Droughts, Floods and Financial Distress in the United States

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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. 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 drought indexes were devised by climate historians from instrument records and tree rings, and because they are unfamiliar to most economic historians and economists, we briefly describe the methodology. The financial literature in the area can be traced to William Stanley Jevons, who connected his sun spot theory to rainfall patterns. The Dust bowl of the 1930s brought the climate-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.

Prior Work on Climate and Financial Markets

The idea that climate affects the financial sector and through the financial sector 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, ultimately, by sunspots. Financial crises had occurred with an average frequency of 10 to 20 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 3+ years was part of the business cycle, and that harvest cycle was related to meteorological conditions (shown in part in the 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."

Similarly, 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, is 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 as a product of climate and agriculture. Friedman and 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 (1939, 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, p. 1, August 5, 1894, p.8, and subsequent stories). Friedman and Schwartz concluded (1963, 140) that the economic revival after 1896 was reinforced by "another one of those fortuitous combinations of good harvests 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 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 might this be so? 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. One purpose of this study is to determine the frequency of climate driven banking shocks in American financial history.

Measuring Drought

Today researchers have a vast array of instruments to measure weather conditions around the globe from satellites and weather stations based on land and sea and in the atmosphere. Unfortunately the time-depth of these readings is inadequate for an historical study that reaches back to the era when farming was a dominant source of national income. Understanding the practical limitations of empirical research requires a brief discussion of technology, concepts, private efforts and government action that unfolded since the early 1700s.

Instrument readings. Ideally one would have a geographically dense array of comparable instrument readings that cover various aspects of weather over the past several centuries. Devices for measuring temperature and rainfall, however, were crude until the early eighteenth century, when Daniel Fahrenheit invented the mercury thermometer (1714) and Reverend Horsely developed the rain gauge (pluviometer) consisting of a funnel placed at the top of a cylinder (1722). In the 1720s Anders Celsius assisted Erik Burman in recording temperatures in Uppsala, and soon thereafter observational sites appeared elsewhere in Sweden.

Although the new technologies solved the problem of consistency, enabling people in distant places to take comparable readings, these early efforts were based on various thermometer scales that had to be converted into a common metric. Recordkeeping efforts were largely private or handled by scientific societies until well into the nineteenth century. Systematic study of weather patterns and their causes, much less climate change and its implications, could not begin effectively until a substantial body of evidence had accumulated. In the United States the Smithsonian Institution took the lead in developing a weather network in 1849 based on 150 voluntary observers. In 1874 the task passed to the U.S. Army Signal Service, whose functions were transferred to the newly created U.S. Weather Bureau in 1891. By 1900 numerous countries had created national meteorological services.

Concepts. After data collection became routine, researchers suggested ideas for measuring drought (Heim, 2002). In the early 1900s drought was defined by a rule of thumb: 21 or more days with rainfall below one-third of normal. Thornthwait (1931) proposed the concept of evapotranspiration or the sum of evaporation and plant transpiration, which led to ideas of water balance and alternative time scales. Palmer (1965) developed four measures: (a) a hydrological drought index based on measures of groundwater and stream flow with a horizon of 1+ years; (b) a drought severity index with a 9 month horizon; (c) a Z index that measures moisture anomaly in a particular month; and (d) a crop moisture index that monitors weekly conditions. Soon other measures appeared, such as the standardized precipitation index, a surface water supply index, and the vegetation condition index measured from satellite images.

Here we analyze Palmer's Drought Severity Index (PDSI), which has a time scale useful for assessing the economic consequences of yearly fluctuations or clusters of annual patterns in effective moisture (precipitation minus losses from evapotranspiration). Its water balance equation includes rainfall, runoff, evaporation, transpiration, and soil recharge, which are converted to a scale of -6 (extreme drought) to +6 (extremely wet) relative to normal or average conditions for a locality (Palmer 1965). It ignores stream flow, reservoir levels and snowfall, and is less useful in mountain areas or regions of microclimates (Alley 1984). It is fortunate for our purposes that the PDSI can be reconstructed from tree rings, which provide a chronology over hundreds, or even thousands of years if especially long-lived trees are available (such as bristlecone pines) or preserved logs can be extracted from peat bogs or old buildings.

Dendochronology. Leonardo da Vinci recognized that rings in the branches of trees show annual growth and the thickness of the rings indicate the years that were more or less dry. Andrew Douglas was a pioneer who formulated the scientific basis of the field in the 1920s and 1930s, and importantly the principle of cross dating, whereby overlapping chronologies from different trees could be merged to form long series. He founded the Laboratory of Tree Ring Research at the University of Arizona, where he and co-workers collected a vast number of cores using a tubular boring device.

To understand the meaning of tree rings, growth is decomposed into five parts:

$$R_t = A_t + C_t + \varphi D1_t + \varphi D2_t + E_t \tag{1}$$

where R denotes ring width; t the year; φ is a presence or absence indicator (taking values of 0 or 1) A is the age trend of tree growth; C indicates climate; D1 represents external disturbance processes such as a fire; D2 represents internal growth disturbance such as a disease; and E is an error term. The goal is to decipher or solve for C given R and information on A, D1 and D2. To reduce the effects of disturbances it is useful to collect large samples in a particular locality.

The Drought Database

Researchers have estimated the Palmer Drought Severity Index from instrument records, which cover the period 1900 to the present, and from tree rings, which go back as much as two thousand years depending upon the locality. Thus there is a break in our data source in 1900, and for this reason it is prudent to divide the analysis into two corresponding parts. We are aware that contrasts in the results across the two periods might be attributable to different data sources or to a structural shift in the relationship between drought and economic activity.

Assembling tree ring chronologies and estimating PDSI is an ongoing process, which is described in The North American Drought Atlas by Cook and Krusic (2004). Here we use PDSI values estimated from 835 tree ring chronologies scattered across North America, which researchers used to estimate PDSI values at 286 grid points (the raw data are available at http://www.ncdc.noaa.gov/paleo/pdsi.html). The points are evenly spaced over a 2.5 degree grid (roughly 175 miles apart), which provides a useful approximation to annual net moisture conditions at the local (state) level.[1]

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[1] Cook and Krusic used point-by-point regression, which is a sequential, automated fitting of single-point principal component regression models to a grid of climate variables taken from instrument readings. The method assumes that only those tree-ring chronologies close to a given PDSI grid point are good predictors of drought at that location. They used instrument data from 1928-1978 (the calibration period) to develop each regression equation. The remaining data from 1900-1927 (the verification period) of the instrument record were used to test the validity of the PDSI estimates. Additional details, including a map of the grid points and a discussion of statistical methods, are available at: http://iridl.ldeo.columbia.edu/SOURCES/.LDEO/.TRL/.NADA2004/.pdsi-atlas.html.

In this study we use two sets of drought indexes obtained from the North American Drought Atlas by Cook and Lamont (2004). The first is a set of instrumental PDSI readings for the sample period from 1900 to 2005. The second is a set of reconstructed PDSI readings using tree ring data that can be used to extrapolate the PDSI data far back into the past.

Our Bank "Stress Test"

There are many variables that could be used to measure the degree of stress placed on a banking system by adverse climatic changes. These include bank failures; changes in various balance sheet items, such as surplus accounts; rates of return on various categories of assets, such as rates of returns on loans; and the rate of return to bank equity.

At first thought, bank failure rates might seem to be a best measure of stress. There are, however, several problems with this measure. (1) In many periods there were relatively few National Bank failures. Failures were concentrated among state chartered and private banks, and economic historians, as far as we are aware, have not assembled the data for these sectors. (2) Panics sometimes led to the temporary or permanent closure of many smaller banks because of lack of liquidity, even though these banks were solvent. It is often difficult to determine from existing information whether closures were temporary or permanent, and whether they were the result of insolvency from bad investments or illiquidity from panics that spread from region to region. Obviously, these considerations do not suggest that failure rates contain no information; they merely suggest that using the existing data would be more difficult than it might seem.

Another measure of bank stress would be changes in the surplus account, the account where accountants write down the value of non-performing loans. To test the usefulness of this variable we selected 18 states that we thought to be likely suspects for a significant relationship between drought and banking stress. We then compiled surplus and other capital accounts for all banks in the state (national, state, and private) for the period 1896 to 1955 from *All Bank Statistics* (Board of Governors of the Federal Reserve 1959). Finally, we regressed these variables on drought indexes, but found no systematic relationships. It may be that the assumption that surplus accounts in that era were sensitive indicators of poor loan performance is mistaken.

For these reasons we turned to rates of return to bank equity as an indicator of bank stress. The data that we use is for National Banks because these banks regularly reported information on their balance sheets and income and expenditures 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 we would expect drought to have played an important role. Unfortunately, the form in which state bank balance sheets were reported varied from state to state and the crucial income and expenditure data was seldom included. 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). We have focused instead on the rate of return to bank equity because it has several important strengths as a measure of bank stress. (1) It is available from 1869, while most other series are available from a later date. (2) It can be computed from data that were regularly reported to the Comptroller with relatively few judgment calls by the historian. (3) It reflects losses due to late payments and reductions in surplus due to the writing down the value of nonperforming loans. (4) It represents a decision variable for banks, banking authorities, and the public. At some point a bank that earns no income must be closed. (5) The alternative, bank lending rates, was hard to interpret in the specific cases, Kansas after the Civil

War and Oklahoma in the 1930s that we explored in detail. Scott A. Redenius compiled the data we use and was kind enough to share it with us.[2]

Before proceeding to our empirical tests of the relationship between drought and banking stress, we will look at two cases that are well known to historians: Kansas after the Civil War and Oklahoma in the Great Depression. These examples should give us a better appreciation of the effects we can expect in extreme circumstances.

In God we trusted, in Kansas we busted

Perhaps the clearest examples of climate driven financial distress in U.S. history come from Kansas between the Civil War and 1900. This was the period in which Kansas became famous for the motto, emblazoned on the covered wagons of farm families leaving Kansas, “In God we trusted, in Kansas we busted.”

Chart 1 shows the reconstructed Palmer Drought Severity Index for Kansas from 1870 to 1900. The periods of drought in the post-Civil War era match up well with the periods of financial distress. The first year of severe drought after the Civil War, 1874, was the year the famous locust swarms devastated plains farmers. A second postbellum drought followed in 1879 – 1881. Four years of good rain from 1882 through 1885 helped create a land boom in western Kansas, but drought struck again in 1886 through 1888.

We have found little discussion about banking in Kansas during the first (locust) drought. More is available, however, about the second drought. Allan G. Bogue in his classic *Money at Interest* (1955, 103-109) 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

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

1879-1881 drought farmers, hoping for loans to tide them over, or to provide the basis after they defaulted for a new start elsewhere, besieged Watkins' agents. In those circumstances it was hard 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 episode, however, failed to prevent a rapid surge of development in the early 1880s when rain again became abundant. Drought, however, struck once again in 1886. Again Watkins responded by cutting off lending in the affected areas (Bogue 1955, 144-145). Even so, Watkins ended up holding large amounts of land as a result of mortgage foreclosures (Bogue 1955, 167).

The final drought in the nineteenth century lasted four years from 1893 through1896. 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 Palmer Drought Severity Index was as low as it was in the mid-1890s.[3] 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, 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 was disastrous for the financial system of Kansas. Most of the western mortgage companies, including J. B. Watkins failed (Bogue 1955, 187-192). These companies had been raising capital in the Eastern United States and in Europe, some of it with mortgage-backed securities (Snowden 1995) – securities that were similar to those that underlay today's financial crisis. Therefore, Kansas's financial difficulties spread quickly. Once

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[3] It is interesting to note that there was also a sustained drought during 1855 through 1857, the years of "bleeding Kansas."

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.”

Chart 2, which plots National bank capital in Kansas, measured in 1890 dollars, from 1865 to 1910, shows the booms and busts.[4] Bank capital expands rapidly during the boom of the 1880s, reaches a peak in 1890, and then declines for a decade. Total capital finally surpasses 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.

National bank lending rates, however, do not show a strong impact from Kansas's struggles. Chart 3 plots the bank lending rate in the Western Plains less the national average for 1888 (the first year that is available) to 1910. The great drought of the 1890s does not show up as a period of exceptionally high or low rates. There is an uptick in 1897 after the depression began to lift, but this seems to be part of a general increase in regions of new settlement: witness the uptick in rates on the Pacific coast less the national average.

The rate of return to National Bank equity in Kansas, shown in chart 4, tells a somewhat different story. Here we can see clearly the boom of the mid-1880s and then the collapse as the bubble burst, a downturn that seems to precede the national downturn. The drought of 1887 leaves a strong impact on rates of return to equity. But the effect of the drought of the mid1890s is less clear. From 1894 on, Kansas returns follow the national average.

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[4] The chart in nominal terms is similar.

The Comptroller of the Currency in those days assigned a reason for the failure of each national bank. Table 1 shows the 34 National banks that failed in Kansas between 1875 and 1910 and the reasons given by the Comptroller. The 1890s were the hard years. In 1890 alone, the worst year, there were 7 failures. Most of the banks that failed in 1890 and 1891 had been in operation for only a few years, they were creatures of the boom. The exception is the First National Bank of Abilene, which had been in existence for 11 years, but the average was 5 years. In the early 1890s, as in other periods, the Comptroller tended to attribute failures vaguely to injudicious banking, excessive loans to particular stakeholders, or fraud. In 1890 and 1891, however, the Comptroller mentions real estate four times. After that 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. This evidence is consistent with a sudden real estate boom and bust aggravated by an international financial crisis.

The most important economic reason for failure, taking the period as a whole, was “depreciation of securities,” which was mentioned in 16 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 these securities were railroad and municipal bonds. There had been a huge 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).

The Dust Bowl

The dust bowl of the 1930s, another classic case of climate-driven economic distress, was most severe in Oklahoma, the Texas Panhandle, and parts of New Mexico during 1930-36. However, as shown in Chart 5, which plots a 3-year moving average of the Instrumental Palmer Drought Severity Index for Oklahoma and Texas for 1900-1975, the drought of the 1930s, although severe, was far from extraordinary. By this measure it was much less severe than the drought that hit in the 1950s. Hansen and Libecap (2004) explain that the severity of the agriculture 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. Nevertheless, the episode should test the extent to which severe drought challenges financial markets.

It appears that bank lending rates were somewhat higher in the dust bowl region in the period 1933-1936 than might have been expected. Rates in this region rose while lending rates in most other regions (and other interest rates generally) fell. This is evident in Chart 6, which shows the difference between the rate in the West Lower South and the national average, and a linear trend. It is clear that the differential rose above trend in the depression years.

This elevation in rates could also reflect a systemic regional risk premium. This premium, if that is the proper interpretation, began to fall in 1937, although it was the end of the decade before the West Lower South premium had returned to trend. In order to test whether the dust bowl elevation in rates was an isolated event, we ran a series of regressions of the West Lower South rate on lagged values of itself, lagged values of the national rate, and the current and lagged values of the Palmer Drought Severity Index. None of our regressions suggested a systematic relationship between the drought severity index and the bank lending rate.

Chart 7 shows rates of return on national bank equity for Oklahoma, Texas, and the United States as a whole, for the years 1920 to 1950. Somewhat surprisingly, neither the Oklahoma nor the Texas systems show a sharp negative impact as a result of the Dust Bowl. For the most part, Texas, followed the national average reflecting its more diversified economy. Oklahoma actually recovered more rapidly than the system as a whole, and posted positive returns in 1933 and 1934. Possibly the development of a regional risk premium in the lending rate served to protect National Bank earnings in Oklahoma.

It appears that the banking distress that resulted from the depression and the dust bowl was concentrated among the small state banks and private banks that served rural Oklahoma, and often lost money on livestock loans (Doti and Schweikart 1991, 144), rather than the National Banks. One problem faced by rural banks, in addition to farmers who could not pay their mortgages, was a rash of 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 1979, 120-21). Oklahoma and surrounding states would face another severe drought in the 1950s. However, by then economic conditions had changed in Oklahoma. The banks had new fields in which to invest: beef production and, most important, oil (Smallwood 1959, 149-55). There seems, therefore, to have been little imprint of the drought on rates of return to equity in National banks. Nevertheless, long-term time series regressions were more "successful" in generating significant effects running from the drought index to the return on equity, than the experiments using bank loan rates. Financial distress may in turn have aggravated the economic distress in the dust bowl. It would have been more difficult, for example, for a farmer who had developed a relationship with a troubled bank and who wanted a loan to tide him over the hard times to get one, or 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 these areas. It is plausible that unfavorable weather conditions could place regional financial systems under stress. And possibly, during financial panics, ignite or contribute to a contagion of fear, but as our preliminary look at the dust bowl suggests, the interactions between economic and financial conditions can be complex and hard to detect.

Econometric Analysis

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. (1) 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. (2) A supply effect could arise if the weather conditions reduced 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 that the rate of return on bank capital be 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 non-linear effect on the banks rates of return. We will test for this by allowing for the rate of return and foreclosure rates to be non-linearly related to the drought index.

The aim of this analysis is to first 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 the rate of return to bank capital, the farm foreclosure rate, and the farm income rate, as dependent variables in turn.

This section is broken up into three parts: (1) we first determine the underlying unit root properties of the time series we use in our regressions, (2) we then test for a relationship between our measures of bank and financial stress and drought at a national level and then (3) at a regional level.

Unit Root Analysis Tests

Table 2 contains various panel unit root tests for the rate of return on bank capital, the foreclosure rate, real farm income, 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 for this test 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 was chosen using the Schwarz-Bayesian Information Criterion (SBIC). The results for all the tests below 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% level with only a few tests resulting in a rejection of the null hypothesis at the 5% 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.

Effects of Drought on Rates of Return

The first set of regressions uses the rate of return on bank capital as the dependent variable and our measures of drought severity (PDSI) as the explanatory variables. We estimated a linear panel regression with fixed effects for the States listed in Table 3. Cluster robust standard errors are used with the clusters defined by the nine divisions reported in Table 3 which are based on the US Census regional divisions.[5] 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 non-linear 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 4 through 8. In Table 4 the results of the linear and quadratic specifications are reported for a panel consisting of the 42 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

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[5] 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 which we do not want to happen.

(from 1900-1976 for atmospheric PDSI and from 1850-1976 for the tree-ring reconstructed PDSI).[6] 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 re-estimate the model for different sub-periods, also reported in Table 4, we see that the period from 1900-1940 is where 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 suggests 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 1900-1940 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 1900-1940 period. However, this was not the case. A possible explanation is that a combination of limited farming activity in some states in the early part of the sample and a less than fully developed banking system in some western states early in the sample have biased the results. We will try to explore this conjecture by breaking our panel into regional units.

Given our results for the US as a whole (or at least for our 42 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 5, 6, 7 and 8. In Tables 5 and 6 results are reported for the four major US Census sub-regions 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 upwards of a 100 basis points increase in the rate of return to bank capital. Again, we see that this

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[6] 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 start in the late 1860’s but some States only have data from 1890.

result is biggest during the period from 1900-1940. Table 6 reports the results from the quadratic specification for those regions where the quadratic term was significant at the 10% level. Unlike the earlier results for the whole sample, we do not find a consistent non-linear 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 a 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 Tables 7 and 8.[7] 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.

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[7] For these regressions the clusters are the individual States.

And there was a non-linear effect for this division: at severe levels of drought the effect of additional drought was larger. We do not see a significant effect for this region in the 1850-1900 period. 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. We also find strong effects of drought for the East North Central and East South Central regions for the period 1900-1940, and for the West South Central for the 1940-1976 period. We had expected to see a strong effect for this region before World War II because this was the region hit by the dustbowl. This region, however, also includes Texas and Louisiana. It may be that the effects of the dustbowl 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 sector that is 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.

The Effect of Drought on Farm Foreclosures

Drought (or excessive rainfall) is likely to affect the banking system by reducing farm incomes and reducing the servicing of loans to farmers, so it is important to check the internal links in the chain connecting drought with bank returns. Using data from 1926 to 1948 on the number of farm foreclosures per 1000 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 9. The results here are consistent with the results from the rates of return on bank capital regressions in that there appears to a significant and non-linear effect on foreclosures for the whole panel and that 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 1000 farms.

The Effect of Drought on Farm Income

To fill in another link in the chain connecting drought and bank stress we also looked at the relationship between drought and farm income for the period 1926 to 1948. The results of these regressions are shown in Tables 10 (nominal farm incomes) and 11 (real farm incomes).[8] 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. Once more 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 10) we see significant linear effects in all of the central farming regions. If we focus on real farm income (Table 11) 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.

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[8] To get real farm incomes we simply deflated nominal incomes by the GDP deflator. This procedure adjusts for broad movements affecting the whole economy, but not for interregional variations.

Conclusions and Conjectures

Did drought or excessive rainfall produced distress in the U.S. banking system? In many cases it did. We explored two of the famous historical cases, Kansas after the Civil War and Oklahoma during the dustbowl 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 the relationship between drought and banking stress more systematically we turned to panel data regressions relating 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, although the relationships were found only in the central farming regions. We also tested in the interwar years for relationships between drought and farm income, and drought and farm mortgage foreclosures. Again we found statistically and economically significant relationships for the central farming regions. Thus, for some regions and periods, we can trace a chain running from drought to farm income to farm foreclosures to bank stress.

While the evidence for climate related banking distress is clear, we also found evidence of adaptation. Our case studies showed that a combination of climatic 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 economy. Our econometric evidence shows that climate 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 climate 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 for breaking up large banks is that when banks know they are too big to 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, however, had its own banking system. An adverse climatic event, if piled on top of a general economic depression, had the potential to create severe stress 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 banking market stress. 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 that helped integrate financial markets. Perhaps there is a lesson here for policymakers wrestling with the question of how best to prepare small open economies for the risks of climate related banking problems.

Table 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
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

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

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

Table 2: Panel Unit Root p-values for Drought, Rate of Return and Foreclosure Data

Test	PDSI- Atmospheric	PDSI- 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

Table 3: Regional Classifications

Northeast		***Midwest***	
New England	*Mid-Atlantic*	*East N. Central*	*West N. Central*
Massachusetts	New York	Illinois	Iowa
Maine	Pennsylvania	Indiana	Kansas
Vermont		Michigan	Minnesota
		Ohio	Missouri
		Wisconsin	Nebraska
			North Dakota
			South Dakota

South			***West***	
South Atlantic	*East S. Central*	*West S. Central*	*Mountain*	*Pacific*
Florida	Alabama	Arkansas	Arizona	California
Georgia	Kentucky	Louisiana	Colorado	Oregon
Maryland	Mississippi	Oklahoma	Idaho	Washington
North Carolina	Tennessee	Texas	Montana	
South Carolina			New Mexico	
Virginia			Nevada	
			Utah	
			Wyoming	

Table 4: Panel regression Results for Rates of Return on Bank Capital (US sample)

	Full Sample period[†]	1850-1900	1900-1940	1940-1976
(Linear Spec.)				
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 Spec.)**				
PDSI-Actual	0.4879		0.7185	0.1038
	(0.0528)		(0.0691)	(0.0468)
$PDSI^2$-Actual	-0.0870		-0.0863	-0.001
	(0.0233)		(0.0344)	(0.0135)
PDSI- Reconstructed	0.3528	0.1026	0.6509	0.1970
	(0.0489)	(0.0775)	(0.0871)	(0.0517)
$PDSI^2$- Reconstructed	-0.0700	-0.0664	-0.1002	0.0400
	(0.0206)	(0.0406)	(0.0330)	(0.0146)

Notes:

[†] 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 here are clustered robust standard errors.

[*] Results are only reported for quadratic regressions where there is a significant effect at the 10% level.

Table 5: Results of Rate of Return Panel Regressions for Linear Specification by Census Region

Region	Full Sample	1850-1900	1900-1940	1940-1976
Actual PDSI				
Northeast	0.6248		0.9149	0.4166
	(0.1545)		(0.2823)	(0.0897)
Midwest	0.7361		1.033	0.0782
	(0.0815)		(0.1275)	(0.0522)
South	0.4895		0.4987	0.3657
	(0.097)		(0.1099)	(0.0574)
West	0.2820		0.6569	-0.1667
	(0.0922)		(0.1072)	(0.0536)
Reconstructed PDSI				
Northeast	0.3492	-0.1692	0.4951	0.5658
	(0.0927)	(0.1063)	(0.1592)	(0.1178)
Midwest	0.5269	0.0766	0.9583	0.2433
	(0.0772)	(0.1458)	(0.1044)	(0.0283)
South	0.3267	0.3169	0.1790	0.4345
	(0.0267)	(0.1125)	(0.0916)	(0.0629)
West	0.2837	0.0402	0.9098	-0.1621
	(0.1008)	(0.1617)	(0.1625)	(0.0751)

Notes: All standard errors are computed using clustered robust standard errors.

Table 6: Results of Rate of Return Panel Regressions for Quadratic Specification by Census Region

Region	Variable	Full Sample	1850-1900	1900-1940	1940-1976
Actual PDSI					
Northeast	PDSI	0.6489			0.4559
		(0.1442)			(0.1287)
	$PDSI^2$	0.1996			0.1287
		(0.0403)			(0.0399)
Midwest	PDSI	0.6362		0.8772	
		(0.0813)		(0.1379)	
	$PDSI^2$	-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		0.6507	
		(0.0822)		(0.0983)	
	$PDSI^2$	-0.0674		-0.0841	
		(0.0250)		(0.0493)	
Reconstructed PDSI					
Northeast	PDSI				
	$PDSI^2$				
Midwest	PDSI	0.4854		0.8161	
		(0.0692)		(0.0871)	
	$PDSI^2$	-0.1075		-0.2105	
		(0.0210)		(0.0504)	
South	PDSI				0.4396
					(0.0526)
	$PDSI^2$				0.0747
					(0.0135)
West	PDSI	0.2490		0.8746	
		(0.1109)		(0.1706)	
	$PDSI^2$	-0.0988		-0.1030	
		(0.0391)		(0.0550)	

Notes: 1. All standard errors are computed using clustered robust standard errors.
2. Results are only reported for those regressions with a significant quadratic effect.

Table 7: Results of Rate of Return Panel Regressions for Linear Specification by selected Census sub-regions

Region	Full Sample	1850-1900	1900-1940	1940-1976
Actual PDSI				
E. North Central	0.7468		0.9835	0.1488
	(0.0890)		(0.1180)	(0.1085)
W. North Central	0.7318		1.0514	0.0483
	(0.1128)		(0.1755)	(0.0560)
E. South Central	0.6002		0.5757	0.4872
	(0.0991)		(0.0544)	(0.1372)
W. South Central	0.1889		0.1398	0.2174
	(0.0708)		(0.0767)	(0.0488)
Reconstructed PDSI				
E. North Central	0.3854	-0.1369	0.8694	0.1908
	(0.0727)	(0.1375)	(0.1111)	(0.0456)
W. North Central	0.5981	0.2171	0.9999	0.2652
	(0.1069)	(0.2146)	(0.1479)	(0.0358)
E. South Central	0.4499	0.0831	0.4506	0.6045
	(0.0285)	(0.1306)	(0.0843)	(0.1351)
W. South Central	0.2207	0.5970	0.0169	0.2631
	(0.1103)	(0.1577)	(0.1216)	(0.0555)

Notes: All standard errors are computed using clustered robust standard errors.

Table 8: Results of Rate of Return Panel Regressions for Quadratic Specification by Selected Census sub-regions.

Region	Variable	Full Sample	1850-1900	1900-1940	1940-1976
Actual PDSI					
E. North Central	PDSI	0.5043		0.4617	
		(0.0958)		(0.1377)	
	$PDSI^2$	-0.3171		-0.4032	
		(0.0863)		(0.1637)	
W. North Central	PDSI	0.6644		0.9590	
		(0.1118)		(0.1815)	
	$PDSI^2$	-0.1933		-0.2164	
		(0.0423)		(0.0408)	
E. South Central	PDSI			0.7474	
				(0.0681)	
	$PDSI^2$			0.2491	
				(0.1052)	
W. South Central	PDSI				0.2398
					(0.0497)
	$PDSI^2$				-0.0502
					(0.0147)
Reconstructed PDSI					
E. North Central	PDSI	0.3810			
		(0.0850)			
	$PDSI^2$	-0.1161			
		(0.0523)			
W. North Central	PDSI	0.5417	0.8389		
		(0.0979)	(0.1328)		
	$PDSI^2$	-0.1004	-0.1874		
		(0.0236)	(0.0421)		
E. South Central	PDSI				
	$PDSI^2$				
W. South Central	PDSI		0.5878		0.3021
			(0.1698)		(0.0396)
	$PDSI^2$		-0.2271		0.0560
			(0.0745)		(0.0077)

Notes: 1. All standard errors are computed using clustered robust standard errors.
2. Results are only reported for those regressions with a significant quadratic effect.

Table 9: Results of Farm Foreclosures Panel Regressions

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

Notes: All standard errors are computed using clustered robust standard errors.

Table 10: Results of Farm Income Panel Regressions (Nominal Values)

	Linear Spec.	Quadratic Spec.	
Region	PDSI	PDSI	PDSI^{2}
US	**0.0423**^{c}	**0.0408**^{c}	**-0.0083**^{b}
	(0.0061)	**(0.0058)**	**(0.0034)**
Northeast	**0.0294**^{a}	0.0284	**0.0091**^{a}
	(0.0141)	(0.0146)	**(0.0039)**
Midwest	**0.0544**^{a}	**0.0438**^{a}	**-0.0180**^{b}
	(0.0094)	**(0.0084)**	**(0.0066)**
South	**0.0346**^{a}	**0.0344**^{a}	0.0009
	(0.0073)	**(0.0070)**	(0.0031)
West	**0.0406**^{b}	**0.0396**^{b}	-0.0069
	(0.0144)	**(0.0139)**	(0.0048)
E. North Central	**0.0479**^{b}	**0.0536**^{b}	0.0094
	(0.0170)	**(0.0193)**	(0.0059)
W. North Central	**0.0573**^{c}	**0.0423**^{c}	**-0.0261**^{b}
	(0.0118)	**(0.0096)**	**(0.0071)**
E. South Central	**0.0193**^{a}	**0.0192**^{a}	0.0061
	(0.0066)	**(0.0070)**	(0.0108)
W. South Central	**0.0420**^{a}	**0.0422**^{b}	-0.0005
	(0.0137)	**(0.0124)**	(0.0038)

Notes: All standard errors are computed using clustered robust standard errors. ^{a}: p-value <0.1, ^{b}: p-value <0.05, ^{c}: p-value <0.01

Table 11: Results of Farm Income Panel Regressions (Real Values)

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

Notes: All standard errors are computed using clustered robust standard errors. [a]: p-value <0.1, [b]: p-value <0.05, [c]: p-value <0.01

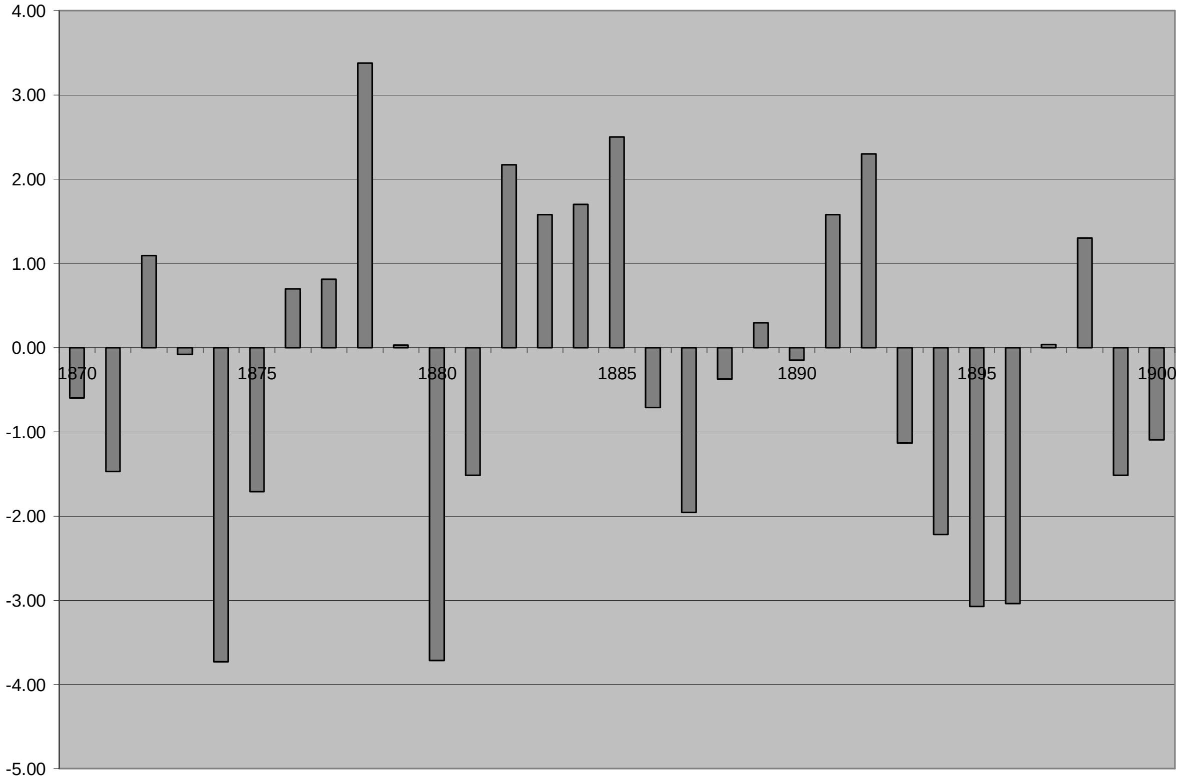

Chart 1. The Reconstructed Drought Severity Index for Kansas, 1870-1900

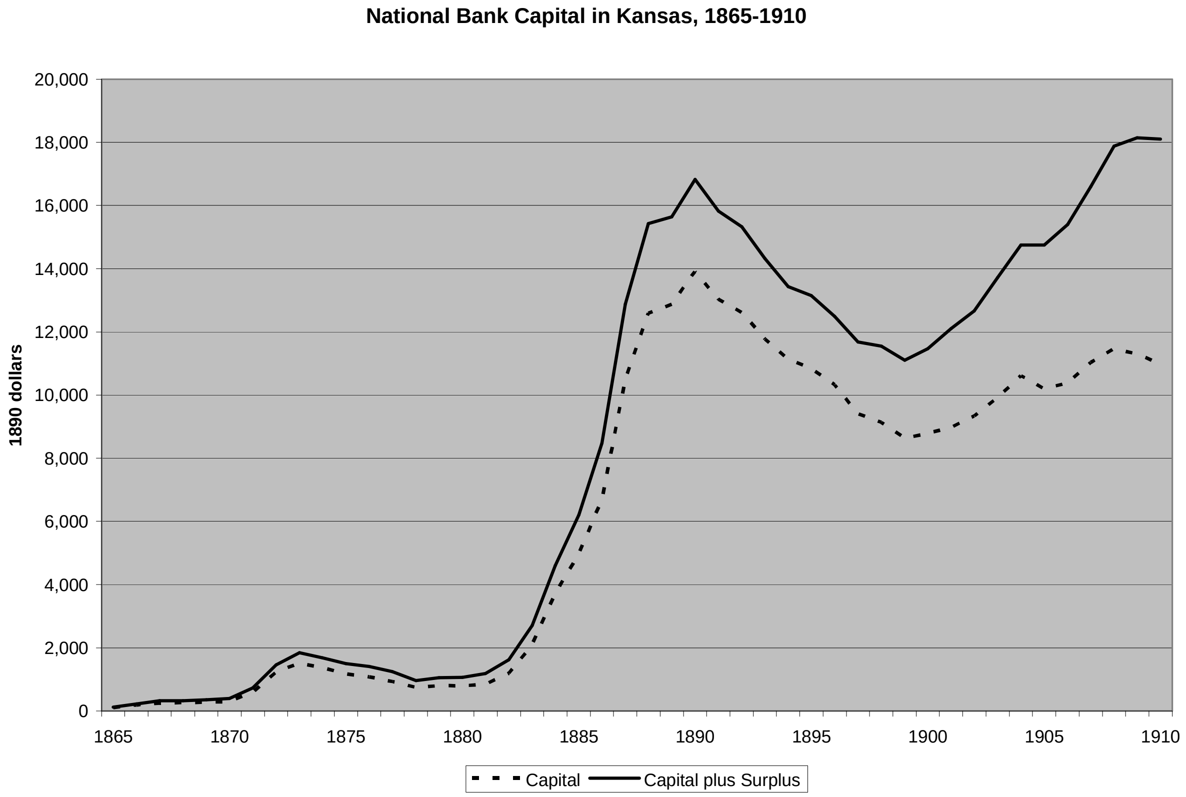

Chart 2. National Bank Capital in Kansas, 1865-1910

Source. Comptroller of the Currency, *Annual Reports*.

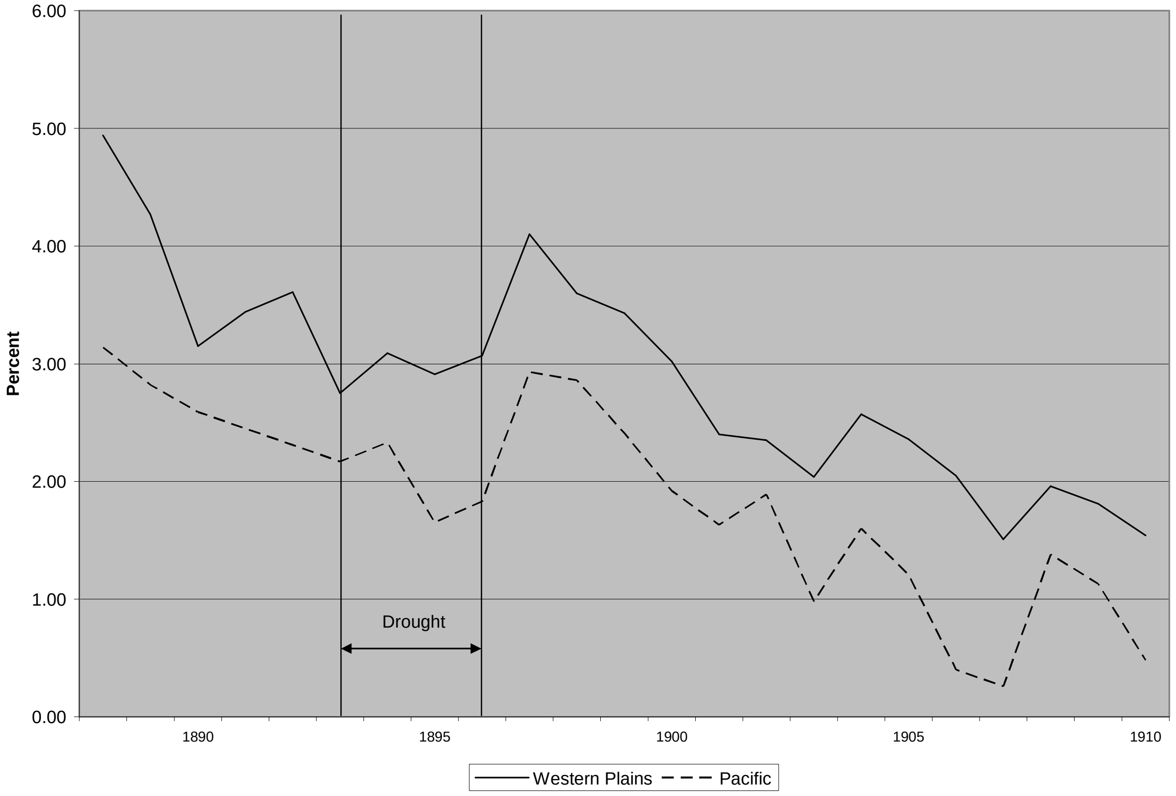

Chart 3. Bank lending rates in excess of the national average, Western plains and the Pacific, 1888-1910.

Source: Redenius (2007a).

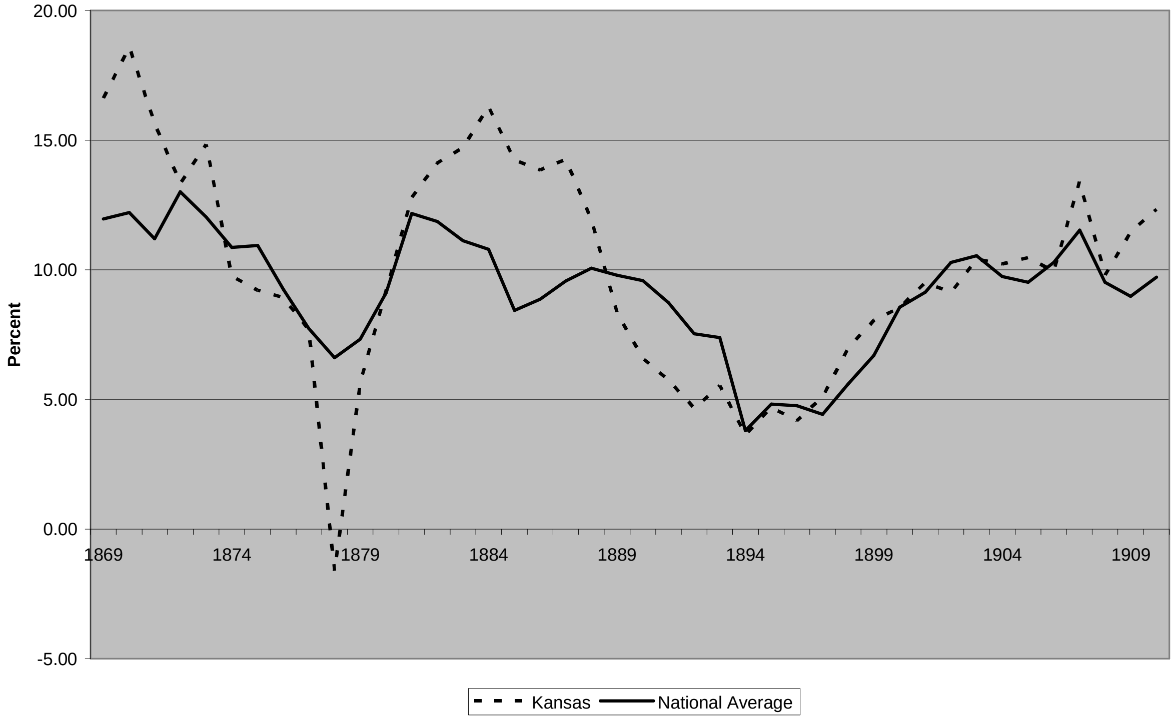

Chart 4. The Rate of Return to Equity in National Banks in Kansas, 1869-1910.

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

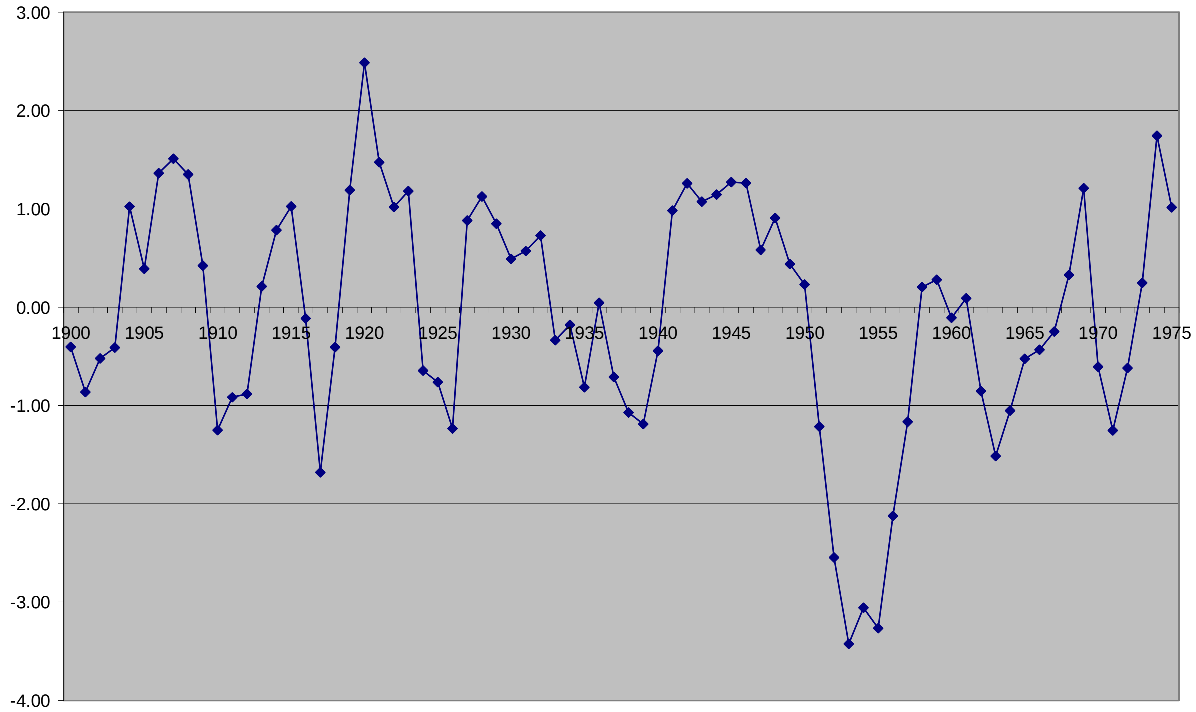

Chart 5. The Palmer Drought Severity Index for Texas and Oklahoma, 3-Year Moving Average, 1900-1975.

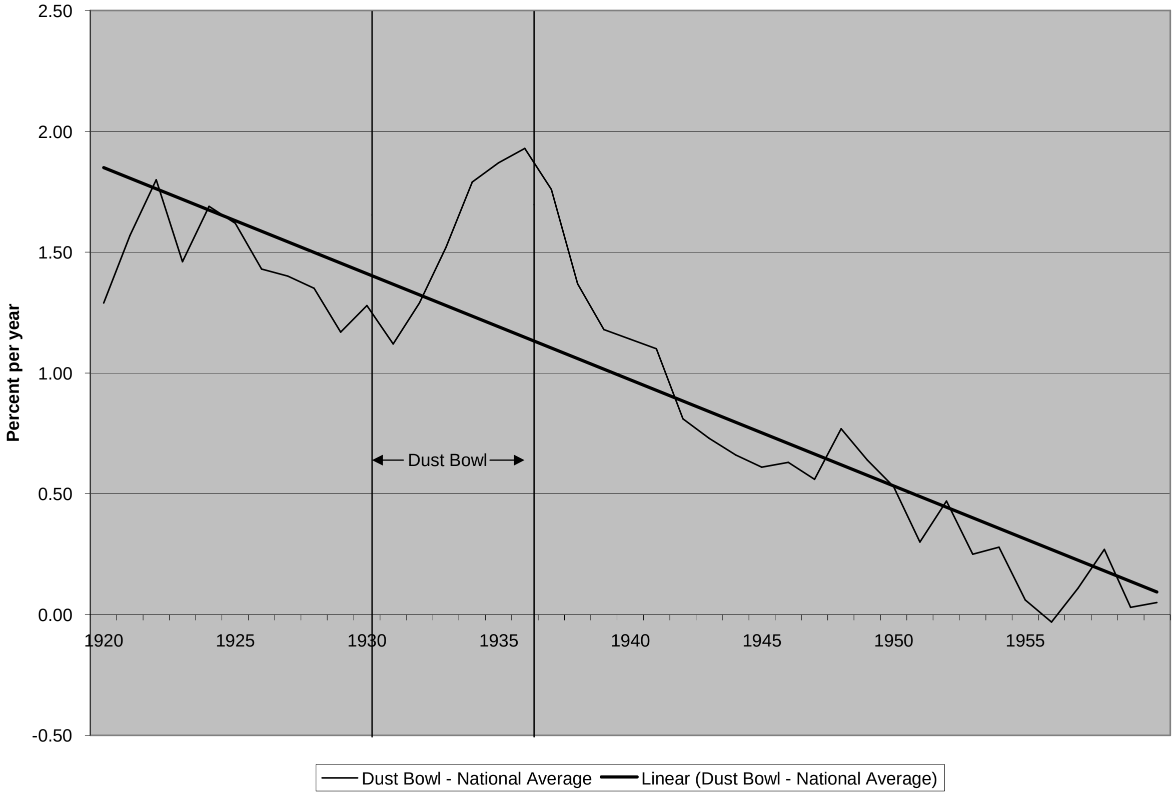

Chart 6. Bank lending rate in excess of the national average, West Lower South (Dust Bowl), 1920-1959.

Source. (Redenius 2007a).

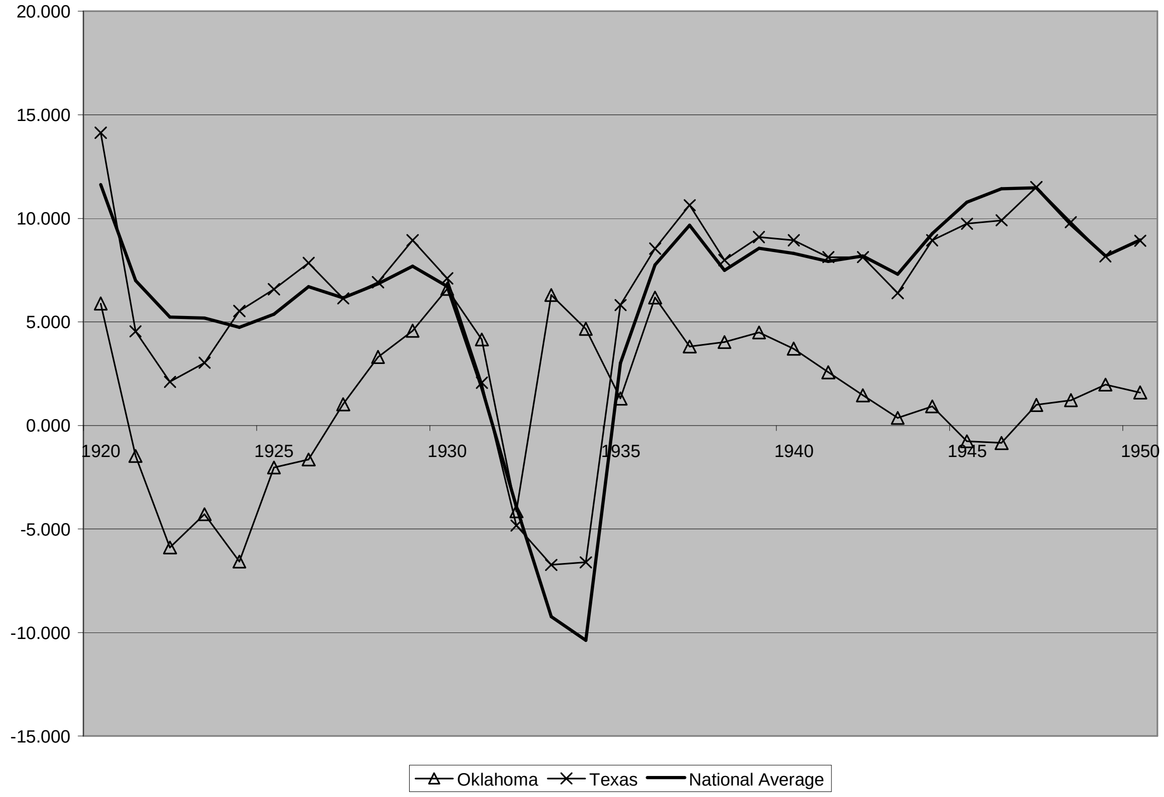

Chart 7. Rates of return on equity in National Banks, Oklahoma, Texas, and the National Average, 1920-1950.

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

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