment of deposits among a bank's branches, and other changes in the distribution of deposits across banks not associated with mergers.

For rural counties over the entire period, the mean and median changes in HHI values were 286 and 134 points, respectively. For individual years, the mean (median) changes range from 224 (112) points to 440 (175) points. Hence, HHI values tended to increase more in rural counties where mergers occurred than in MSAs. In general, rural banking markets are more concentrated than urban markets. Among rural counties where mergers occurred, the mean HHI value before a

merger was 2088 points, compared with 1366 points in MSAs. Many rural banking markets span more than one county, however, and as noted previously, banking regulators may consider the presence of credit unions and other factors that are not reflected in HHI values when evaluating the competitive effects of proposed bank mergers. Nonetheless, it appears that, on average, unassisted bank mergers during 2007-10 had a larger impact on concentration in rural counties than in MSA banking markets; Wheelock (2011) finds a similar result for mergers involving failed banks.

CONCLUSION

The number of U.S. commercial banks and savings institutions declined by 1,011, or about 12 percent, between December 31, 2006, and December 31, 2010. Unassisted mergers of non-failed banks eliminated 1,002 banks during this period, whereas failures eliminated 324 banks (the chartering of new banks, voluntary liquidations, and other changes resulted in a net addition of 315 banks). The consolidation of the banking industry during 2007-10 continued a trend begun in the mid-1980s. Advances in information-processing and other technologies and the resulting economies of scale have encouraged growth in the size of banks, which deregulation of bank branching, first by states and later by the federal government, has facilitated.[26]

Banking industry consolidation has been marked by sharply higher shares of U.S. bank deposits held by the largest banks, as well as increased concentration of deposits measured at the level of U.S. Census regions. This article extends prior research on the structure of U.S. banking markets by investigating changes in deposit concentration at both the local and regional levels. It shows that trends toward increased concentration at the regional level in the 1990s continued through 2010. However, concentration of local banking markets has changed

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[26] Berger (2003) discusses the implications of technological progress for the banking industry, whereas Hughes, Mester, and Moon (2001) and Wheelock and Wilson (forthcoming) report evidence of significant economies of scale in banking.

little over time, even during the recent financial crisis and recession when several large bank mergers occurred. Further, the average number of banks holding at least 50 percent of deposits in a region declined over time in most U.S. Census regions, but the number holding at least 50 percent of deposits in local banking markets remained fairly constant over time. Antitrust policy is predicated on the assumption that banking markets are local in nature, and enforcement has helped keep local banking markets from becoming significantly more concentrated.

The article also examines the effects on local market concentration of mergers of banks operating in the same markets. Two of the largest mergers during 2007-10 were the merger of Wachovia Bank with Wells Fargo Bank and the merger of National City Bank with PNC Bank. In approving these applications, the Board of Governors of the Federal Reserve System noted plans to divest local branch offices and other mitigating circumstances that offset pro forma analysis of market concentration levels based on the Herfindahl-Hirschman Index. Further, the article finds that deposit concentration did not increase to the extent predicted by simple pro forma analysis in markets where these mergers had raised the most serious concerns about their competitive effects.

Finally, the article finds that deposit concentration did not increase substantially, on average, in local banking markets where any unassisted mergers occurred during 2007-10, though rural counties generally saw larger average increases in concentration than urban markets.

Changes in regulation and technology have reduced the cost of obtaining banking services from distant banks. However, many consumers continue to rely exclusively on local banks for financial services and evidence suggests that the pricing of banking services continues to reflect, at least in part, the structure of local banking markets. The recent financial crisis and recession did not alter the trend toward industry consolidation or change patterns of concentration at either the local or regional levels. Antitrust enforcement has ensured that the structures of local banking markets have not changed significantly as a result of unassisted mergers and acquisitions, even as the industry as a whole has consolidated and total U.S. deposits have become increasingly concentrated among the very largest banks. As technology evolves and the costs of obtaining banking services from distant providers fall further, however, local market characteristics may become less relevant for analysis of competition in banking.

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The Effectiveness of Unconventional Monetary Policy: The Term Auction Facility

Daniel L. Thornton

This paper investigates the effectiveness of one of the Federal Reserve's unconventional monetary policy tools, the term auction facility (TAF). At issue is whether the TAF reduced the spread between the London interbank offered rate (LIBOR) rates and equivalent-term Treasury rates by reducing the liquidity premium embedded in LIBOR rates. This paper suggests that rather than reducing the liquidity premium in LIBOR rates, the announcement of the TAF increased the risk premium in financial and other bond rates because market participants interpreted the announcement by the Fed and other central banks as a sign that the financial crisis was worse than previously thought. Evidence is presented that supports this hypothesis. (JEL E52, E58, G14)

BACKGROUND

The Federal Reserve's actions in the wake of the financial crisis have spurred research into the effectiveness of unconventional monetary policy. One unconventional policy that has received considerable attention is the term auction facility (TAF). At issue is whether the TAF reduced the spread between the London interbank offered rate (LIBOR) rates and equivalent-term Treasury or overnight indexed swap (OIS) rates. The Fed introduced the TAF based on the belief that the increase in the spreads between term LIBOR rates and equivalent-term Treasury or OIS rates at the onset of the financial crisis was due to an increase in the liquidity premium in the interbank market. In announcing the TAF the Fed noted that, by allowing the Federal Reserve to inject term funds through a broader range of counterparties and against a broader range of collateral than traditional open market operations, this facility could help promote the efficient dissemination of liquidity when the unsecured interbank markets are under stress.[1] In testimony before Congress on January 17, 2008, Chairman Bernanke (2008) indicated that the goal of the TAF was to reduce the incentive for banks to hoard cash and increase their willingness to provide credit to households and firms. That is, the Fed believed banks were hoarding liquidity. Consequently, the increase in the LIBOR spreads was a result of an increase in a liquidity premium that banks were requiring to lend in the interbank market. Christensen, Lopez, and Rudebusch (2009, p. 2; hereafter CLR) summarize the intended effectiveness of the TAF:

> In theory, the provision of central bank liquidity could lower the liquidity premium on interbank debt through a variety of channels. On the supply side, banks that have a greater assurance of meeting their own unforeseen liquidity needs over time should be more willing to extend term loans to other banks. In addition, creditors should also be more willing to provide funding to banks that have easy and dependable access to funds, since there is a

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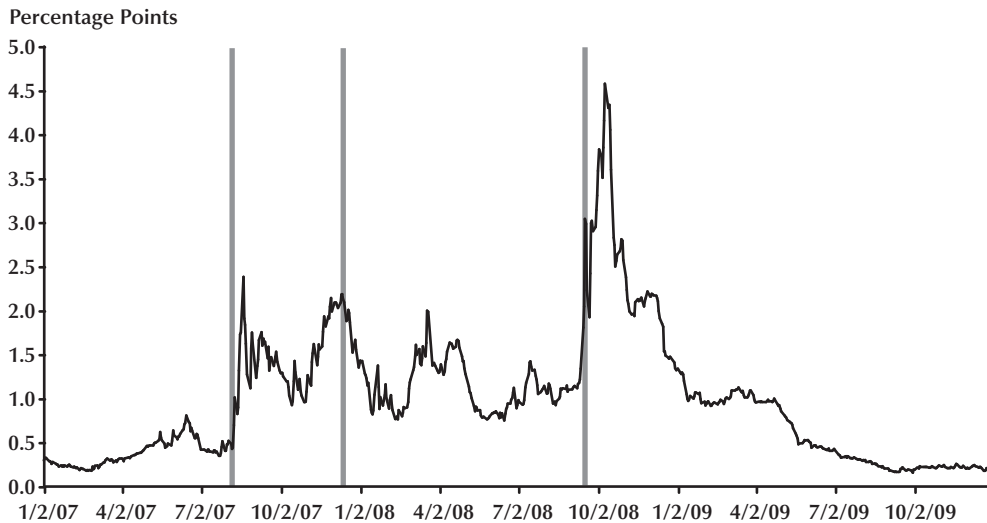[1] Board of Governors of the Federal Reserve System (2007).

Figure 1

Daily Spread Between the 3-Month LIBOR and T-Bill Rates (January 2, 2007–December 31, 2009)

greater reassurance of timely repayment. On the demand side, with a central bank liquidity backstop, banks should be less inclined to borrow from other banks to satisfy any precautionary demand for liquid funds because their future idiosyncratic demands for liquidity over time can be met via the backstop.

To understand the issue, it is useful to consider Figure 1, which shows the daily spread between the 3-month LIBOR and Treasury bill rates from January 2, 2007, through December 31, 2009. The three vertical lines denote the dates of three important events: August 9, 2007, when BNP Paribas, France's largest bank, halted redemption on three investment funds (the financial crisis is assumed to begin on this date); December 12, 2007, when the Fed announced the TAF; and September 15, 2008, when Lehman Brothers filed for Chapter 11 bankruptcy protection.[2] The spread began increasing in March 2007, on news of problems with subprime loans in the mortgage market, to a peak of 80 basis points in late June 2007 and then declined. The spread increased dramatically

at the outset of the financial crisis to a peak of about 240 basis points, declined again, and increased again to a peak of nearly 220 basis points on December 12, 2007; it then declined dramatically following the TAF announcement to a cyclical low of about 80 basis points in mid-January 2008. From January 17, 2008, through September 14, 2008, the spread averaged 112 basis points. The spread increased dramatically again on Lehman's announcement, to a peak of 452 basis points on October 10, 2008, and then declined, eventually reaching pre-financial-crisis levels in the latter half of 2009.

The Fed argued that the dramatic increase in spreads in August 2007 reflected an increase in banks' liquidity premium—that is, banks were demanding a higher rate on interbank lending because of an increased demand for liquidity. Taylor and Williams (2008a,b, 2009) and others have argued that the increase in the interbank rate spreads was due to an increase in the risk premium rather than an increase in a liquidity premium. If the increase in the LIBOR/T-bill spreads was the consequence of an increase in the credit risk premium, the TAF would have no effect on it. Hence, this is a key question: Was the increase in

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[2] For a complete time line of events during the financial crisis, see http://timeline.stlouisfed.org/index.cfm?p=timeline#.

the LIBOR/T-bill spreads at the outset of the finan-cial crisis due to an increase in a liquidity pre-mium or an increase in the credit risk premium.[3]

LIBOR spreads can reflect both liquidity and credit risk premiums. To identify each type of premium, it is necessary to compare rates and rate spreads for banks that are without significant liquidity constraints with comparable rates and rate spreads for market participants that are liquid-ity constrained. Most investigations of the efficacy of the TAF have relied on an event-study method-ology (e.g., Taylor and Williams, 2008a,b, 2009; McAndrews, Sarkar, and Wang, 2008; and Wu, 2008), which has yielded mixed results. Recently, CLR have presented evidence from a six-factor term structure model that indicates that the announcement effect of the TAF had a very large effect on the LIBOR rate. Specifically, CLR con-duct a counterfactual experiment and find that the announcement of the TAF reduced the liquidity premium in the 3-month LIBOR rate by 82 basis points relative to what the spread would have been otherwise.

This paper adds to the existing literature in three ways. First, and importantly, I consider the behavior of the LIBOR/T-bill spreads both before and after the TAF announcement because, if nearly all of the change in the LIBOR/T-bill spreads before the TAF can be accounted for by changes in risk spreads, it is difficult to see how the TAF could have generated a large reduction in the liquidity premium. (If the liquidity pre-mium did not increase significantly at the outside of the financial crisis, the announcement of the TAF could not have reduced it dramatically.) Second, I show that CLR's conclusion depends critically on the marked increase in the spreads between AA-rated financial bond rates and equivalent-maturity LIBOR rates immediately following the TAF announcement. I offer an alter-native hypothesis for the marked increase in the financial bond/ LIBOR rate spreads and present

a variety of evidence supporting this hypothesis. Finally, I show that nearly all of the behavior of the LIBOR/T-bill spreads both before and after the TAF announcement is accounted for by the risk premium and that when the risk premium is accounted for, the TAF has at most a modest effect on the LIBOR/T-bill spreads.

The remainder of the paper is as follows. The next section briefly reviews the event-study empirical analyses of the effect of the TAF. The third section presents CLR's affine-term-structure-model approach for analyzing the effect of the TAF. The section shows that CLR's announcement effect depends critically on the marked increase in the spread between rates on (i) highly rated corporate financial bond rates and (ii) equivalent-maturity LIBOR rates immediately following the announcement of the TAF. The fourth section offers an alternative hypothesis for the marked increase in this spread and presents evidence consistent with this hypothesis. An empirical analysis of the effect of the TAF on the LIBOR/T-bill spreads is presented in the fifth section. The final section offers conclusions.

Event-Study Investigations of the Effects of the TAF

Taylor and Williams (2008a) were the first to investigate whether the TAF had a significant effect on the LIBOR rate. They investigated the effect of the TAF by regressing the 1- and 3-month spreads between the LIBOR and OIS rates on vari-ous measures of counterparty risk and dummy variables for TAF bid submission dates. In all cases considered, the coefficient on the measure of counterpart risk was positive and statistically significant, indicating that some of the increase in the spread was accounted for by risk premiums. The coefficients on the TAF dummy variable were also positive, but not statistically significant. Based on their economic and empirical analyses, Taylor and Williams concluded that increased counterparty risk between banks contributed to the rise in spreads and find no empirical evidence that the TAF has reduced spreads.[4]

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[3] See Krishnamurthy (2010) for a discussion of how an increase in credit risk can cause an increase in the demand for liquid assets—that is, assets that can be converted to cash quickly with no appre-ciable market risk. However, this effect is endemic to the market and is not unique to banks. Consequently, as I will show, it is reflected in risk spreads generally.

[4] Taylor and Williams (2008a, title page).

McAndrews, Sarkar, and Wang (2008) investigate the effect of the TAF on the LIBOR/OIS spreads using a regression methodology similar to that of Taylor and Williams (2008a). However, they suggest that Taylor and Williams's use of the level of the spread in their regressions is valid only under the assumption that the liquidity risk premium falls on a day with a TAF event but reverts to the previous level immediately after the TAF event.[5] Using the change in the spread as the dependent variable and dummy variables for all of the various auction announcements and operations, they find that the TAF significantly reduced the size of the LIBOR/OIS spreads.

Wu (2008) suggests that the methodology used by Taylor and Williams (2008a) and McAndrews, Sarkar, and Wang (2008) is problematic because they (i) assume that the TAF had no effect on the spreads other than on event days associated with it, (ii) do not control for systematic counterparty risk among major financial institutions, and (iii) fail to separate the effects of lowering the counterparty risk premiums from those relieving liquidity concerns.[6]

Wu's (2008) approach to analyzing the effectiveness of the TAF differs from the two previous approaches in three respects. First, rather than using a TAF dummy variable for specific event days only, Wu uses a TAF dummy variable that is zero for all days prior to the TAF announcement on December 12, 2007, and 1 thereafter. Wu (2008) argues that because TAF lending was for maturities of 28 days or longer, one would expect that such loans would be able to relieve the financial strains for the duration of the loans—and not simply affect the spreads on specific event days. Wu also included alternative measures of stock and bond market volatility and the eurodollar rate volatility as well as a mortgage default risk factor in his regression equations.[7] In contrast to the findings of Taylor and Williams (2008a), Wu finds that the TAF has, on average, reduced the 1-month LIBOR/OIS spread by at least 31 basis

points and the 3-month LIBOR/OIS spreads by at least 44 basis points. He also regresses his TAF dummy variable on two measures of systematic risk and, consistent with Taylor and Williams's analysis, finds that the coefficient is positive and statistically significant, suggesting that the TAF has not been able to reduce the counterparty default risk premiums.[8]

A later paper by Taylor and Williams (2008b) responds to criticism by McAndrews, Sarkar, and Wang (2008) and Wu (2008) and others regarding their earlier (2008a) work. First, they show that the spreads between the LIBOR/OIS rates were very similar to the spread between the LIBOR rate and the repo rate on government securities, arguing that the LIBOR/repo spread is a very good measure of interbank risk because it is the difference in rates between secured and unsecured lending between banks at the same maturity.[9] The close correspondence between these rates suggests that the LIBOR/OIS spreads primarily reflects credit risk and not liquidity risk.

The authors also suggest that one could discriminate between liquidity risk and counterparty risk by comparing the behavior of rates paid to others who lend to banks but are not liquidity constrained, such as the rates paid on certificates of deposit (CDs). Term CDs and term LIBOR loans are alternative ways that banks finance their shorter-term lending. Because purchasers of CDs are not liquidity constrained, there is no reason for CD rates to increase because of liquidity concerns. However, because these instruments are uninsured, CD rates will rise when market participants believe that lending to banks is more risky. Consequently, the TAF should have no effect on any liquidity premium embedded in CD rates. Taylor and Williams (2008b) note that CD rates have tracked LIBOR rates of comparable maturities very closely, suggesting that liquidity risk is not a significant separate factor driving term lending rates.[10] They also perform additional regression analysis altering the timing of how the TAF

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[5] McAndrews, Sarkar, and Wang (2008, p. 10).

[6] Wu (2008, p. 3).

[7] The mortgage risk factor is the first principal component for credit default swap rates for three mortgage companies.

[8] Wu (2008, p. 2).

[9] Taylor and Williams (2008b, p. 6).

[10] Taylor and Williams (2008b, p. 10).

might affect interest rates and using CD rates based on a broader set of banks; they also conduct regression analysis with the spreads between the CD, term federal funds, and eurodollar rates and the OIS rate (the dependent variable). They find no evidence of a significant effect of the TAF in any of these regressions.

Taylor and Williams (2008b) find that the results using Wu's (2008) TAF dummy variable were fragile. Specifically, the coefficient was large and statistically significant over one sample, but not when the sample was extended.[11] They also investigate the effectiveness of the TAF using the outstanding TAF loan balance. The estimated coefficients were sometimes negative, but seldom statistically significant.

Finally, the authors find that the results using the first difference of the spread rather than the level of the spread depended critically on the timing of the variable in the regression and on the particular TAF events considered. Noting that the relationship between LIBOR/OIS spreads and various measures of counterparty risk are robust, they conclude that, while other researchers have found significant TAF effects by altering the specification of the empirical equation they originally proposed, these results are sensitive to small changes in specification, measures of the spread, or measures of risk.[12]

THE EFFECTIVENESS OF THE TAF: RESULTS FROM A SIX-FACTOR TERM STRUCTURE MODEL

CLR use a very different approach, noting that the McAndrews, Sarkar, and Wang (2008) and Wu (2008) conclusions about the effectiveness of the TAF using regression analyses of Taylor and Williams (2008a,b) are sensitive to only small differences in the specifications of their regression equations.[13] Specifically, they analyze the effectiveness of the TAF by estimat-

ing a six-factor arbitrage-free term structure model based on a Nelson and Siegel (1987) yield curve. There are three Nelson-Siegel factors for Treasury yields, two Nelson-Siegel factors for bank bond yields, and a single LIBOR factor. They estimate the model using weekly data over the sample period January 6, 1995, to July 25, 2008. They note that their LIBOR factor changed significantly immediately following the announcement of the TAF (December 14, 2007), as did parameters of their model that involve the LIBOR factor. They then conduct a counterfactual experiment to quantify the effect of the change in the model's behavior for the 3-month LIBOR rate. Specifically, they fix the mean of the LIBOR factor at its pre-announcement level and leave the other factors unchanged. Their counterfactual experiment suggests that the 3-month LIBOR rate would have averaged about 80 basis points higher without the TAF.[14]

Given the sensitivity of the regression approaches to the specification of the equations and other issues, CLR's counterfactual result constitutes the most compelling evidence that the TAF had a significant effect of reducing the LIBOR spreads. Consequently, it is important that this evidence be analyzed carefully. Particularly important is that CLR's counterfactual result depends critically on their LIBOR factor, which is based on the spreads between the 3-, 6-, and 12-month LIBOR rates and rates on AA-rated corporate financial bonds with the same maturities. Their factor differs little from the first principal component obtained from these spreads. Given that CLR assume that the LIBOR is independent of the other five factors, this result is not surprising.

Figure 2 shows CLR's factor and the first principal component of the three rate spreads. The vertical line denotes December 14, 2007 (the week of the TAF announcement). The two factors are very similar. Most important is the fact that both decline markedly immediately following the announcement of the TAF. The marked decline in the LIBOR factor is a consequence of the AA-rated corporate financial bond rates declining relatively less than equivalent-term LIBOR rates

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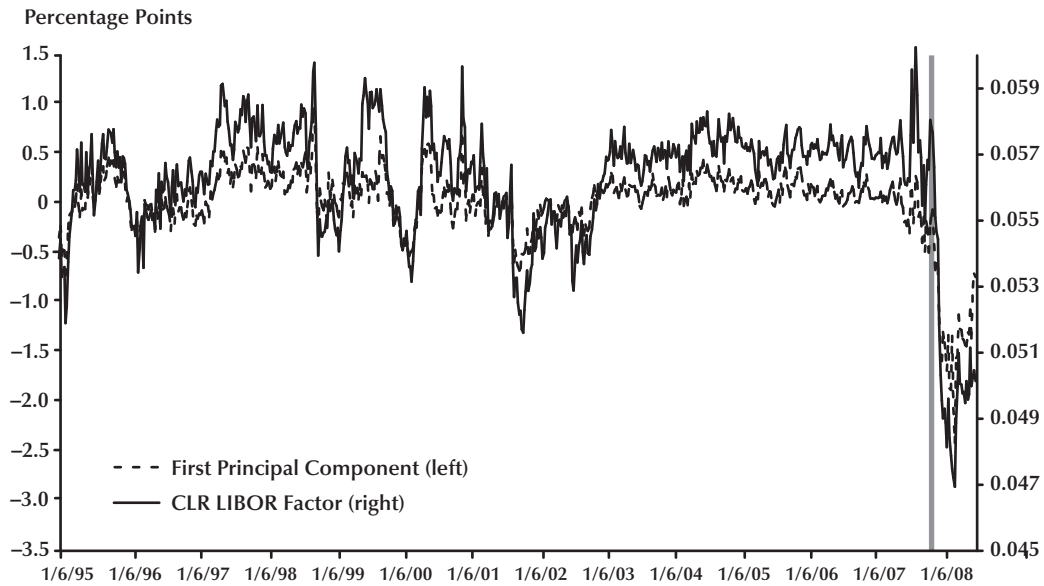[11] Also see Taylor and Williams (2009), which reflects work from their two 2008 papers.

[12] Taylor and Williams (2008b, p. 20).

[13] Christensen, Lopez, and Rudebusch (2009, p. 4).

[14] Christensen, Lopez, and Rudebusch (2009, p. 29).

Figure 2

CLR LIBOR Factor and the First Principal Component

Percentage Points

Figure 3

3-Month AA-Rated Corporate Financial Bond and LIBOR Rates and Their Spread
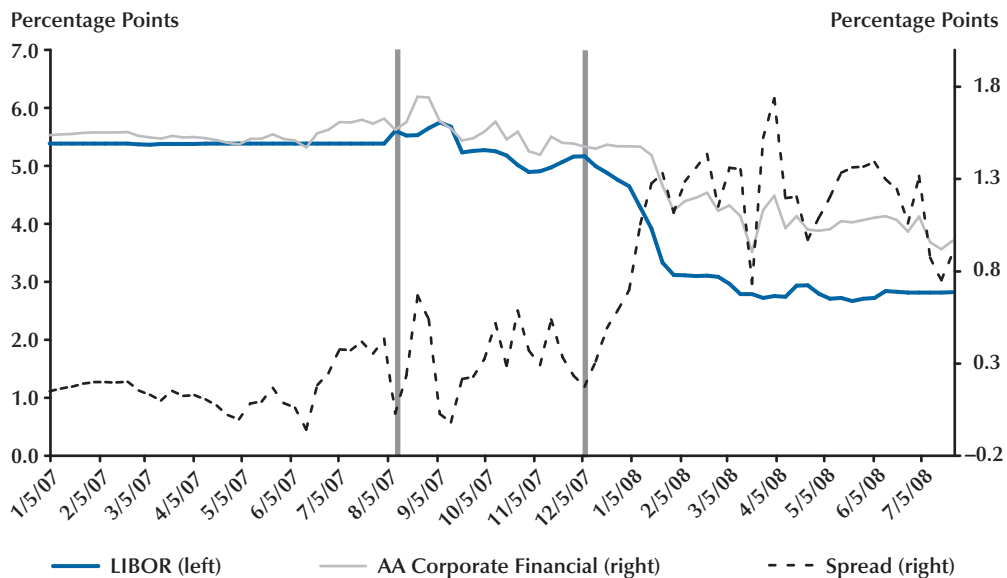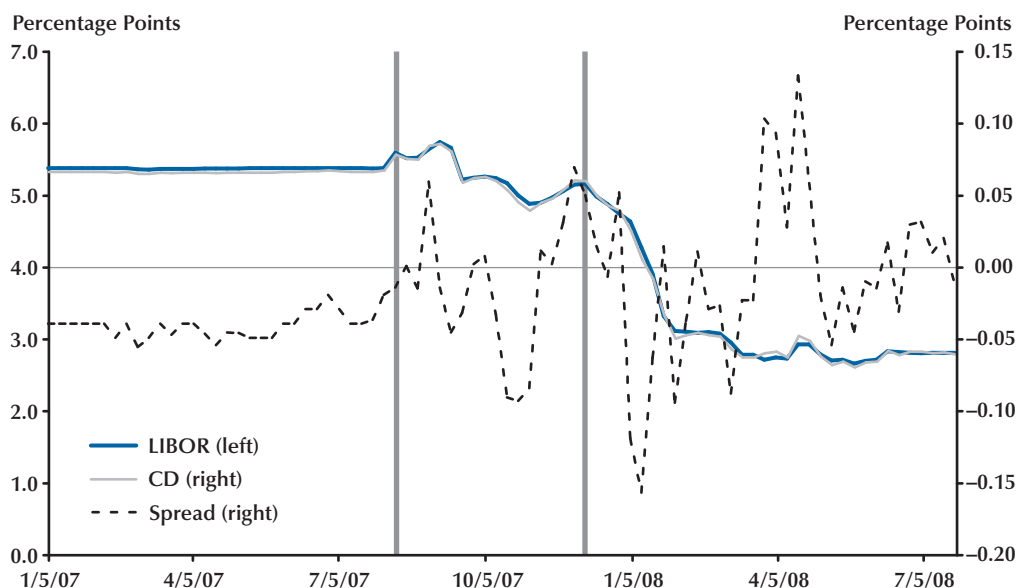
Figure 4

3-Month CD and LIBOR Rates and Their Spread

immediately following the TAF announcement. This is illustrated in Figure 3, which shows the 3-month AA-rated corporate financial bond rate, the 3-month LIBOR rate, and their spread weekly from January 5, 2007, through July 25, 2008. The first vertical line denotes the week of the onset of the financial crisis; the second denotes the week of the TAF announcement. Both rates fell on the TAF announcement, but the LIBOR rate declined more than AA-rated corporate financial bond rates, so the spread increased.[15]

Because this marked and very persistent increase in the spread of AA-rated corporate financial bond rates over LIBOR rates is responsible for CLR's counterfactual result, it is important to understand *why* highly rated corporate financial bond rates increased relative to LIBOR rates following the TAF announcement. CLR suggest that this decline in LIBOR rates relative to financial bond rates is due to a marked reduction in the

liquidity premium that banks required to lend in the interbank market. Specifically, CLR suggest that the bank bond rates are derived from debt obligations issued to a broad class of investors that overwhelmingly consists of nonbank institutions. While these two classes of lenders most likely attach similar probabilities and prices to credit risk, they likely have different tolerances for liquidity problems.[16] That is, the spread widened because of a marked decline in the liquidity premium in the LIBOR rates relative to AA-rated corporate financial bond rates.

There are two reasons to be skeptical of CLR's interpretation. First, if the sharp increase in the spread of AA-rated corporate financial bond rates over LIBOR rates were due to a decline in the liquidity premium required by banks, the same logic would imply that this spread should have declined markedly at the onset of the financial crisis because the liquidity premium required by banks would have increased relative to that of the

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[15] The behavior of the 6- and 12-month spreads is very similar to that of the 3-month spread. Indeed, the first principal component of these three spreads accounts for 84 percent of the variance of the three spreads.

[16] Christensen, Lopez, and Rudebusch (2009, pp. 26-27).

financial bond rate. However, this did not occur. Indeed, Figure 3 shows that, rather than decreasing at the onset of the financial crisis, as CLR's interpretation would suggest, the spread increased; however, it declined subsequently. On average between the onset of the financial crisis and the TAF announcement, the spread changed little from the level for the weeks prior to the beginning of the financial crisis. In short, the spread increased rather than decreased, contrary to the logic of CLR's hypothesis.

Second, CLR's interpretation suggests that there should have been a comparable increase in the spread between the 3-month CD and LIBOR rates. CDs represent loans to banks by *a broad class of investors that overwhelmingly consists of nonbank institutions* and are a major source of funds for bank lending. Lenders in the CD market are not liquidity constrained and did not acquire liquidity through the TAF. Consequently, we should expect to see a marked decline in the LIBOR rate relative to the CD rate following the TAF announcement. Figure 4 shows the 3-month CD and LIBOR rates and CD/LIBOR spread weekly for the period January 5, 2007, through July 25, 2008. As before, the first and second vertical lines denote the week of the onset of the financial crisis and the TAF announcement, respectively. The 3-month CD and LIBOR rates are nearly identical before and after the onset of the financial crisis and before and after the TAF announcement. The variability of the CD/LIBOR spread increased with the onset of the financial crisis, but there was virtually no change in the average spread, which was –4 basis points before the financial crisis and –1 basis point after the TAF announcement.

AN ALTERNATIVE HYPOTHESIS FOR THE BEHAVIOR OF THE CORPORATE FINANCIAL BOND/ LIBOR SPREAD

This section offers an alternative hypothesis for this marked change in behavior of the AA corporate financial/LIBOR spread following the

TAF announcement, which I call the increased-risk-premium hypothesis (IRPH).[17] Specifically, it is possible that the market participants interpreted the Fed's announcement of the TAF as an indicator that the financial crisis was more serious than previously thought. The IRPH seems particularly credible given that the Bank of England, the Swiss National Bank, the Bank of Canada, and the European Central Bank announced measures designed to address elevated pressures in short-term funding markets on the same day. If market participants believed these announcements signaled that the financial crisis was worse than previously thought, the TAF and other announcements could have caused a reassessment of the credit risk of financial firms, increasing the spread between corporate financial bond rates and LIBOR rates.

Evidence of the IRPH: The Behavior of Risk Spreads

The IRPH is supported by the fact that spreads between corporate financial and non-financial bond rates and the LIBOR rate increased following the TAF announcement. Figure 5 shows the spreads between 3-month (i) AA-rated corporate financial, (ii) AA-rated corporate industrial, and (iii) BBB-rated corporate industrial weekly bond rates and the 3-month LIBOR rate weekly over the period January 5, 2007, through July 25, 2008. The vertical lines denote the onset of the financial crisis and the TAF announcement, respectively. The spreads initially declined with the onset of the financial crisis and the industrial spreads declined prior to the TAF announcement, while the AA-rated corporate financial bond spread remained relatively stable at about 50 basis points. All three spreads increased following the TAF announcement. Moreover, all three spreads increased by similar amounts between the week

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[17] There were reports that the LIBOR rate (which is obtained from surveys) was understating the rate that banks were actually paying in the interbank market during the financial crisis (e.g., Mollenkamp and Whitehouse, 2008). Kuo, Skeie, and Vickery (2010) provide evidence supporting these claims. However, their estimates of the degree of understatement during this period is not large enough to account for CLR's findings.

Figure 5

Spreads Between the 3-Month AA-Rated Corporate Financial and AA-Rated and BBB-Rated Industrial Bond Rates and the 3-Month LIBOR Rate
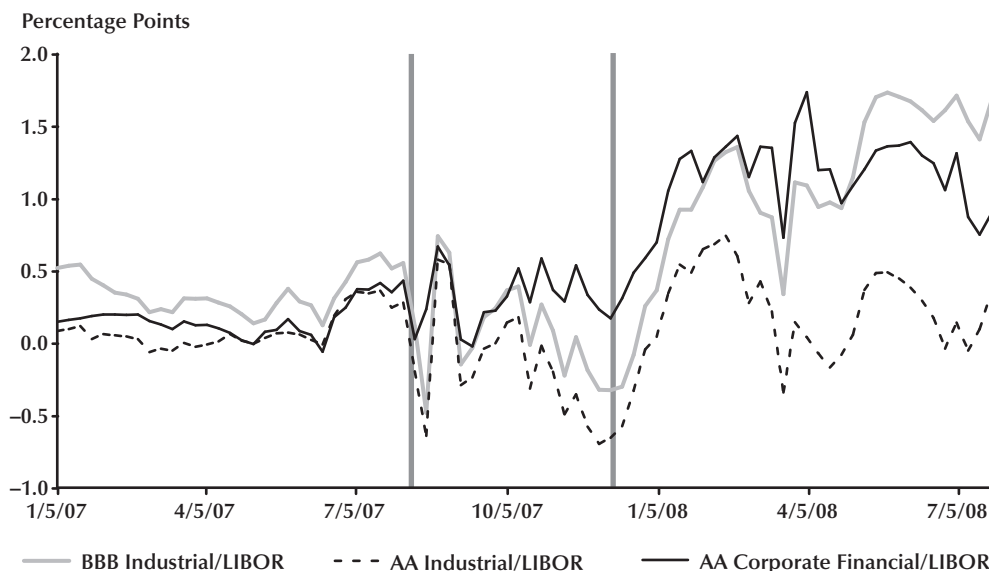
of the announcement and the week of January 25, 2008: The AA corporate financial/LIBOR, AA industrial/LIBOR, and BBB industrial/LIBOR spreads increased by 102, 123, and 106 basis points, respectively. The similarity in the behavior of the spreads before and after the TAF announcement strongly supports the IRPH. As noted above, if the announcement was taken as an indicator that the financial crisis was worse than previously thought, credit risk premiums would have increased, which they did. Indeed, not only did all of these corporate bond rates rise relative to the LIBOR rate, but the spread between BBB and AA industrial corporate bonds—a commonly used measure of credit risk—also increased dramatically, from 33 basis points prior to the TAF announcement to a peak of 165 basis point in early June 2008. This establishes the possibility that the marked increase in the AA corporate financial/LIBOR spread, which accounts for CLR's counterfactual result, is due to an increase in the risk premium rather than to a decrease in a liquidity premium, as they hypothesize.

Evidence of the IRPH: The Behavior of Corporate Financial and Bank Bond Spreads

The IPRH is also consistent with the relative behavior of corporate financial and bank bond rates. Figure 6 shows the spread between 3-month AA-rated corporate financial and AA-rated bank bond rates. The data are weekly over the period January 5, 2007, through July 25, 2008. The vertical lines denote the onset of the financial crisis and the TAF announcement, respectively. The spread averaged a few basis points in early 2007 and rose on news of subprime mortgage problems. The spread increased further following the onset of the financial crisis, averaging about 10 basis points before the financial crisis and 49 basis points from the onset of the financial crisis to the week prior to the TAF announcement. The spread increased further following the announcement before declining in June 2008. The behavior of the AA corporate financial/AA bank bond spread is consistent with the IRPH for two rea-

Figure 6

3-Month AA Corporate Financial/AA Bank Bond Spread
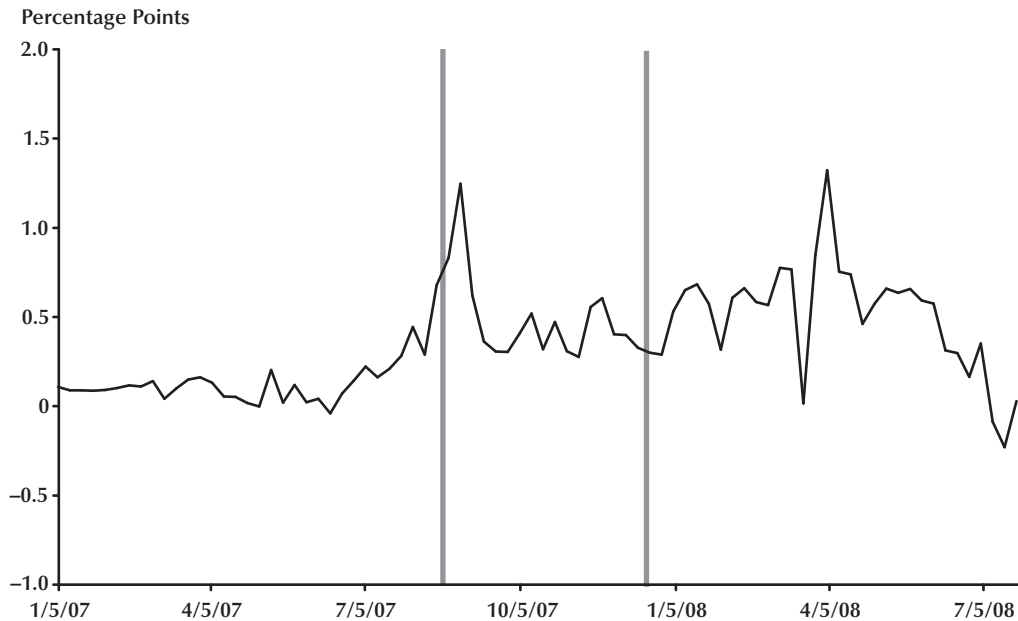
sons. First, the implicit guarantee to bank investors associated with "too big to fail" was initially thought not to apply to non-bank financial corporations, at least before the Bear Sterns bailout. Second, financial corporations had greater exposure to mortgage-backed securities (MBS) than did banks generally.[18] For both of these reasons, it is reasonable to expect that corporate financial bond rates would rise relative to bank bond rates.

Evidence of the IRPH: CLR's LIBOR Factor and Risk Spreads

The analysis above strongly suggests that CLR's LIBOR factor reflects a marked change in the risk premium rather than a marked change in a liquidity premium, as they hypothesize. To see how much of the variation in CLR's LIBOR factor can be accounted for by risk premiums,

the LIBOR factor is regressed on risk premiums reflected in the spreads between BBB-rated and AA-rated corporate bank and industrial bond rates. The spreads are for maturities of 3, 6, and 12 months—the same maturities that CLR used to obtain their LIBOR factor. The sample period begins with the availability of AA-rated bank bond rate data, March 17, 2000. These six risk premiums account for 44 percent of the weekly variation in CLR's LIBOR factor over the sample period March 10, 2000, through July 25, 2008.

To see whether these risk premiums account for more or less of the variation during periods when the LIBOR factor is relatively more variable (especially following the announcement of the TAF), the regression equation is estimated using a rolling window of 60 weeks. Figure 7 presents the rolling window regression estimates of $\overline{R}^2$ over the sample period. The data are plotted on the last week in the sample. The vertical line denotes the first sample to include post-TAF-announcement data. The estimates show that the risk premiums account for relatively more of the variation in

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[18] Of the $4.4 trillion of agency and GSE-backed securities held by financial institutions in the second quarter of 2007, only $1.1 trillion was held by banks.

Figure 7

60-Week Rolling Estimates of Adjusted R^2 of the CLR LIBOR Factor on Corporate Risk Spreads
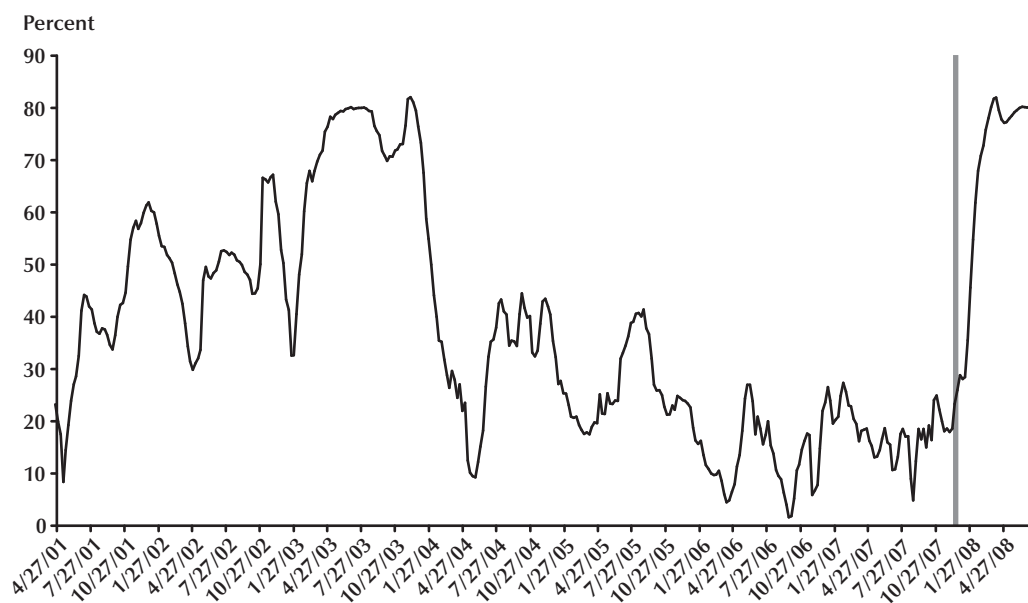
CLR's LIBOR factor when it is particularly variable (see Figure 2). For example, between 2001 and 2003, risk premiums account for over 80 percent of the variation for a period of a year or longer. Importantly, for the issue of whether CLR's counterfactual results are evidence of the success of the TAF in reducing liquidity premiums, the estimate of $\bar{R}^2$ increases dramatically when post-TAF-announcement data are included in the sample. The estimate of $\bar{R}^2$ peaks at 82 percent for the 60-week period ending April 4, 2008.

It may also be the case that the sharp increase in the spread of LIBOR rates over equivalent-maturity Treasury rates was at least partly due to an increase in the risk premium associated with bank lending. To investigate this possibility, the 3-month LIBOR/T-bill spread was regressed on the same six risk premiums over the same sample period. The risk premiums account for 50 percent of the variation in the LIBOR/T-bill spread over the entire sample period. Figure 8, which plots the 60-week rolling estimate of $\bar{R}^2$ for a regression of the LIBOR/T-bill spread on the six risk premiums, shows that after declining to essentially zero,

the estimate of $\bar{R}^2$ increased dramatically following the onset of the financial crisis (the first vertical line). It continued to increase to a peak of nearly 70 percent following the TAF announcement (the second vertical line).

## EXPLAINING THE BEHAVIOR OF THE LIBOR/T-BILL SPREADS

The analysis in the previous section suggests that CLR's LIBOR factor is largely accounted for by risk premiums and does not present strong support for the effectiveness of the TAF. However, the evidence using weekly data suggests that the TAF may have been effective in reducing the LIBOR/T-bill spread.

This issue is investigated more thoroughly in this section using daily data using corporate bond/T-bill spreads not previous used in the literature. The corporate bond/T-bill spreads are for corporate bank, industrial, and retail bonds. These spreads are denoted $BT3$, $IT3$, and $RT3$, respectively. The CD/T-bill and LIBOR/T-bill spreads

Figure 8

60-Week Rolling Estimates of Adjusted R^2 of the 3-Month LIBOR/T-Bill Spread on Corporate/T-Bill Risk Spreads
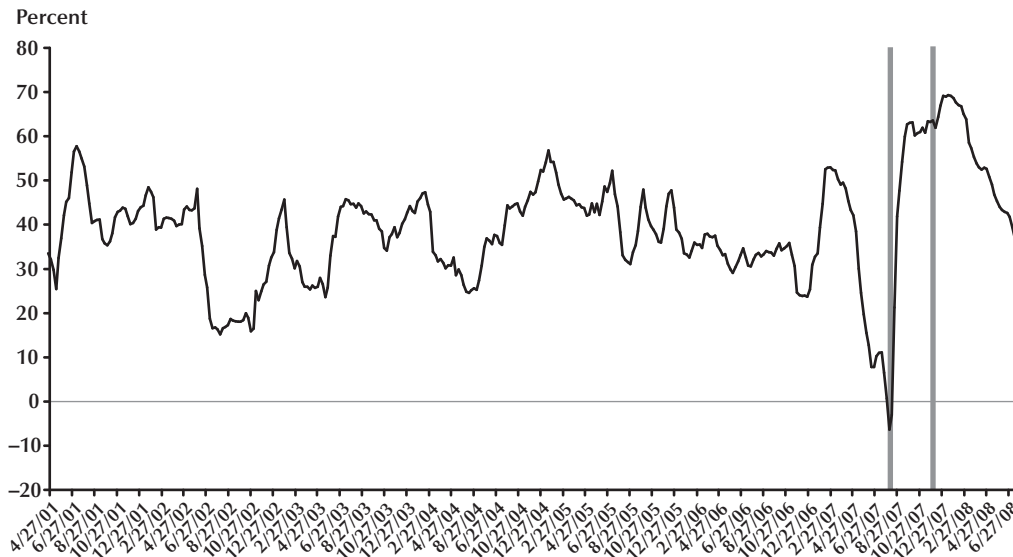
are denoted $CDT3$ and $LT3$, respectively. The effect of the TAF is investigated further by estimating the equation

$$LT3_t = \alpha + \beta_b BT3_t + \beta_i IT3_t + \beta_r RT3_t + \delta\text{DUMVEC} + \epsilon_t,$$

where DUMVEC is a vector of dummy variables that reflect important TAF dates used in the previous event-study literature and ϵ_t is an i.i.d. error term. To make the results comparable to the previous event studies, different sets of dummy variables identical to those used by Taylor and Williams (2008ab), McAndrews, Sarkar, and Wang (2008), and Wu (2008) are used. There are six dummy variables. The first five are those used by McAndrews, Sarkar, and Wang (2008): The dates of international announcements related to the TAF (ANI), domestic TAF announcements (AND), dates when the conditions of the announcement were set (CON), when the auction took place (AUC), and when banks were notified (NOT).[19] The sixth dummy variable is that used by Wu

(2008), denoted Wu, which is zero before December 12, 2007, and 1 thereafter. The sample period is March 10, 2000, through April 30, 2008.[20]

The results are presented in Table 1. The p-values are based on HAC standard errors. The results in the first two columns use McAndrews, Sarkar, and Wang's (2008) dummy variables. The results indicate that $LT3$ is significantly related to each of the corporate bond spreads; the coefficient on each bond spread is positive and highly statistically significant. Moreover, the sum of the coefficients is 0.92 and the hypothesis that the sum of the coefficients is 1 is not rejected at the 5 percent significance level. The estimates of the coefficients on TAF dummy variables provide no evidence that the TAF had any significant effect on the LIBOR/T-bill spread: The coefficients on the ANI and AND dummy variables are positive, but not statistically significant. The coefficients on TAF operation dummy variables are negative,

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[19] These dates can be found in McAndrews, Sarkar, and Wang (2008, Table 1, p. 20).

[20] The sample ends on April 30, 2008, to make the TAF sample period similar to that used by McAndrews, Sarkar, and Wang (2008) and Wu (2008).

Table 1

The Effect of the TAF on the 3-Month LIBOR/T-Bill Spread

	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value
Constant	–0.040	0.111	–0.040	0.116	–0.089	0.001	0.060	0.000
β_b	0.415	0.000	0.414	0.000	0.547	0.000	–0.014	0.229
β_i	0.275	0.007	0.275	0.007	0.266	0.002	0.007	0.431
β_r	0.226	0.001	0.225	0.001	0.230	0.000	0.058	0.000
ANI	0.331	0.168	—	—	—	—	—	—
AND	0.115	0.541	—	—	—	—	—	—
ANI+AND	—	—	0.224	0.241	0.281	0.131	0.042	0.082
CON	–0.005	0.968	–0.004	0.975	0.096	0.377	0.016	0.350
AUC	–0.168	0.160	–0.167	0.160	–0.048	0.639	–0.006	0.591
NOT	–0.214	0.121	–0.213	0.108	–0.087	0.375	–0.016	0.136
Wu	—	—	—	—	–0.340	0.012	–0.031	0.058
CDT3	—	—	—	—	—	—	0.928	0.000
$\bar{R}^2$	0.764	—	0.764	—	0.778	—	0.995	—
SE	0.172	—	0.172	—	0.166	—	0.026	—

NOTE: SE, standard error.

but not statistically significant. The results in the next two columns show that the conclusion does not change when the *ANI* and *AND* are combined.

There is some evidence that the TAF has been effective in reducing the LIBOR/T-bill spread when Wu's dummy variable is included. The estimate of the coefficient on *Wu* is negative and statistically significant, but the coefficient estimate, 34 basis points, is 10 basis points smaller than Wu's estimate. Moreover, consistent with the findings of Taylor and Williams, the coefficient on *Wu* tends to decline and becomes statistically insignificant as the length of the sample increases. It is also the case that evidence of the effectiveness of the TAF all but disappears when *CDT*3 is included as a regressor: The estimate is negative and statistically significant at slightly higher than the 5 percent significance level, but the magnitude of the effect is only 3 basis points.

CONCLUSION

This paper reviews the previous literature on the effectiveness of the TAF in reducing the spread between equivalent-maturity LIBOR and T-bill rates and further investigates the effectiveness of the TAF using weekly and daily data. The previous literature using event-study methodologies finds mixed results. The most compelling evidence for the effectiveness of the TAF comes from CLR's (2009) six-factor term structure model. Performing a counterfactual analysis based on a marked change in the LIBOR factor of their model, CLR indicated that the 3-month LIBOR/T-bill spread would have been 82 basis points higher were it not for the TAF. Noting that CLR's LIBOR factor is based on the spreads between AA-rate financial corporate bond rates and LIBOR rates, I show that these spreads are highly correlated with risk spreads, especially during the post-TAF-announcement period.

I offer an alternative hypothesis for the behavior of the spread between AA-rated financial corporate bond rates and LIBOR rates following the announcement of the TAF. Specifically, I hypothesize that market participants revised up their expectations of the seriousness of the financial crisis in the wake of the TAF announcement and

the announcements of other central banks. I present evidence from a variety of risk spreads that is consistent with this alternative hypothesis, including the fact that over 80 percent of CLR's LIBOR factor is accounted for by risk spreads during this period. This suggests that much of the effect of the TAF that CLR report is actually due to an increase in the risk premium on financial bonds rather than a reduction in the liquidity premium embedded in LIBOR rates. Moreover, this evidence is consistent with the fact that there was no significant decline in the spread between the AA-rated corporate financial bond rates and the LIBOR at the outset of the financial crisis: If there was no significant increase in banks' liquidity premium, it is difficult to understand how the TAF could have reduced it.

I also show that the majority of the 3-month LIBOR/T-bill spread before and after the TAF announcement can be accounted for by the spreads between financial and nonfinancial corporate bond rates. Further analysis using daily data indicates that controlling for these risk premiums, TAF appears to have had little or no effect on the 3-month LIBOR/T-bill spread.

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A Federal Reserve System Conference on Research in Applied Microeconomics

Thomas A. Garrett

This article summarizes some of the papers presented at the System Applied Microeconomics Conference organized and hosted by the Federal Reserve Bank of St. Louis on May 5-6, 2011. This annual conference brings together economists from the Federal Reserve District Banks across the Federal Reserve System and the Federal Reserve Board to present their latest economic research.

The Federal Reserve Bank of St. Louis hosted the annual System Applied Microeconomics Conference on May 5-6, 2011. The papers presented at the conference, some of which are summarized in this article, showcased research in the areas of public policy, education and human capital, labor markets, and housing and consumer finance during the Great Recession.[1]

ANALYSIS OF PUBLIC POLICY

The first group of papers focused on public policy issues. In "Assessing the Evidence on Neighborhood Effects from Moving to Opportunity," Aliprantis provides a new framework and a robust instrument to estimate neighborhood effects using data from the Moving to Opportunity for Fair Housing (MTO) program. The MTO program, a 10-year research project, combines tenant-based rental subsidies with housing counseling

to help poor families move from poor urban areas to less-poor neighborhoods. Aliprantis's framework improves on earlier methods for studying the effects of housing mobility programs by distinguishing between program and neighborhood effect.

In "The Spending and Debt Response to Minimum Wage Hikes," Aaronson, Agarwal, and French explore how minimum wage increases influence spending and debt accumulation by minimum wage earners. They find that (i) both consumer spending and debt accumulation increase after a minimum wage increase and (ii) most spending induced by such an increase goes toward financing durables. The authors' empirical findings are consistent with an augmented buffer-stock model in which households are collateral constrained.

Given the recent decline in aid from state to local governments, in "Designing Formulas for Distributing State Aid Reductions," Zhao and Coyne develop a new formula for allocation of such funds. Their formula improves on other methods because it is based on the underlying fiscal health of local governments rather than commonly used ad hoc measures.

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[1] View the conference agenda at http://research.stlouisfed.org/conferences/appliedmicro/agenda.html. Not all papers presented at the conference are included herein because authors were given the option to not include their papers in these proceedings.

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HUMAN CAPITAL

A second group of papers focused on the topic of human capital. In "The Role of Schools in the Production of Achievement," Canon states that previous research has been unable to simultaneously consider the three types of inputs believed to influence student skills: ability, family inputs, and school inputs. Canon uses parents' savings for higher education as a measure of ability in an empirical framework that corrects for the endogeneity of the three inputs. Unlike earlier studies that do not address the simultaneity among the three inputs, Canon presents evidence that school inputs are important for the formation of student skills when controlling for the ability to learn.

In "Economic Literacy and Inflation Expectations: Evidence from a Laboratory Experiment," Burke and Manz present new experimental evidence on heterogeneity in the formation of inflation expectations. They conduct a laboratory experiment in which subjects complete a set of inflation-forecasting exercises in a simulated economic environment. They find that the subjects' demographic characteristics play a small role in the variation of their inflation expectations, but economic literacy plays a large role in explaining the accuracy of inflation forecasts.

In "Financial Literacy and Mortgage Equity Withdrawals," Duca and Kumar examine whether an individual's financial literacy influences the decision to make or not make mortgage equity withdrawals. Their results indicate that the financially literate are 3 to 5 percentage points less likely to withdraw housing equity but that this result does not apply to home equity lines of credit.

LABOR MARKET ISSUES

A third group of papers, of which one is summarized here, focused on labor market issues. In "When Does the Labor Market Consider You a Smoker and Do You Care?" Armour, Hotchkiss, and Pitts explore the wage differential between smokers and nonsmokers. Using a switching regression framework with unknown sample

selection, they find that smokers do face a wage penalty. However, this penalty is not a result of smokers having lower productivity but rather of the set of personal characteristics smokers bring to the workplace. The authors also find that individual smoking behavior is responsive to the earnings penalty associated with smoking.

LESSONS FROM THE GREAT RECESSION AND HOUSING CRISIS

A fourth group of papers, of which one is summarized here, examined housing and consumer finance during the Great Recession. In "Financing Constraints and Unemployment: Evidence from the Great Recession," Duygan-Bump, Levkov, and Montoriol-Garriga examine the link between small-business lending and unemployment during the Great Recession. They argue that if a reduction in lending to small businesses influences unemployment, then unemployment should increase more in smaller firms with greater dependence on bank financing. The authors find that individuals working in sectors with high external financial dependence, of which a large portion is small businesses, were more likely to become unemployed. However, they find no difference in the likelihood of unemployment for workers in small and large firms in sectors with low external financial dependence.

CONTRIBUTIONS

The following section provides more-detailed summaries of selected conference papers.

"Assessing the Evidence on Neighborhood Effects from Moving to Opportunity"

Building on recent developments in the program evaluation literature, Aliprantis defines several treatment-effect parameters and estimates and interprets some of these parameters using data from the MTO program. The evaluation framework makes a clear distinction between (i) program effects from intent-to-treat and treatment-on-the-

treated parameters and (ii) neighborhood effects from local-average-treatment-effect parameters. This distinction helps to clarify that, although the results from MTO are informative about the design of housing mobility programs, they are only informative about a small subset of neighborhood effects. Furthermore, examination of the local average treatment effect identifying assumptions helps to illustrate the limitations of searching for exogenous variation in one causal variable while abstracting from all others.

Aliprantis presents empirical tests for instrument strength that show that MTO induced large changes in neighborhood poverty rates but remarkably little variation in many of the other neighborhood characteristics believed to influence outcomes. He argues that this reinterpretation of the MTO data stresses the importance of understanding heterogeneity in response to treatment and suggests two important conclusions. First, if alternative housing mobility programs were designed to induce moves to neighborhoods with characteristics other than low poverty, it is entirely feasible that such programs might induce larger effects than those realized with MTO. Second, local-average-treatment-effect estimates appear to reconcile the evidence from MTO with prevailing theories of neighborhood effects.

"The Spending and Debt Response to Minimum Wage Hikes"

Aaronson, Agarwal, and French provide new evidence on the spending and debt responses of consumers to an exogenous income change, in particular an increase in the minimum wage among households with an adult minimum wage worker. They present four key empirical findings based on a variety of large survey and administrative datasets. First, a $1 per hour minimum wage hike increases total household spending by approximately $700 per quarter in the near term. This exceeds the roughly $250 per quarter increase in household income resulting from the hike. This pattern is corroborated by independent data showing that debt rises substantially after a minimum wage increase. Second, the majority of this additional spending goes toward durable goods, espe-

cially vehicles. Consequently, the spending response is concentrated among a small number of households. Third, total spending increases within one quarter *after* a minimum wage hike, although legislation of the increase typically passes 6 to 18 months before the hike. Finally, high levels of durables spending and debt accumulation persist for several quarters after a minimum wage hike.

Aaronson, Agarwal, and French argue that these results are hard to explain using two canonical models: the permanent income model and the buffer-stock model with no borrowing. If households were spreading an income gain over their lifetime, as in the permanent income hypothesis, the short-run spending increase should be much smaller than what is observed in the data. The authors show that augmenting the permanent income model to account for durables raises the predicted short-term spending response. However, it is still an order of magnitude smaller than what the empirical estimates imply. Moreover, a buffer-stock model in which households cannot borrow against durable goods generates a spending response of less than $200 per quarter and fails to explain why some minimum wage households increase their debt after a minimum wage hike.

The authors further consider an augmented buffer-stock model in which households are collateral constrained; that is, they can borrow against part, but not all, of the value of their durable goods. If households face collateral constraints, small income increases can generate small down payments, which in turn can be used for large durable goods purchases. For example, with a 20 percent down payment, each additional dollar of income can purchase $5 of durable goods. Such a model does much better matching the facts, including for the magnitude, composition, and timing of spending and debt. An augmented buffer-stock model that allows for the cost of adjusting durables (e.g., the time it takes to shop for a new car or the trade-in value of a vehicle) also replicates the skewness of the spending responses shown in the data. The authors' results provide direct microeconomic evidence of the quantitative importance of collateral constraints, a factor increasingly used to understand the

dynamics of consumer durables, housing, and entrepreneurship.

"Designing Formulas for Distributing State Aid Reductions"

Zhao and Coyne present a new framework for distributing state aid to local governments. Given the ongoing state and local fiscal crises across the nation, state aid to local governments has become an increasingly important and contentious budgetary issue. States tend to disproportionately and quickly cut local aid during a fiscal crisis. Indeed, the Congressional Budget Office reports that 22 states reduced aid to local governments in fiscal year 2010 and that 20 states propose additional cuts in fiscal year 2011. Some states cut aid on an ad hoc basis, while others cut aid across the board, with every community receiving the same percent or per capita dollar cut. Such approaches are widely considered unfair: Critics say ad hoc approaches are not based on economic rationale and lack transparency in the decisionmaking process and that across-the-board cuts are more burdensome for poorer communities that tend to rely more heavily on state aid.

To address these concerns, Zhao and Coyne develop a framework that reduces aid distribution based on underlying local fiscal health. They use a local fiscal gap measure to indicate fiscal health outside the direct control of local officials. Based on this framework, state government would cut less aid from communities with larger fiscal gaps and less existing aid. The framework also accommodates aid increases, thus providing policymakers with a single tool for aid revision. The authors use Massachusetts data on unrestricted municipal aid to conduct simulations and explore policy implications.

Unlike the Zhao-Coyne framework, the current literature on state aid distribution focuses on gap-based formulas that preserve existing aid distributions, or hold them harmless, and distribute only aid increases. Therefore, those formulas are incompatible with aid-reduction scenarios.

The Zhao-Coyne analysis is useful for policymaking and discussion. First, it provides a more rational and fair framework for cutting local aid

than commonly used ad hoc or across-the-board methods. Adopting their gap-based framework for aid reduction can help reduce the burden for communities with the worst underlying fiscal health and, therefore, advance fiscal equalization across cities and towns. Second, the framework helps the transition from non-gap-based to gap-based aid distribution even in years of aid cuts: States can accelerate the reform process (without waiting for aid increases) to implement a gap-based formula with a hold-harmless clause. Third, the research is practical and timely because many states are making or planning to make additional local aid cuts. The framework can be used for distributing school or non-school aid and is potentially applicable to all states.

"The Role of Schools in the Production of Achievement"

The literature on sources of inequality finds that "pre-market" factors (i.e., skills individuals acquire before entering the labor market) explain most income inequality across individuals and between groups of individuals. But what explains differences in pre-market factors? Three types of inputs are believed to determine these factors: ability, family inputs, and school inputs. Therefore, to answer the question it is crucial to understand first the relative importance of each input.

A growing literature in economics tries to provide an answer to the question by studying children's scores on performance tests. The literature on the production of achievement has not been able to provide an estimation that simultaneously accounts for the three factors at the student level. Canon intends to fill this gap by providing an estimation of the production function of achievement where both investment types (families and schools) are considered in a framework in which the inputs are allowed to be correlated with the unobserved term: ability to learn. Canon does so by applying an algorithm, which accommodates endogeneity problems in the choice of inputs for the production of achievement, to a very suitable dataset for this problem—the National Education Longitudinal Study of 1988 (from the Institute of Education Sciences, U.S. Department of Education).

This dataset provides information on both home and school inputs at the student level as well as parents' savings for their children's post-secondary education. Canon uses the savings data to control for the unobserved component (i.e., the ability to learn) in the production of skills. This allows recovery of the parameters of interest in the production function of achievement: the effect of period-by-period investment and the impact of the achievement acquired in previous periods. What makes the savings for postsecondary education measure informative is that parents decide to save at the same time they choose the family and school inputs that will affect the observed test score (the current outcome). However, those savings will not affect the current outcome but instead will affect future labor market outcomes through the choice to attend college.

Canon's estimates for the role of family inputs are in line with previous findings: They foster students' achievement and these inputs are more crucial at some times than others. However, her estimates of school inputs show that, contrary to what has been found in the existing literature, they are important for the formation of students' skills. Moreover, school inputs seem to be as important as family inputs if late remediation policies are considered. Additionally, Canon also finds evidence that savings for postsecondary education are a good proxy for students' unobserved ability to learn.

"Economic Literacy and Inflation Expectations: Evidence from a Laboratory Experiment"

Burke and Manz present new experimental evidence on heterogeneity in the formation of inflation expectations and relate the variation to economic literacy and demographics. They conduct a laboratory experiment in which subjects complete a set of inflation-forecasting exercises in a simulated economic environment. Subjects complete (i) a questionnaire that measures economic and financial literacy and (ii) two simulation exercises that require them to provide forecasts of near-term and medium-term inflation for the U.S. economy. In the first exercise, sub-

jects select information from a menu of information sources with varying degrees of economic relevance; in the other, they receive preselected, uniform information sets. These separate exercises identify two important sources of heterogeneity across individuals with respect to expectations formation: (i) differences in the types of information used in forming inflation expectations (i.e., information is selected by the subjects) and (ii) differences in the use of identical information when forming inflation expectations (i.e., information is chosen for the subjects).

Burke and Manz find that heterogeneity in information selection significantly increases the variability of forecasting performance compared with the case in which information is homogeneous. This finding suggests that models of the inflation-expectations process vary across subjects, and this variability may contribute to real-world disagreement (and aggregate biases) in inflation expectations.

Compared with previous studies of survey data, the authors find that fewer demographic and socioeconomic factors are associated with variation in inflation expectations. For example, they do not observe robust gender differences in inflation expectations. In some cases, apparent demographic variation in expectations—such as between African Americans and whites—is explained by variation in economic literacy. More important, economic literacy contributes significantly to the accuracy of inflation forecasts and is associated with a reduced tendency to overestimate inflation in particular. The impact of literacy is nonlinear, however: Very poor performance in the bottom quartile of the distribution drives much of the variation, and the marginal impact of literacy becomes negligible above the 75th or 80th percentile. The contribution of economic literacy is not reducible to overall educational attainment or socioeconomic status and instead reflects a combination of economic knowledge and general numeracy.

Burke and Manz find that economic literacy contributes to the accuracy of forecasts through both sources of heterogeneity described above. First, more-literate subjects choose better (more-relevant) information sources in making their

forecasts. For example, compared with less-literate individuals, they are more likely to view data on aggregate inflation and less likely to rely exclusively on information about price changes for specific goods such as milk and oil. Second, more-literate subjects make better use of given data in the exercises involving preselected information. The results suggest that modest educational interventions targeted at individuals with very low economic literacy levels could lead to significant improvements in inflation forecasting. For example, directing subjects to more-relevant information, such as recent data on aggregate inflation rather than specific price changes, may reduce forecasting errors considerably.

"Financial Literacy and Mortgage Equity Withdrawals"

Duca and Kumar assert that mortgage equity withdrawals (MEWs) have been linked to the U.K. consumption boom of the late 1980s and the U.S. consumption boom of the early 2000s. MEWs have been linked to an increased sensitivity of consumption to housing wealth and liquidity constraints, consistent with permanent income models incorporating credit constraints, which imply that housing wealth influences consumption by providing collateral for loans to otherwise credit-constrained families.

However, the recent mortgage bust suggests that many households were unaware of the risks they took with MEWs, which is consistent with evidence that many are financially illiterate. Using data from the Health and Retirement Study (sponsored by the National Institute on Aging), earlier research documents that many families incorrectly answered questions about compound interest, money illusion, and portfolio diversification. Incorrect answers have been linked to suboptimal saving for retirements, overborrowing, and low stock market participation. Previous research indicates that state-mandated high school financial education and employer-based financial literacy programs led to higher saving. In addition, there is evidence that many homeowners do not choose the lowest-cost home mortgage option because they may be confused by

terms in mortgage contracts. Despite a role for increased MEWs during the recent boom and bust in consumption, potential linkages between financial literacy and MEWs are yet unexplored.

Duca and Kumar address this gap by examining whether financial literacy is linked to MEWs. Using three different measures of financial literacy—compound interest, money illusion, and portfolio diversification—they find that individuals' knowledge of portfolio diversification has the most significant impact on their propensity to make MEWs. The authors' results indicate that the financially literate are 3 to 5 percentage points less likely to withdraw housing equity by increasing mortgage debt; however, this result does not apply to their tapping home equity lines of credit. The authors also find that the propensity to make MEWs rises with house price appreciation and incentives to lower mortgage interest rates. In line with earlier research, the findings of Duca and Kumar indicate that legal conditions across states are correlated with MEW behavior. Given the recent evidence in the literature that MEWs were correlated with mortgage delinquencies as the housing crisis deepened, the Duca-Kumar findings suggest that financial education programs might be effective in preventing mortgage defaults.

"When Does the Labor Market Consider You a Smoker and Do You Care?"

Armour, Hotchkiss, and Pitts investigate when the labor market considers an individual a smoker, how being a smoker affects earnings, and how the expected earnings differential affects an individual's propensity to smoke.[2] They use a switching regression with an unknown sample-selection framework that allows for the data to indicate when the labor market begins treating workers differently based on whether they smoke. Their analysis is performed using data from the annual Current Population Survey Tobacco Use Supplement (from the Bureau of Labor Statistics) for 2000 to 2007.

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[2] The authors' paper and this summary do not represent the views of the Centers for Disease Control and Prevention.

Their analysis indicates that the labor market classifies an individual who smokes at all as a smoker. This suggests that even the most casual smokers experience wage penalties for smoking. Furthermore, the characteristics of smokers reduce the wage penalty, indicating that the wage differential is not a result of smokers bringing less-productive endowments to the labor market. Instead, the differential is from employers placing less value on the endowments brought by smokers than the same endowments brought by non-smokers (the coefficient effect is positive), indicating that employers treat smokers differently than nonsmokers.

The analysis also indicates that individual smoking behavior responds to the labor market penalty associated with smoking. The implication is that policies designed to increase the labor market penalty of smoking could be a powerful tool in reducing smoking. The authors' results remain robust when they compare different types of current nonsmokers with current smokers and estimate the model on a subsample of married people only.

"Financing Constraints and Unemployment: Evidence from the Great Recession"

Duygan-Bump, Levkov, and Montoriol-Garriga assert that lending to small businesses in the United States has fallen dramatically since the onset of the Great Recession. According to the most recent data, small-business loans made by commercial banks declined over $40 billion between the second quarter of 2008 and the second quarter of 2010. Similarly, the responses to the Federal Reserve's Senior Loan Officer Opinion Survey on Bank Lending Practices indicate that banks have significantly tightened credit standards on commercial and industrial loans to small firms in 13 consecutive quarters (2007:Q1–2010:Q1).

The decline in small-business lending has received much attention from policymakers, especially because of its potential link to the high unemployment rate. Indeed, almost 80 percent of all firms in the United States have fewer than nine employees, and small firms employ roughly 50 percent of all Americans. Unlike larger firms, which have broader access to capital markets, small businesses are highly dependent on bank financing. Accordingly, smaller firms are likely to have been disproportionately affected when banks restricted credit following shocks to their balance sheets.

The authors investigate the link between small-business lending and unemployment during the Great Recession. They argue that if reductions in small-business lending affect unemployment, then unemployment would be expected to increase more in smaller firms, but only among firms that depend on bank financing. They test their hypothesis by exploiting variation across firm size and external financial dependence. Specifically, they combine information on workers' firm size and unemployment status from the Current Population Survey (from the Bureau of Labor Statistics) with firms' financial information from Compustat and the Survey of Small Business Finances (from the Board of Governors of the Federal Reserve System). They then estimate changes in the unemployment rate during the recent financial crisis by firm size and across industrial sectors with different degrees of financial need.

Duygan-Bump, Levkov, and Montoriol-Garriga find that during the Great Recession workers in sectors with high external financial dependence were more likely to become unemployed, especially workers in smaller firms. By contrast, the authors do not find significant differences in unemployment propensity between workers in small and large firms in sectors with low external financial dependence. They estimate that during the financial crisis the likelihood of unemployment among workers in small, financially constrained firms increased by 0.55 percentage points relative to other workers. One explanation of this finding is that the financial crisis propagated to the real economy through a reduction in bank credit.

An alternative explanation of their finding is that changes in unemployment are not driven by changes in the supply of credit, but rather reflect a disproportionate reduction in the demand for goods and services produced by finance-dependent

sectors. To address this possible explanation, the authors repeat their analyses using data around the 2001 recession. They exploit the fact that the 2001 recession did not originate from stressed bank balance sheets. The resulting estimates for that recession show almost identical changes in the unemployment rate among small and large firms with different degrees of financial dependence. Comparison of the 2007-09 and 2001 recessions indicates that changes in the supply of credit contributed to changes in the rate of unemployment during the recent financial crisis.

This paper has important implications for policy intervention. The authors suggest that policies aimed at making credit available to small businesses, such as the recent $30 billion Small Business Jobs Act or the loans guaranteed by the Small Business Administration, would help stabilize the labor markets and economic activity in the United States.

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