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Chapter Authors: John Landon-Lane, Hugh Rockoff, Richard H. Steckel

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Droughts, Floods, and Financial Distress in the United States

John Landon-Lane, Hugh Rockoff,
and Richard H. Steckel

The relationships among the weather, agricultural markets, and financial markets have long been of interest to economic historians, but relatively little empirical work has been done, especially at the regional or state level. We push this literature forward by using modern drought indexes, which are available in detail over a wide area and for long periods of time to perform a battery of tests on the relationship between these indexes and sensitive indicators of financial stress. The financial literature in the area can be traced to William Stanley Jevons, who connected his sunspot theory to rainfall patterns. The Dust Bowl of the 1930s brought the weather-finance link to the attention of the general public. Here we assemble new evidence to test various hypotheses involving the impact of extreme swings in moisture on financial stress in the United States.

3.1 Prior Work on Weather, Financial Markets, and Business Cycles

The idea that weather affects agriculture and through agriculture, financial markets and the economy as a whole has a long, if not always persuasive, history among economists. The British economist William Stanley Jevons (1884, 221–43) famously argued that financial crises were produced,

John Landon-Lane is an associate professor of economics at Rutgers University. Hugh Rockoff is a professor of economics at Rutgers University, and a research associate of the National Bureau of Economic Research. Richard H. Steckel is the Social and Behavioral Sciences Distinguished Professor of Economics, Anthropology, and History and a Distinguished University Professor at Ohio State University, and a research associate of the National Bureau of Economic Research.

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ultimately, by sunspots. Financial crises had occurred with an average frequency of ten to twenty years in Jevons's time (1825, 1836, 1847, and 1866). Could it be an accident, Jevons asked, that spots appeared on the surface of the sun at (approximately) the same intervals? The connection, Jevons concluded, was through India. Sunspot activity disrupted rainfall and harvests in India. Low incomes in India depressed imports from Britain. The disruption of British trade with India in turn produced the financial crises. Jevons's son, H. Stanley Jevons (1933), attempted to defend and extend his father's theory. He recognized that the business cycle was the result of several factors. However, he argued that a harvest cycle of three or more years was part of the business cycle and that the harvest cycle was related to meteorological conditions (shown in part in tree ring data), and the regular fluctuations in meteorological conditions were partly the result of fluctuations in solar radiation.

Although Jevons's sunspot theory was often ridiculed, John Maynard Keynes's (1936, 531) cautious conclusion is to be preferred: "The theory was prejudiced by being stated in too precise and categorical a form. Nevertheless, Jevons notion, that meteorological phenomena play a part in harvest fluctuations and that harvest fluctuations play a part (though more important formerly than to-day) in the trade cycle, is not to be lightly dismissed." A. C. Pigou was an influential contemporary of Keynes who gave his imprimatur to the idea that fluctuations in the weather contributed significantly to the trade cycle, especially in countries such as the United States where agriculture was an important part of overall economic activity (Pigou 1927).

The American economist Henry Ludwell Moore (1921) argued that the business cycle was produced by the "transit of Venus." Every eight years, Venus stands between the Earth and the Sun, disrupting the Sun's radiation on its path to the earth. The result, according to Moore, was a regular eight-year rainfall cycle (identifiable in part by evidence from tree rings), a regular eight-year crop cycle, and a regular eight-year business cycle.

Weather driven fluctuations in harvests also play a role in accounts of particular episodes. Indeed, the business cycle at the end of the nineteenth century has often been described by economic historians as a product of fluctuations in weather. Milton Friedman and Anna J. Schwartz (1963, 98) argued that the cyclical expansion from 1879 to 1882 was reinforced by "two successive years of bumper crops in the United States and unusually short crops elsewhere." Katherine Coman (1911, 315) thought that the bumper crop of 1884 had produced the opposite effect because it sold for low prices: "The wheat crop of 1884 was the largest that had ever been harvested, and the price fell to sixty four cents a bushel, half that obtained three years before." As a result, there was a rash of bankruptcies in the wheat growing areas and the "inability of the agriculturists to meet their obligations to Eastern capitalists and to purchase the products of Eastern mills and workshops, extended and prolonged the industrial depression." Wesley

Clair Mitchell (1941, 2) argued that the recovery from the 1890 financial crisis was partly a harvest driven event: "Unusually large American crops of grain, sold at exceptionally high prices, cut short what was promising to be an extended period of liquidation after the crisis of 1890 and suddenly set the tide of business rising." O. M. W. Sprague (1910, 154) attributed the severity of the depression that followed the crisis of 1893 to low farm prices and high farm mortgages. Ernest Ludlow Bogart (1930, 690) agreed that the farm sector was heavily involved in the depression of the 1890s because of "the ruinous failure of the corn crop in 1894, and the falling off of the European demand for wheat, the price of which fell to less than fifty cents a bushel." The poor corn harvest was the result of drought (*New York Times,* August 4, 1894, 1; August 5, 1894, 8; and subsequent stories). Friedman and Schwartz (1963, 140) concluded that the economic revival after 1896 was reinforced by "another one of those fortuitous combinations of good harvest at home and poor harvests abroad that were so critical from time to time in nineteenth-century American economic history."

A. Piatt Andrew (1906) surveyed many of these individual episodes. He concluded that although corn, cotton, and wheat were the most important U.S. crops and that all influenced the business cycle, the latter two especially through exports, it was fluctuations in the value of the wheat crop that had the most impact on the business cycle. The reason was that wheat was an international crop and, hence, the influence of the American harvest could be offset or reinforced by the success or failure of wheat crops abroad. Recent work by Davis, Hanes, and Rhode (2009) has reinforced the view that weather-driven harvest events influenced the macroeconomy in the period between the U.S. return to the gold standard after the Civil War and World War I. The channel ran through the balance of payments: strong cotton exports produced increased imports of gold, expansion of the money supply, and lower interest rates. However, they challenge the claim of earlier writers that wheat and corn harvests mattered, finding little statistical evidence for a relationship running from the wheat or corn to industrial production.

A related literature that focuses more on regions and individual states emphasizes that the restrictions on branch banking in the United States weakened the U.S. banking system, especially when compared with foreign systems that permitted branch banking, such as the Canadian system (Bordo, Rockoff, and Redish 1994; Calomiris 2000, chapter 1; Ramirez 2003). Why? There are several possibilities. A recent paper by Carlson and Mitchener (2009), for example, argues that branch banking increased stability in the 1930s by increasing competition and, thus, forcing more prudent behavior on competing banks and branches. Clearly, however, an obvious potential explanation for the apparent stability of branch banking systems is that branch banking permitted banks to diversify local weather-related agricultural shocks. The main purpose of this study is to determine the frequency and severity of weather generated banking stress in American financial history.

We first describe (in sections 3.2 and 3.3) two classic examples of weather-driven economic distress: Kansas during the Populist era and Oklahoma during the Dust Bowl. These case studies allow us to bring in some qualitative evidence on the chain running from weather to agriculture to financial markets and allow us to explore alternative measures of bank stress that can be used in formal econometric tests. These examples, it seems to us, establish a strong prima facie case that that weather driven economic distress can have an important impact on the local financial system. We then turn to formal panel regressions. First, we examine the effects of extreme weather on farm incomes and mortgage foreclosure rates. We find significant and substantial effects. We then turn to panel regressions that directly test the effects of extreme weather on banking markets.

3.2 "In God we trusted, in Kansas we busted"

One of the best known examples of weather-driven financial distress in U.S. history comes from Kansas between the Civil War and 1900. This was the period in which the Populist movement took hold, and Kansas became famous for a motto emblazoned on the covered wagons of farm families leaving Kansas: "In God we trusted, in Kansas we busted."

There were three severe droughts in Kansas in the postbellum era. These show up clearly in figure 3.1, which plots the Palmer Drought Severity Index (PDSI) reconstructed from data on thickness of tree rings for Kansas from 1870 to 1900. The first year of severe drought after the Civil War, 1874, was the year the famous locust swarms that devastated plains farmers. A second postbellum drought followed in 1879 to 1881. Four years of good rain from 1882 through 1885 contributed to a land boom in western Kansas, but drought struck again in 1886 through 1888. Again, several years of good rain followed. But another drought, one of the most prolonged of the century, hit from 1893 through 1896.

We have found little discussion in the financial history literature about Kansas during the first drought. More is available, however, about the second and subsequent droughts. In particular, we have Allan G. Bogue's classic *Money at Interest* (1955, 103–9), which describes the experience of J. B. Watkins and Company, a major supplier of mortgage money in western Kansas, and other mortgage bankers. When crops failed during the 1879 to 1881 drought farmers besieged Watkins's agents, hoping for loans to tide them over or to provide the basis after they defaulted for a new start elsewhere. In those circumstances, it was hard for Watkins to make safe loans because desperate farmers and their friends were willing to attest to any value for a property in order to get some cash. In the end, Watkins was stuck with a large number of defaults, and for a time he stopped lending in some of the western counties.

This experience, however, failed to prevent a rapid surge of development

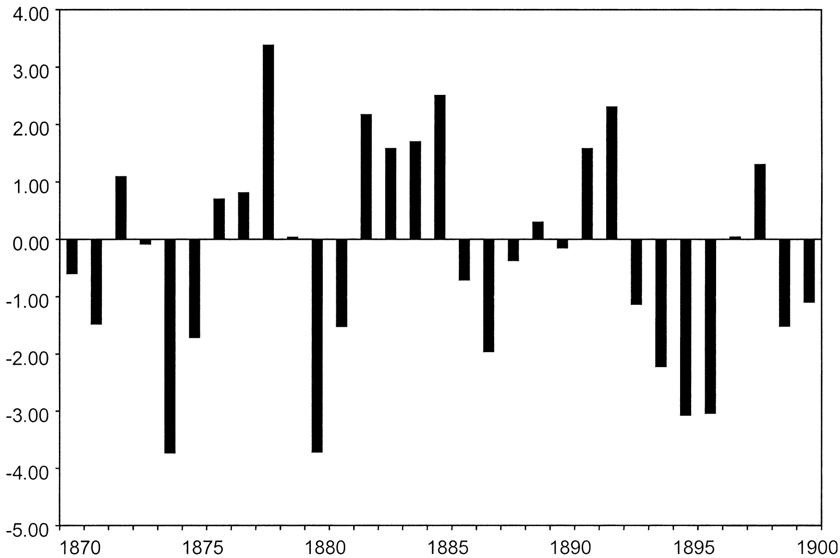

Fig. 3.1 The Reconstructed Drought Severity Index for Kansas, 1870–1900
Source: See the discussion of the reconstructed Palmer Drought Severity Index.

in the early 1880s when rain again became abundant. Drought, however, as shown in figure 3.1, returned in 1886. Again, Watkins responded by cutting off lending in the affected areas (Bogue [1955] 1969, 144–45). Even so, Watkins ended up holding large amounts of land as a result of foreclosures (Bogue [1955] 1969, 167). It is not surprising that in these years of drought, poor crops, and foreclosures, the local farmers turned to Populism. Indeed, James H. Stock (1984) has shown that support for Populism, nationally, was closely tied to mortgage foreclosures.

The final drought in Kansas in the nineteenth century lasted, as shown in figure 3.1, four years from 1893 through 1896. This was an unusually prolonged drought. One would have to go back to the Civil War Years or forward to the 1950s to find periods in which a four-year average of the PDSI was as low as it was in the mid-1890s.[1] It was also a period of international financial distress following the Panic of 1893, and as was often the case when there was a depression of international scope, a period of low prices for basic agricultural products. Kansas, in other words, was hit by a perfect storm (perfect lack of storms?): insufficient rain to grow familiar crops, an international financial crisis and depression, and low prices for agricultural products.

The drought and depression of the 1890s had a severe impact on the finan-

1. It is interesting to note that there was also a sustained drought during 1855 through 1857, the years of “bleeding Kansas.”

cial system of Kansas. Most of the western mortgage companies, including J. B. Watkins, failed (Bogue [1955] 1969, 187–92). These companies had been raising capital in the eastern United States and in Europe, some of it with mortgage-backed securities (Snowden 1995)—securities similar to those that underlay today's financial crisis. Therefore, Kansas's financial difficulties spread quickly. Once again, farmers left Kansas with the motto "In God We Trusted, in Kansas we Busted" emblazoned on their "prairie schooners." The farmers who used the motto, despite the hardships they had endured, were not always done with pioneering. The *Emporia Daily Gazette* (Emporia, KS, Monday, August 21, 1893) reported a line of prairie schooners bearing the motto "In God we trusted, in Kansas we busted. So now let 'er rip for the Cherokee Strip."

How did these developments that were clearly important to farmers and mortgage brokers like Watkins affect the national (federally chartered) banks in Kansas? This is an important issue for us because the data that are available consistently and for long periods of time are for the national banking system. We, therefore, need to know whether the national banking system was affected by the Kansas droughts and, if so, which measures of the health of the system were sensitive to the distress produced by extreme weather and poor harvests. Although it may seem plausible that the national system was affected along with other sectors, it is by no means a sure thing. The national system was subject to a different set of regulations than other sectors of the financial system, particularly with respect to real estate loans, and may even have profited to some degree during periods of financial distress from the transfer of funds to what was regarded as the safer part of the financial system.

The Comptroller of the Currency, the regulatory authority for the national banks, in those days provided an explanation for every failure of a national bank. Table 3.1 shows the thirty-four national banks that failed in Kansas between 1875 and 1910 and the explanations given by the comptroller. The 1890s were the hard years. In 1890, the worst year, there were seven failures. Most of the banks that failed in 1890 and 1891 had been in operation for only a few years (the average was five): they were creatures of the boom. The exception was the First National Bank of Abilene, which had been in existence for eleven years before it failed. In the early 1890s, as in other periods, the comptroller tended to attribute failures vaguely to injudicious banking, or more informatively to excessive loans to particular stakeholders, or fraud. In 1890 and 1891, however, the comptroller mentions real estate four times. After that, however, real estate is cited only once more, in 1896. "Stringency" in the money market, on the other hand, is not mentioned before 1893, but is given as a reason in three of the failures that occur in that year. Thus, this evidence is consistent with the notion that the national banking sector in Kansas was hard hit by the real estate boom and bust and that the distress resulting from the boom and bust was aggravated by the international financial crisis.

Table 3.1 National bank failures in Kansas, 1875–1910

Bank	Failure	Organized	Capital	Reason for failure
FNB Wichita	1876	1872	50,000	Defalcation of officers and fraudulent management
Merchants NB, Fort Scott	1878	1872	50,000	Investments in real estate and mortgages, and depreciation of securities
FNB Abilene	1890	1879	50,000	Excessive loans to others, injudicious banking, and depreciation of securities
State NB, Wellington	1890	1886	50,000	Injudicious banking and failure of large debtors
Kingman NB	1890	1886	75,000	Investments in real estate and mortgages, and depreciation of securities
FNB Alma	1890	1887	50,000	Excessive loans to officers and directors, and investments in real estate and mortgages
FNB Belleville	1890	1885	50,000	Excessive loans to officers and directors, and depreciation of securities
FNB Meade Center	1890	1887	50,000	Injudicious banking and depreciation of securities
American NB, Arkansas City	1890	1889	100,000	Excessive loans to officers and directors, and depreciation of securities
FNB Ellsworth Kansas	1891	1884	50,000	Excessive loans to others, injudicious banking, and depreciation of securities
SNB McPherson Kansas	1891	1887	50,000	Fraudulent management and injudicious banking
Pratt County NB	1891	1887	50,000	Excessive loans to officers and directors, and investments in real estates and mortgages
FNB Kansas City	1891	1887	100,000	Excessive loans to officers and directors, and depreciation of securities
FNB, Coldwater Kansas	1891	1887	52,000	Excessive loans to officers and directors, and investments in real estates and mortgages
FNB, Downs Kansas	1892	1886	50,000	Injudicious banking and depreciation of securities
Cherryvale NB	1892	1890	50,000	Fraudulent management, excessive loans to officers and directors, and depreciation of securities
FNB, Erie	1892	1889	50,000	Injudicious banking and depreciation of securities
Newton NB	1893	1885	65,000	General stringency of the money market, shrinkage in values, and imprudent methods of banking
FNB, Arkansas City[a]	1893	1885	50,000	Excessive loans to officers and directors, and depreciation of securities
FNB, Marion	1893	1883	75,000	General stringency of the money market, shrinkage in values, and imprudent methods of banking

(*continued*)

Table 3.1 (continued)

Bank	Failure	Organized	Capital	Reason for failure
Hutchison NB	1893	1884	50,000	General stringency of the money market, shrinkage in values, and imprudent methods of banking
State NB, Wichita	1894	1886	52,000	Excessive loans to others, injudicious banking, and depreciation of securities
Wichita NB	1894	1882	50,000	Depreciation of securities
FNB Wellington	1895	1883	50,000	Injudicious banking and depreciation of securities
Humbolt FNB	1896	1887	60,000	Injudicious banking and failure of large debtors
Sumner NB, Wellington	1896	1888	75,000	Investments in real estate and mortgages, and depreciation of securities
FNB, Larned	1896	1882	50,000	Injudicious banking
FNB Garnett	1896	1883	50,000	General stringency of the money market, shrinkage in values, and imprudent methods of banking
NB of Paola	1898	1887	100,000	Injudicious banking and failure of large debtors
FNB Emporia	1898	1872	50,000	Fraudulent management
Atchison NB	1899	1873	70,000	Excessive loans to others, injudicious banking, and depreciation of securities
FNB McPherson[b]	1899	1886	50,000	Failure of large debtors
FNB Topeka	1905	1882	50,000	Failure of large debtors
FNB Fort Scott	1908	1871	50,000	Fraudulent management and injudicious banking

Source: Annual Report Comptroller of the Currency 1910, table 44.

Notes: FNB stands for First National Bank. The location of the bank is shown when it is not part of the name of the bank.

[a]Temporarily restored to solvency before finally failing in 1899.

[b]In voluntary liquidation, prior to failure.

The most important economic reason for failure, taking the period as a whole, was "depreciation of securities," which was mentioned in sixteen cases. The nature of these "securities" is not clear from the information in the Comptroller's Reports. It might be possible to learn more in the archives of the comptroller, where detailed records of the liquidation of closed national banks are available. One possibility is that they were mortgage-backed securities issued by the land companies. Holding these securities was probably not consistent with the provisions of National Banking Act then in effect that prohibited lending on real estate, but banks might have held them anyway. After all, they were "securities." Our guess, however, is that many of the securities held by the banks that failed were railroad and municipal bonds. There had been a railroad construction boom in Kansas in the years leading up to the debacle of the 1890s fueled by expectations of rapid expansion of agriculture (Miller 1925, 470–71). Many of these railroads went bankrupt. And it seems probable that many of the securities issued by these railroads had been taken initially by local banks. Overall, capital in national banks in Kansas expanded rapidly during the boom of the 1880s, reached a peak in 1890, and then declined for a decade.[2] Total capital began to rise at the turn of the century and finally surpassed the 1890 level in 1908, but even then the par value of outstanding shares was still below the 1890 level. This suggests that most of the growth after 1899 was due to reinvestment of bank profits rather than outside investment.

Another indicator of the health of the national banks, national bank lending rates, however, does not provide a clear indicator of Kansas's struggles. When we compared bank lending rates in the Western Plains with the national average for 1888 (the first year that is available) to 1910, we found that the droughts and agricultural distress of the 1880s and 1890s did not leave a clear imprint on rates charged, despite the clear story told by the chronology of failures. The rate of return to national bank equity in Kansas, however, shown in figure 3.2, tells a story closer to what we learn from Bogue, from the comptroller's analyses of national bank failures, and from the aggregate capital figures. Here we can clearly see the boom of the mid-1880s and then the collapse as the bubble burst, a downturn that precedes the national business downturn. The drought of 1887 leaves a strong impact on rates of return to equity. From 1894 on, however, the returns to national bank capital in Kansas follow the national average, suggesting that the adaptation to the postdistress world had begun.

3.3 The Dust Bowl

The Dust Bowl of the 1930s, another classic case of weather-driven economic distress, was most severe in Oklahoma, the Texas Panhandle, and

2. The story is much the same whether one looks at bank capital in nominal or real terms.

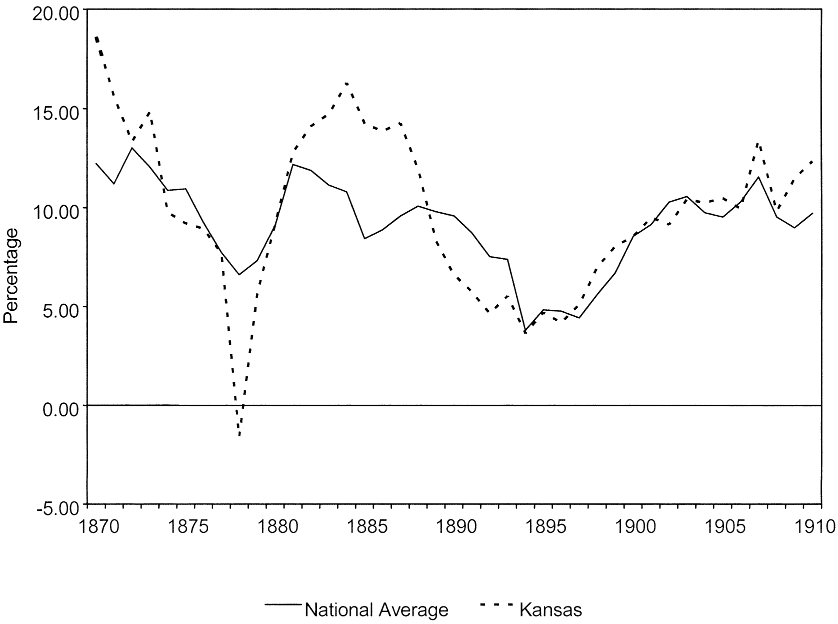

Fig. 3.2 The rate of return to equity in national banks, Kansas and the national average, 1870–1910

Source: State level rates of return to bank equity compiled by Scott A. Redenius; see text.

parts of New Mexico during 1930 to 1936. The dust storms are legendary, and the economic distress became an enduring part of the nation's cultural landscape with the publication of John Steinbeck's *The Grapes of Wrath* (1939). Somewhat surprisingly, given the role of the Dust Bowl in American cultural history, the Instrumental Palmer Drought Severity Index for Oklahoma and Texas shows that the drought of the 1930s, although severe, was far from extraordinary. By this measure the drought was much less severe than the drought that hit in the 1950s. Hansen and Libecap (2004) explain that the severity of the agricultural crisis in the 1930s was due in part to the prevalence of small farms that did not engage sufficiently in practices to limit wind erosion. The economic suffering, of course, was greatly aggravated by the low farm prices that prevailed during the Depression. Nevertheless, a closer look at this episode will shed some light on how weather-driven agricultural distress challenges local financial markets.

Historians of western banking are clear that the distress that resulted from the Dust Bowl was felt much more intensely by the small state chartered banks and private banks that served rural parts of the affected regions, rather than by the national banks that served urban areas. In particular, the rural banks lost money on livestock loans (Doti and Schweikart 1991, 144). Indeed, the national banks may have benefited to some degree from an attempt by depositors to switch funds from risky rural banks to the larger and safer national banks.

Loan losses, of course, were the main problem faced by the rural banks, but these banks also faced another problem that also became part of the cultural landscape: a rash of daring bank robberies. The most notorious of all the Oklahoma bank robbers was Charles "Pretty Boy" Floyd, who by 1934 had become the FBI's "public enemy number one" (Smallwood and Oklahoma Heritage Association 1979, 120–21). Bonnie and Clyde ranged over a wider area of the Midwest.

Financial distress in turn may have aggravated agricultural distress in the Dust Bowl. It would have been more difficult, for example, for a farmer who wanted a loan to tide him over the hard times to get one if the bank that he had developed a relationship with had failed or was deeply distressed. It would also have been harder for a farmer who wanted to borrow to expand his holdings by purchasing smaller failed farms to get the credit to do so. Conceivably, the Canadian banking system in which banks in rural areas, including drought stricken areas, were branches of large nationwide systems was better able to provide services in areas affected by extreme drought.[3]

Although the effects of the Dust Bowl were felt most keenly by the state and private banks, we need to look at the indicators for the national banks because these are the indicators that are available on a consistent long-term basis for most states. It appears that national bank lending rates were somewhat higher in the Dust Bowl region in the period 1933 to 1936 than might have been expected on the basis of long-term trends: the gap between rates in this region and in other regions rose relative to trend during the Dust Bowl years. The bulge in the premium began to decline in 1937 although it was the end of the decade before the West Lower South premium had returned to trend.

Figure 3.3 shows rates of return on national bank equity for Oklahoma and the United States as a whole, for the years 1925 to 1965. The Oklahoma returns were somewhat more volatile in the 1920s and 1930s than the national average. But in general, the Oklahoma nationals do not seem to have fared worse than national banks in other regions. Possibly the increase (compared with trend) in the regional risk premium in the lending rate served to protect national bank earnings in Oklahoma. The great drought of the 1950s, moreover, appears to have left virtually no impact on the rate of return to equity, which was close to the national average. By the 1950s, economic conditions had changed in Oklahoma. The banks had new fields in which to invest: beef production on large scale ranches and, most important, oil (Smallwood and Oklahoma Heritage Association 1979, 149–55).

Although space constraints have forced us to leave out many details, the case studies of Kansas prior to 1900 and Oklahoma in the Dust Bowl, we

3. This conjecture is suggested by Bernanke (1983).

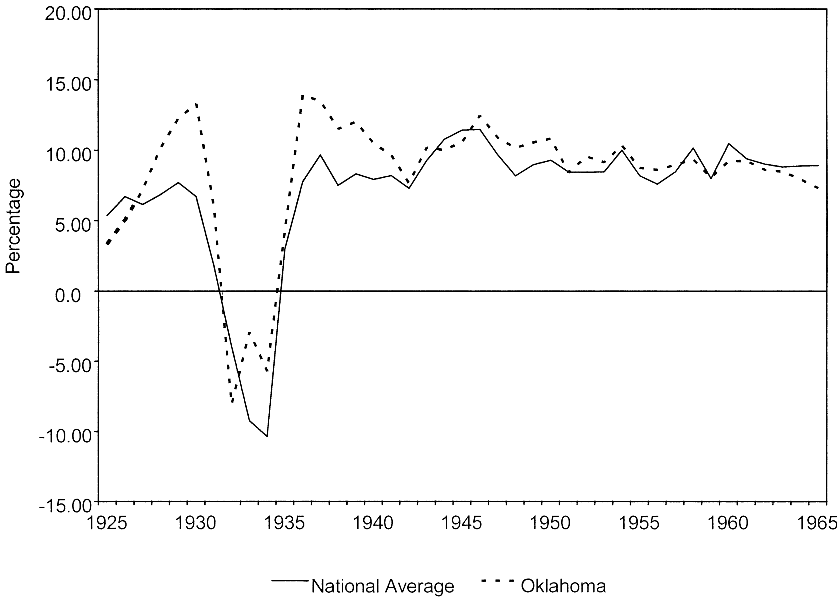

Fig. 3.3 The rate of return to equity in national banks, Oklahoma and the national average, 1925–1965

Source: State level rates of return to bank equity compiled by Scott A. Redenius; see text.

believe, establish a strong prima facie argument that extreme weather can cause distress in agriculture and local financial markets. We now turn to formal econometric analysis to determine systematically the impact of extreme weather conditions on agriculture and through agriculture on the banking system.

3.4 Econometric Analysis

We first look at the effect of extreme weather on farm income and farm mortgage foreclosures. Once we show that extreme weather has a negative effect on farm income and farm mortgage foreclosures, we then turn to the effect of extreme weather on local banking systems. In all cases, we regress our various measures of financial and economic stress on our drought indexes. Thus, we are isolating the combined effect of weather on our measures of bank stress (by a linear projection of the determinants of stress onto the space spanned by weather). As weather is clearly exogenous in the short run, we are able to get consistent estimates of the aggregate effect of weather on our measures of financial distress. The effect that we estimate is a reduced form amalgam of the effects of weather through various channels, some of which we do not observe. Therefore, the omission of relevant variables for the determination of bank stress does not affect our estimates of the effect of weather on financial markets.

We would expect there to be two possible effects of drought (or excessive rainfall) on the banking sector: a demand effect and a supply effect. (a) A demand effect would arise because drought affects the income of farmers and businesses related to farming. Low farm incomes would mean that farmers were likely to fall behind on loan repayments, which would directly reduce rates of return to equity. Drought, moreover, would lower aggregate demand in the region affected by the drought, which would lower the demand for new loans, which in turn would reduce interest rates and rates of return to equity. (b) A supply effect could arise if the adverse weather conditions and poor harvests led to bank runs and bank failures that in turn reduced the stock of bank capital, reduced the supply of loanable funds, and increased interest rates and rates of return. If the demand effect dominates, then we would expect the rate of return to be positively related to the drought index—that is, in periods of drought, we would see the rate of return on bank capital declining, and in periods of abundant rainfall, we would see the rate of return on bank capital increasing. If the supply effect dominates, we would expect to see the rate of return on bank capital negatively correlated with drought severity. Conceivably, the demand effect could dominate during normal periods with the supply effect only apparent during periods of "high stress," such as severe drought or flood. In this case, we would expect to see the drought index having a nonlinear effect on the rate of return. We will test for this by allowing for farm income, the foreclosure rates, and the rate of return to equity to be nonlinearly related to the drought index.

3.4.1 Our Bank "Stress Test"

The use of farm income or farm mortgage foreclosures as measures of the effect of extreme weather on agriculture is straightforward, but a word is in order about why we settled on the rate of return to equity in national banks as our "stress test" for banks. There were a number of considerations. First, the rate of return to bank equity was a key decision variable for banks, banking authorities, and the public. It reflected losses due to late payments and reductions in surplus due to the writing down of the value of nonperforming loans, but ultimately it was the return to equity that would determine whether more capital was invested in a bank or whether, because it earned no income, a bank had to be closed.

Second, The data for national banks about their assets and liabilities and their income and expenditures was regularly reported in standardized form to the Comptroller of the Currency. Data on state-chartered banks would be valuable because state banks were important in many of the agricultural states where extreme weather played an important role, as we saw in our case studies of pioneer Kansas and Dust Bowl Oklahoma. Unfortunately, the form in which state bank balance sheets were reported varied from state to state, and the crucial income and expenditure data was almost always missing.

Third, typically, the national bank data has been used to compute regional bank lending rates. Major contributions include Lance Davis (1965), Richard Sylla (1969), Gene Smiley (1975), and John James (1976). The most recent, and in our view, best data now available are the estimates prepared by Scott A. Redenius (2007a). But as our case studies indicated, the bank lending rate often provided an ambiguous signal concerning the stress that had been placed on the banking system by poor harvests and adverse weather. The rate of return to equity, moreover, is computed from data that were regularly reported to the comptroller with relatively few judgment calls by the historian and is available from 1869. The estimates of bank lending rates, on the other hand, are somewhat synthetic measures and are available from a later date. Scott A. Redenius compiled the data we use and was kind enough to share it with us.[4]

Fourth, the national banks were subject to various regulations that isolated them somewhat from weather-related problems in agriculture: rules, for example, limiting their investments in mortgages and forcing investment in government bonds. Therefore, our choice national bank profit rates as a measure of stress biases our estimates of the effects of extreme weather on banking downward. The true effect of weather on banking markets is likely to be greater than those we find.

The aim of this analysis is to determine whether there was any relationship between drought and our variables of financial stress: farm income, foreclosures on farm mortgages, and the rate of return to bank capital. We also want to determine if there were systematic relationships across the country as a whole or whether any effect we find is confined to only certain regions of the country.

We do this by estimating a panel (fixed effects) regression with farm income, the farm foreclosure rate, and the rate of return to bank capital as dependent variables and our drought indexes as the explanatory variables.

3.4.2 Unit Root Analysis Tests

Table 3.2 contains various panel unit root tests for real farm income, the foreclosure rate, the rate of return on bank capital, and for both of our drought indexes. We report two types of panel unit root tests: the first type are tests that assume a common unit root among the variables—in this case, we assume a common unit root across states—and the second type of tests assume that each state has individual unit roots. In all tests, the null hypothesis is that the time series contains a unit root and the alternative is that the time series is stationary. The number of lags used in the panel unit root tests

4. Redenius (20007b) uses this data to explore several hypotheses about the integration of the American banking market. Scholars who wish to use this data should contact Professor Redenius at Brandeis University.

Table 3.2 Panel unit root *p*-values for drought, rate of return and foreclosure data

Test	Palmer Drought Severity Index: Atmospheric	Palmer Drought Severity Index: Reconstructed	Rates of return	Foreclosures	Farm income
Assuming common unit root					
Levin, Lin, and Chu	0.0000	0.0000	0.0000	0.0024	0.9023
Breitung	0.0000	0.0000	0.0000	0.0000	0.1522
Assuming individual unit root					
Im, Pesaran, and Shin	0.0000	0.0000	0.0000	0.0251	0.3965
ADF-Fisher	0.0000	0.0000	0.0000	0.0497	0.3849

was chosen using the Schwarz-Bayesian Information Criterion (SBIC). The results for all the tests in the following show that the unit root hypothesis can be rejected for all time series except for real income. In almost all cases, the null hypothesis can be rejected at the 1 percent level with only a few tests resulting in a rejection of the null hypothesis at the 5 percent level. Given the results of the unit root tests, we will treat each time series except farm income as a stationary time series so that each series on drought severity, the rate of return on bank capital, and the farm foreclosure rates will enter into our regression equations in levels. For farm income, we use the percentage change in farm income as the dependent variable.

3.5 The of Effect of Drought on Farm Income

In this section, we look at the relationship between drought and farm income for the period 1926 to 1948. The results of these regressions are shown in table 3.3 (nominal farm incomes) and table 3.4 (real farm incomes).[5] Although it makes more sense in most situations to expect real shocks such as drought to affect real variables, here the effects on nominal income are of interest because farm loans were fixed in nominal terms. We see significant effects for the United States as a whole both in the regressions explaining nominal income and the regressions explaining real income. If we look at finer census divisions and focus on nominal farm incomes (table 3.3), we see significant linear effects in all of the central farming regions. If we focus on real farm income (table 3.4), we find statistically significant linear effects of drought in the East North Central and West South Central regions. The estimated effect is actually largest for the West North Central region although it is not statistically significant.

5. To get real farm incomes, we simply deflated nominal incomes by the gross domestic product (GDP) deflator. This procedure adjusts for broad movements affecting the whole economy but not for interregional variations.

Table 3.3 Farm income panel regressions (nominal values)

	Linear specification	Quadratic specification	
Region	PDSI	PDSI	PDSI^2
United States	0.0423*	0.0408*	–0.0083**
	(0.0061)	(0.0058)	(0.0034)
Northeast	0.0294***	0.0284	0.0091***
	(0.0141)	(0.0146)	(0.0039)
Midwest	0.0544***	0.0438***	–0.0180**
	(0.0094)	(0.0084)	(0.0066)
South	0.0346***	0.0344***	0.0009
	(0.0073)	(0.0070)	(0.0031)
West	0.0406**	0.0396**	–0.0069
	(0.0144)	(0.0139)	(0.0048)
East North Central	0.0479**	0.0536**	0.0094
	(0.0170)	(0.0193)	(0.0059)
West North Central	0.0573*	0.0423*	–0.0261**
	(0.0118)	(0.0096)	(0.0071)
East South Central	0.0193***	0.0192***	0.0061
	(0.0066)	(0.0070)	(0.0108)
West South Central	0.0420***	0.0422**	–0.0005
	(0.0137)	(0.0124)	(0.0038)

Notes: PDSI = Palmer Drought Severity Index. All standard errors are computed using clustered robust standard errors (in parentheses).

***p-value < 0.1.

**p-value < 0.05.

*p-value < 0.01.

3.6 The Effect of Drought on Farm Foreclosures

Drought reduced farm incomes, and as shown by Alston (1983) for the interwar period, thereby increased the rate of farm mortgage foreclosures. Here we provide some additional evidence. Using data from 1926 to 1948 on the number of farm foreclosures per 1,000 farms, we estimated a panel regression with foreclosures as the dependent variable and the atmospheric PDSI as the independent variable. The results from these regressions can be found in table 3.5. There appears to be a significant and nonlinear effect of drought on foreclosures for the whole panel. The region with the biggest effect is the Midwest. When we go to the finer census divisions, we see that the largest effects were in the East North Central and West North Central regions. Both regions also show substantial quadratic effects although the quadratic coefficient is statistically significant only for the wheat growing West North Central states. In this region, a one unit decrease in PDSI caused an increase in farm foreclosures of about 4 per 1,000 farms.

Table 3.4 **Farm income panel regressions (real values)**

	Linear specification	Quadratic specification	
Region	PDSI	PDSI	PDSI^2
United States	0.0679**	0.0651**	–0.0152*
	(0.0276)	(0.0267)	(0.0091)
Northeast	0.0329	0.0316	0.0114***
	(0.0160)	(0.0163)	(0.0046)
Midwest	0.0884	0.0761	–0.0210
	(0.0542)	(0.0599)	(0.0126)
South	0.0344**	0.0338**	0.0034
	(0.0150)	(0.0148)	(0.0042)
West	0.0843	0.0811	–0.0224
	(0.0666)	(0.0643)	(0.0231)
East North Central	0.0673***	0.0727***	0.0089
	(0.0268)	(0.0312)	(0.0096)
West North Central	0.0978	0.0807	–0.0298
	(0.0805)	(0.0877)	(0.0157)
East South Central	0.0431	0.0430	0.0089
	(0.0239)	(0.0236)	(0.0162)
West South Central	0.0458***	0.0466***	–0.0017
	(0.0173)	(0.0159)	(0.0043)

Notes: See table 3.3 notes.
***p-value < 0.1.
**p-value < 0.05.
*p-value < 0.01.

The previous two sets of results show that weather did affect farm income and the farm mortgage foreclosure rate. We now turn to our central concern: the effect of extreme weather on the banking system as measured by rates of return to capital.

3.7 The Effect of Drought on Rates of Return to Bank Equity

We estimated a linear panel regression with fixed effects for each state in our sample.[6] Cluster robust standard errors are used with the clusters

6. The states included in our sample are North East (Massachusetts, Maine, Vermont); Mid-Atlantic (New York, Pennsylvania); East North Central (Illinois, Indiana, Michigan, Ohio, Wisconsin); West North Central (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota); South Atlantic (Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia); East South Central (Alabama, Kentucky, Mississippi, Tennessee); West South Central (Arkansas, Louisiana, Oklahoma, Texas); Mountain (Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, Wyoming); and Pacific (California, Oregon,

Table 3.5 Farm foreclosures panel regressions

	Linear specification	Quadratic specification	
Region	PDSI	PDSI	$PDSI^2$
United States	–2.1083*	–2.0014***	0.2033***
	(0.2969)	(0.2744)	(0.0493)
Northeast	–0.8164**	–0.7223*	–0.2998
	(0.2729)	(0.3011)	(0.1859)
Midwest	–3.6036*	–3.4046***	0.1589***
	(0.4378)	(0.4402)	(0.0506)
South	–1.4526*	–1.4377***	0.0621
	(0.1775)	(0.1777)	(0.0765)
West	–1.2055**	–1.1933***	0.1199*
	(0.4018)	(0.3693)	(0.0646)
East North Central	–2.1912*	–1.9125**	0.1820
	(0.2879)	(0.4530)	(0.1859)
West North Central	–4.2253***	–4.0059***	0.1944***
	(0.4866)	(0.4768)	(0.0477)
East South Central	–1.2081*	–1.3690	–0.2303
	(0.4787)	(0.6477)	(0.3348)
West South Central	–1.3863***	–1.3953***	0.0786
	(0.1133)	(0.0696)	(0.0627)

Notes: See table 3.3 notes.
***p-value < 0.1.
**p-value < 0.05.
*p-value < 0.01.

defined by the nine census divisions.[7] The robust standard errors are robust to unknown autocorrelation within the time series and unknown heteroscedasticity across the cluster units. We estimate first a model that is linear in the drought severity index (PDSI) and then add a quadratic term ($PDSI^2$) to check whether extreme weather conditions have a nonlinear effect on the rate of return to bank capital.

The results from the panel regressions with the rate of return of bank capital are found in tables 3.6 through 3.8. In table 3.6, the results of the linear and quadratic specifications are reported for a panel consisting of the forty-two states in our sample. For both drought severity indexes, we find that there is a significant positive effect of the drought index on the rate of return on bank capital: more rain means a higher return. The quadratic term is significant for the regression over the whole period (from 1900 to 1976 for atmospheric PDSI

Washington). Our sample is determined by the availability of the drought index and rate of return to bank equity.

7. We do not include time effects as there is a high degree of correlation between the drought severity indexes across states. By including time effects, we run the risk of capturing weather effects as time effects that we do not want to happen.

Table 3.6 Panel regression results for rates of return on bank capital (U.S. sample)

	Full sample period	1850–1900	1900–1940	1940–1976
	Linear specification			
PDSI-Actual	0.5065*		0.7557*	0.1038**
	(0.0572)		(0.0754)	(0.0466)
PDSI-Reconstructed	0.3758*	0.1027	0.6971*	0.1886*
	(0.0482)	(0.0775)	(0.0887)	(0.0523)
	Quadratic specification			
PDSI-Actual	0.4879*		0.7185*	0.1038**
	(0.0528)		(0.0691)	(0.0468)
$PDSI^2$-Actual	–0.0870*		–0.0863**	–0.0011
	(0.0233)		(0.0344)	(0.0135)
PDSI-Reconstructed	0.3528*	0.0791	0.6509*	0.1970*
	(0.0489)	(0.0843)	(0.0871)	(0.0517)
$PDSI^2$-Reconstructed	–0.0700*	–0.0664***	–0.1002*	0.0400*
	(0.0206)	(0.0406)	(0.0330)	(0.0146)

Notes: PDSI = Palmer Drought Severity Index. Using actual atmospheric readings, the full sample period is from 1900 to 1976, and using the drought index reconstructed from tree rings, the full sample period is from 1850 to 1976.

The standard errors reported are clustered robust standard errors (in parentheses).

***p-value < 0.1.

**p-value < 0.05.

*p-value < 0.01.

and from 1850 to 1976 for the tree ring reconstructed PDSI).[8] The negative sign on the quadratic term indicates that periods of extreme drought have a worsening effect on the rate of return to bank capital and that periods of extreme wet can also adversely affect the rate of return to bank capital.

When we reestimate the model for different subperiods, also reported in table 3.6, we see that the period from 1900 to 1940 is where the biggest effect is found. The coefficient on PDSI is over 50 basis points higher for this period than for the later period from 1940 to 1976. This shows that the effect of weather on the banking system has not been uniform over time. When using the tree ring reconstructed data, we also see lower estimated coefficients on the PDSI term suggesting that the period from 1900 to 1940 was different in terms of how weather affected the banking system.

We had expected to see results for the pre-1900 period that were similar to those found in the 1900 to 1940 period. However, this was not the case. A possible explanation is that a combination of limited farming activity in

8. The data on the reconstructed PDSI runs from 1850 until 1976, but the sample period for the rate of return on bank capital varies by state. Therefore, we have an unbalanced panel when using pre-1900 data. Most state rate of return data starts in the late 1860s, but some states only have data from 1890.

some states in the early part of the sample and a limited number or total absence of national banks in some western states early in the sample have biased the results.

Given our results for the United States as a whole (or at least for the forty-two states in our sample), we now look at the different regions to see if there are regional differences in the effect of drought severity on the rates of return to banks for our sample periods. These results are reported in tables 3.7 and 3.8. In table 3.7, results are reported for the four major U.S. Census subregions of the Northeast, the Midwest, the South, and the West. The results show that the biggest effect of drought on banking stress can be found in the Midwest with a one unit increase in the drought index causing upward of a 100 basis points increase in the rate of return to bank capital. Again, we see that this result is biggest during the period from 1900 to 1940. Table 3.7 reports the results from the quadratic specification for those regions where the quadratic term was significant at the 10 percent level. Unlike the earlier results for the whole sample, we do not find a consistent nonlinear relationship. However, for the Midwest region, we see the same pattern with a large positive coefficient on PDSI and a smaller, but significant, negative coefficient on the $PDSI^2$.

One interesting point is that there is a significant effect of drought on rates of return for the pre-1900 period for the South but not for other regions. The result is not a complete surprise. The South was more dependent on agriculture than the Northeast or Midwest and, hence, more likely to be affected by droughts that reduced farm incomes. Indeed, Davis, Hanes, and Rhode (2009) show that the cotton crop was an important determinant of the business cycle in the late nineteenth and early twentieth centuries. In some of the western areas of new settlement that were highly dependent on agriculture, moreover, we have fewer observations because the national banks came in only after economic development could support larger banks. The expectation that drought-related banking problems should have been greater before 1900 than after may be based on the idea that the internal capital market of the United States was completely integrated after 1900. As shown by Landon-Lane and Rockoff (2007), however, tight integration seems better identified with the post–World War II era.

Finally, we break the regions up into smaller Census divisions and report these results in table 3.8.[9] We report only those divisions making up the center of the country (coefficients for other regions were uniformly insignificant) and see substantial effects although even in these mainly farming states, the effect varies from region to region. The West North Central region had the biggest effect of drought on rates of return to bank capital. During the period 1900 to 1940, a one unit increase in the drought index increased the rate of return to bank equity by 100 basis points. There was a nonlinear effect for this division: at severe levels of drought, the effect of additional

9. For these regressions, the clusters are the individual states.

Table 3.7 Rate of return panel regressions by census region

Region	Variable	Full sample	1850–1900	1900–1940	1940–1976
		PDSI-Actual			
Northeast	PDSI	0.6489**		0.9149**	0.4559*
		(0.1442)		(0.2823)	(0.1287)
	$PDSI^2$	0.1996*		—	0.1287**
		(0.0403)			(0.0399)
Midwest	PDSI	0.6362*		0.08772*	0.0782
		(0.0813)		(0.1379)	(0.0522)
	$PDSI^2$	–0.2135*		–0.2361*	—
		(0.0391)		(0.0421)	
South	PDSI	0.5064*		0.6327*	0.3752*
		(0.1024)		(0.1365)	(0.0535)
	$PDSI^2$	0.0565***		0.1918*	–0.0425*
		(0.0276)		(0.0624)	(0.0139)
West	PDSI	0.2866*		0.6569*	–0.1667**
		(0.0822)		(0.1072)	(0.0536)
	$PDSI^2$	–0.0674**		—	—
		(0.0250)			
		PDSI-Reconstructed			
Northeast	PDSI	0.3492**	–0.1692	0.4951**	0.5658*
		(0.0927)	(0.1063)	(0.1592)	(0.1178)
	$PDSI^2$	—	—	—	—
Midwest	PDSI	0.4854*	0.0766	0.8161*	0.2433*
		(0.0692)	(0.1458)	(0.0871)	(0.0283)
	$PDSI^2$	–0.1075*	—	–0.2105*	—
		(0.0210)		(0.0504)	
South	PDSI	0.3267*	0.3169**	0.1790***	0.4396*
		(0.0267)	(0.1125)	(0.0916)	(0.0526)
	$PDSI^2$	—	—	—	0.0747
					(0.0135)
West	PDSI	0.2490**	0.0402	0.8746*	–0.1621***
		(0.1109)	(0.1617)	(0.1706)	(0.0751)
	$PDSI^2$	–0.0988**	—	–0.1030***	—
		(0.0391)		(0.0550)	

Notes: PDSI = Palmer Drought Severity Index. All standard errors (in parentheses) are computed using clustered robust standard errors. Results are only reported for the quadratic term if it was significant. When the quadratic term is not significant, the results for the linear specification are reported. Dashes indicate variable was not used in the estimating equation.

***p-value < 0.1.

**p-value < 0.05.

*p-value < 0.01.

drought was larger. However, we do not see a significant effect for this region in the period from 1850 to 1900. As our qualitative discussion of Kansas in the 1890s showed, it is likely that there were effects, but the absence of long runs of data in this region, which was a region of new settlement, means that it is hard to detect the effects econometrically.

Table 3.8 Rate of return panel regressions by selected census subregions

Region	Variable	Full sample	1850–1900	1900–1940	1940–1976
		PDSI-Actual			
East North Central	PDSI	0.5043*		0.4617**	0.1488
		(0.0958)		(0.1377)	(0.1085)
	PDSI²	–0.3171***		–0.4032***	—
		(0.0863)		(0.1637)	
West North Central	PDSI	0.6644*		0.9590*	0.0483
		(0.1118)		(0.1815)	(0.0560)
	PDSI²	–0.1933*		–0.2164*	—
		(0.0423)		(0.0408)	
East South Central	PDSI	0.6002*		0.7474*	0.4872**
		(0.0991)		(0.0681)	(0.1372)
	PDSI²	—		0.2491***	—
				(0.1052)	
West South Central	PDSI	0.1889***		0.1398	0.2398**
		(0.0708)		(0.0767)	(0.0497)
	PDSI²	—		—	–0.0502**
					(0.0147)
		PDSI-Reconstructed			
East North Central	PDSI	0.3810**	–0.1369	0.8694*	0.1908**
		(0.0850)	(0.1375)	(0.1111)	(0.0456)
	PDSI²	–0.1161***	—	—	—
		(0.0523)			
West North Central	PDSI	0.5417*	0.2121	0.8389*	0.2652*
		(0.0979)	(0.2146)	(0.1328)	(0.0358)
	PDSI²	–0.1004*	—	–0.1874*	—
		(0.0236)		(0.0421)	
East South Central	PDSI	0.4499*	0.0831	0.4506**	0.6045**
		(0.0285)	(0.1306)	(0.0843)	(0.1351)
	PDSI²	—	—	—	—
West South Central	PDSI	0.2207	0.5878**	0.0169	0.3021*
		(0.1103)	(0.1698)	(0.1216)	(0.0396)
	PDSI²	—	–0.2271***	—	0.0560*
			(0.0745)		(0.0077)

Notes: See table 3.7 notes.
***p-value < 0.1.
**p-value < 0.05.
*p-value < 0.01.

We also find strong effects of drought for the East North Central and East South Central regions for the period 1900 to 1940 and for the West South Central for the period 1940 to 1976. We had expected to see a strong effect for the West South Central before World War II because this was the region hit by the Dust Bowl. This region, however, also includes Texas and Louisiana. It may be that the effects of the Dust Bowl are being obscured by the inclusion of neighboring areas that did relatively well during the Depression because of the growth of petrochemicals or for other reasons. It may also be, as suggested by our case study of Oklahoma, that the damage was concentrated in the state banks and that the shift of funds from the state banks to the national banks offset some of the pressures on the national banks, the source of our data. Our results, to sum up, suggest that drought affected the rates of return to bank capital, and in some cases, this effect was economically significant. We find that the effect was largest in the early twentieth century and in the Midwest.

3.8 Conclusions and Conjectures

Did drought or excessive rainfall produce distress in agriculture and the banking systems in rural areas? In many cases it did. We explored two famous historical cases, Kansas after the Civil War and Oklahoma during the Dust Bowl of the 1930s, in some detail. In both cases, there were several factors at work producing distress in the banking system, but drought made things worse. To explore these relationships more systematically, we turned to panel data regressions. First, we tested for relationships between drought and farm income and drought and farm mortgage foreclosures in the interwar years. We found statistically and economically significant relationships for the central farming regions. Then, we tested for relationships between the rates of return to bank equity (a sensitive measure of the challenges facing a banking system) to the Palmer Drought Severity Index and where appropriate to estimates of the Palmer index derived from data on the thickness of tree rings. These regressions also revealed many statistically and economically significant relationships. Thus, for some regions and periods, we can document a chain running from drought to farm income to farm foreclosures to bank distress.

While the evidence for weather related banking distress is clear, we also found evidence of adaptation. Our case studies showed that a combination of extreme weather and macroeconomic disturbances could stagger a state banking system for a time but also that people and institutions adapted. Farmers began to grow new crops, turned to grazing, or simply moved on to other activities or other places; bankers learned to finance less vulnerable sectors of the local economy. Our econometric evidence shows that weather-related bank stress was more important prior to 1940. The declining role of agriculture and the increased integration of financial markets in the postwar era seem to have cushioned local banks from the full effects of local weather shocks after 1940.

Our results may provide some useful lessons as global warming begins to take a larger toll. One implication may be that large branch banking systems are better able to sustain localized drought induced economic stress than smaller systems. This consideration argues against recent calls for breaking up large banks on the grounds that it would be easier to avoid the adverse incentive effects of "too big to fail," the argument that when banks know they are too big too fail they take excessive risks. However, big banks that branch across regions, as the larger American banks now do, or as the Canadian banks did throughout their history, may be better able to offset temporary regional losses resulting from droughts or excessive rainfall with surpluses earned in other regions.

The American experience, ironically, may have special relevance for small nations facing the problem of climate stress. The American states, in the periods we examined, in many ways resembled small open economies linked by fixed exchange rates and free trade. Each state had its own banking system. An adverse weather event, if piled on top of a general economic depression, had the potential to create severe distress within the local banking system. The creation of the Federal Reserve, which produced high-powered money acceptable in all states, ameliorated the problem. Branch banking that linked the banks in vulnerable states to larger national systems also contributed to breaking the relationship between local droughts and local banking market distress. The analogs in the international sphere would be multinational banks that branched into small nations and international financial institutions, such as the International Monetary Fund and the World Bank, which helped integrate financial markets. Perhaps there are some lessons here for policymakers wrestling with the question of how best to prepare small open economies for the risks of weather-driven banking problems.

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